Environmental Science

Report on the Effects of the California WaterFix Project on the City of Stockton

Exhibit STKN-26

Report on the Effects of the California WaterFix Project on the City of Stockton

Prepared for

City of Stockton
425 N. El Dorado Street
Stockton, CA 95202-1997

Prepared by

Exponent
1055 E. Colorado Blvd., Suite 500
Pasadena, CA 91106

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Acronyms and Abbreviations

AMMP	Adaptive Management and Monitoring Program
B1	Boundary 1 operational scenario
B2	Boundary 2 operational scenario
BA	biological assessment
BDCP	Bay Delta Conservation Plan
BiOp	biological opinion
CCWD	Contra Costa Water District
CVP	Central Valley Project
DSM	Delta Simulation Model
DWR	Department of Water Resources
EIR	environmental impact report
EIS	environmental impact statement
FEIR	final environmental impact report
MAF	million acre feet
RDEIR	recirculated draft environmental impact report
SDEIS	supplemental draft environmental impact statement
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre feet
USFWS	U.S. Fish and Wildlife Service
WaterFix	California WaterFix Project
WYT	water year type

1. Qualifications

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

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

I currently am a Principal and Director of the Environmental and Earth Sciences practice of Exponent, Inc. ("Exponent"). Prior to that, I was the President of Flow Science Incorporated, in Pasadena, California, where I worked for 20 years, first as a consultant (1994-1997), and then as an employee in various positions, including President (1997-2014). I have 25 years of experience with projects involving hydrology, hydrogeology, hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents. I have knowledge of

California water supply issues, including expertise in California's Bay-Delta estuary. My expertise includes designing and implementing field and modeling studies to evaluate groundwater and surface water flows, and contaminant fate and transport. I have designed studies using one-dimensional hydrodynamic models, three-dimensional computational fluid dynamics models, longitudinal dispersion models, and Monte Carlo stochastic models, and I have directed modeling studies and utilized the results of numerical modeling to evaluate surface and ground water flows.

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

2. Summary of Findings

The City of Stockton (the City) has retained Exponent to assist in evaluating the potential impacts of the WaterFix Project on water quality at the City's intake. Exponent has reviewed testimony submitted by the City as part of the State Water Resources Control Board (SWRCB)'s WaterFix proceedings as well as the City's comments on the Draft and Recirculated Draft Environmental Impact Report/Environmental Impact Statement (DEIR/EIS, RDEIR/EIS, respectively). As detailed below, Exponent's analysis of the WaterFix Project relies on a review of the model input and output files for the various alternative operational scenarios that have been provided by the California Department of Water Resources (DWR), including modeling files and documentation provided by DWR in the context of the FEIR/EIS.[1]

A key concern expressed by the City of Stockton was DWR's use of model results from a location known as "Buckley Cove" to evaluate water quality at the City's drinking water intake. DWR previously asserted, and the FEIR/FEIS continues to assert, that model results at the Buckley Cove location are representative of water quality at the City's intake location. However, as explained in detail below, Buckley Cove is over 8 miles from the City's drinking water intake (Figure 1), and both the composition and quality of water at Buckley Cove differ significantly from the composition and quality of water at the City's intake. For these reasons, model results from Buckley Cove are not representative of and cannot be used to accurately assess water quality changes at the City's intake. Because DWR did not evaluate water quality impacts at the location of the City's drinking water intake, Exponent used DWR's model input files and the Delta Simulation Model II (DSM2) to obtain model results to describe water quality impacts at the City's intake location. Exponent has concluded that the Project will result in substantial changes in the source and quality of water present at the City's drinking water intake on the San Joaquin River. Water quality changes relative to existing conditions at the City's intake will result in part from the export from the northern Delta of greater volumes of water and greater volumes of high quality Sacramento River water. Under most operational

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[1] Exponent has previously submitted comments on the FEIR/EIS on behalf of the City; these comments can be found in Appendix G.

scenarios, a greater fraction of the water at the City's intake will come from the San Joaquin River rather than the Sacramento River, and higher salinity and other water quality changes will occur as a result.

Water quality impacts to the City's water supply will result from the implementation of operational scenarios included in Petitioner's WaterFix Petition (i.e., Boundary 1 and Boundary 2) as well as the FEIR/EIS's preferred operational scenario (Alternative 4A). DSM2 model results show that under the Project's Alternative 4A scenario, Boundary 1 condition, and Boundary 2 condition, the chloride concentration at the City's intake will exceed the City's threshold of 110 mg/L more frequently than under existing conditions. For other operational scenarios, impacts are even greater.[2]

Both the WaterFix Petition and the FEIR/EIS do not disclose the impacts of the project to the City's drinking water supply in several additional ways. Namely, DWR has used an inappropriate existing condition baseline to model water quality impacts in the Delta; has not disclosed water quality changes modeled by DWR over the full operational range of the Project; and, as mentioned previously, has not modeled water quality at the City's drinking water intake. In addition, DWR's presentation of only monthly average water quality data in the Petition and FEIR/EIS masks salinity increases that occur over shorter time intervals and that must be assessed to evaluate water quality impacts at the City's intake, which operates on an hourly basis, not a monthly average basis. Lastly, the Petition and the FEIR/EIS do not adequately address potential for an increase in *Microcystis* blooms, which are a risk to humans and wildlife. Rather, DWR uses a whole-Delta analysis approach which does not consider area-specific changes as they relate to key beneficial uses in the Delta.

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[2] Exponent's technical analysis has focused primarily on chloride and *Microcystis* as well as changes in the hydrodynamics and residence times of the Delta indicated by the modeling. The City is also concerned about the potential for degradation of its water supply due to WaterFix-related increases in other water quality constituents, such bromide, nitrate and pesticides, and increased temperature, which could affect its compliance with wastewater discharge permit requirements. Based on Exponent's experience, the modeling and evaluation of chloride, and changes in the distribution and residence time of water within the Delta, Exponent would expect degradation for these water quality constituents of concern.

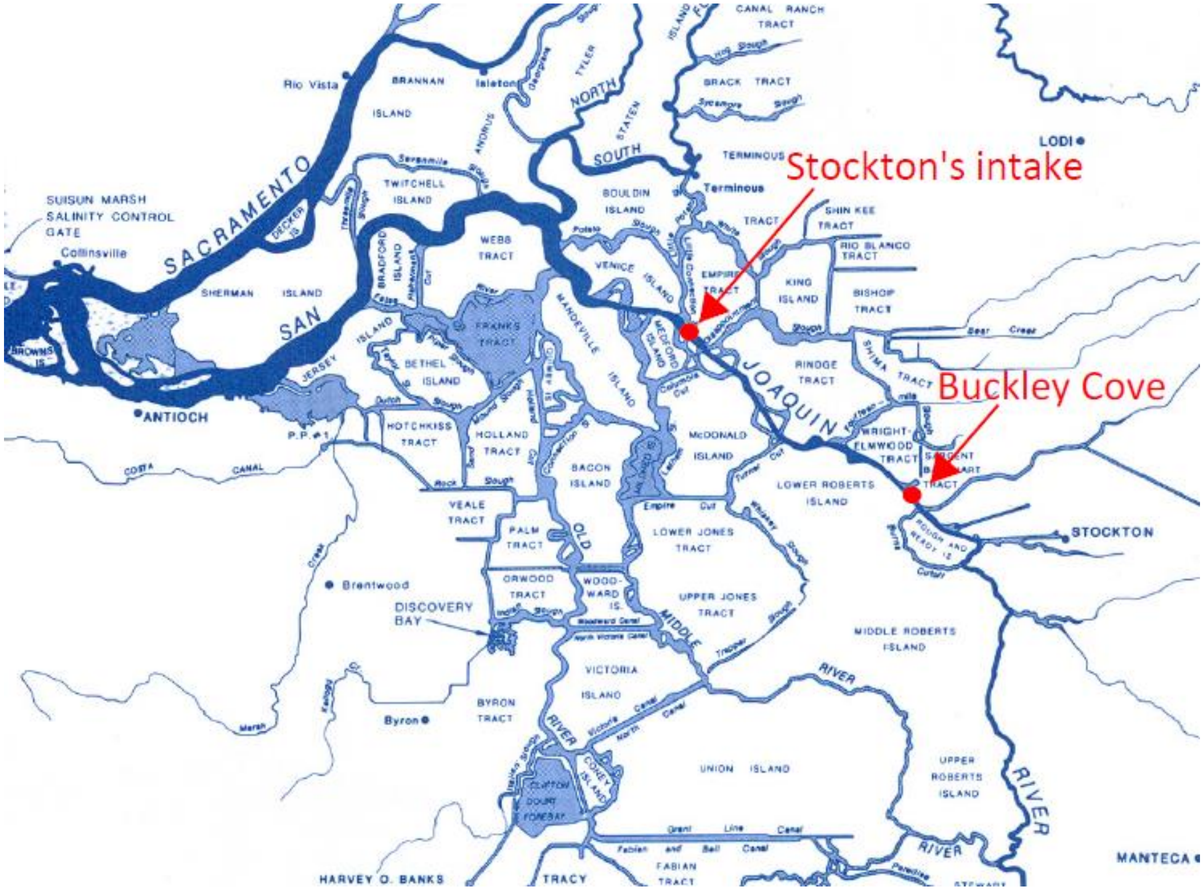

Figure 1. Location of Buckley Cove and City of Stockton’s water intake. Map adapted from DWR Sacramento-San Joaquin Delta Atlas (1995), available at http://baydeltaoffice.water.ca.gov/DeltaAtlas/

3. Background

The City of Stockton is located on the San Joaquin River in the southeast Sacramento-San Joaquin Delta (the Delta). In 2012, the City began obtaining a portion of its potable water supply from the San Joaquin River in order to establish a long-term reliable water supply.[3] Currently, the City obtains approximately 38 percent of its water supply from the San Joaquin River, with purchased water and groundwater providing the remaining supply. The volume of water extracted from the San Joaquin River is projected to increase over time, such that by 2035 water from the river intake will constitute about 50 percent of the City's supply. The current operational capacity of the intake is 30 million gallons per day (MGD) and the projected capacity in 2035 is 90 MGD. In 2015, the City's potable and raw water demand was approximately 26,300 acre-feet/year (ac-ft/yr), while the City's projected demand in 2035 is expected to be over 40,000 ac-ft/yr. Stockton's intake pump station facility is located on the San Joaquin River as shown in Figure 1, which also shows the location of Buckley Cove.

The City of Stockton retained Exponent to evaluate and prepare technical comments on the WaterFix project, including the WaterFix proceedings and the FEIR/EIS. Specifically, the City asked Exponent to evaluate whether the proposed diversions will have an impact on the supply and quality of water available to Stockton. In conducting this work, Exponent evaluated model runs performed by DWR, performed DSM2 modeling using DWR's model input files to obtain output not provided by DWR, and reviewed DWR's assessment of the proposed Project. Exponent previously submitted technical comments for the City on the FEIR/EIS, which are included in this report as Appendix G.

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[3] Brown and Caldwell. 2016. City of Stockton 2015 Urban Watershed Management Plan. July.

4. Methods

4.1. Operation of the 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). QUAL simulates the concentrations of conservative (i.e., no decay or growth) variables, such as EC (electrical conductivity, a measure of salinity), given the flows in the Delta channels simulated by HYDRO. Although QUAL can simulate non-conservative variables, such as temperature and turbidity, results for non-conservative variables are not considered in this testimony. The particle tracking model (PTM) simulates mixing and transport of neutrally buoyant (suspended) particles based on the channel geometry and tidal flows simulated by HYDRO. The model results (model output) provided by DWR as part of the WaterFix proceedings include hydrodynamic and water quality information.

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 the proposed Project for a range of model conditions and operational scenarios. In addition to describing hydrodynamics and water quality, the DSM2 model can be used to perform “volumetric fingerprinting” to track inflows to the Delta throughout the model domain. Volumetric fingerprinting can be used to “tag” inflows to the Delta and to determine the source of water within the estuary. Exponent used the model input files provided by DWR and the DSM2 model to perform volumetric source fingerprinting to determine the location and time that flows from various sources entered the Delta. Exponent also used the model to evaluate hydrodynamics, water quality, and source fingerprints at the location of the City’s drinking water intake, since DWR did not analyze these quantities at that location. Exponent’s analysis was performed for select WaterFix Project scenarios (scenarios Boundary 1, Boundary 2, 4A (from the FEIR/EIS), and NAA) and for the existing condition model run described below.

In Exponent's volumetric fingerprinting analysis, source water fingerprints were used to determine both the location and time at which freshwater flows entered the Delta. Five inflows are typically considered in the DSM2 model for fingerprinting purposes: the Sacramento River, San Joaquin River, east-side streams, agricultural return flows, and flows from the Bay at Martinez. For a given date and location, the DSM2 model was used to calculate the percentage contribution from each of the respective inflow sources.

Because the water quality of the various sources of water to the Delta differs, source water fingerprints provide information to explain and interpret water quality data within the Delta. DSM2 has been widely used by DWR and others to analyze the source of water within the Delta for various time periods and conditions, and for both observed and hypothetical conditions (e.g., to evaluate the impacts of potential operational changes). Source water fingerprints were presented by DWR in FEIR/FEIS Appendix 8D for various locations in the Delta under different modeled scenarios; however, DWR did not provide source fingerprints in for Stockton's intake.

4.2. Water year type (WYT) classifications

Hydrology in the Delta varies from year to year. Water years in the Delta, defined as October through September of the following year, are classified as wet, above normal, below normal, dry, or critical. DWR determines the water year type by calculating a water year index number, which accounts for both the hydrology of the current year and the previous year's index.[4] By this classification system, the water years modeled in DSM2 by DWR fall into the following categories:

- Critical: 1976, 1977, 1988, 1990, 1991
- Dry: 1981, 1985, 1987, 1989
- Below Normal: 1979
- Above Normal: 1978, 1980
- Wet: 1982, 1983, 1984, 1986

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[4] Water year classifications from CDEC, accessed at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

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

4.3. Water Usability at Stockton’s Intake and overview of operations

Exponent produced volumetric fingerprints for both Buckley Cove and the City’s intake for several Project operational scenarios. Those scenarios included existing biological conditions 1 (EBC1, which includes current sea levels and excludes Fall X2 requirement), a no action alternative (NAA), Boundary 1, Boundary 2, and the preferred Project Alternative 4A. Exponent also evaluated the existing biological conditions 2 model run (EBC2, which includes current sea levels and the Fall X2 requirement).

Exponent evaluated modeled salinity data at Buckley Cove and the City’s intake under the EBC2, NAA, Boundary 1, Boundary 2, and Alternative 4A scenarios. The modeled salinity data were used to evaluate the effects of the Project on the water quality conditions at the City’s intake in the San Joaquin River. The City typically employs a chloride threshold of 110 mg/L at the intake for diverting water which is useable for municipal and industrial supply; if the chloride concentration exceeds 110 mg/L, the City must generally use an alternative water supply, such as purchased water or groundwater. Because the City is able to turn its intake on and off over relatively short timescales, Exponent evaluated the number of one-hour intervals (added together and reported in terms of “equivalent” days) that the water in the San Joaquin River exceeded 110 mg/L chloride under various water year types and operational scenarios. Specifically, Exponent averaged the 15-minute DSM2 model output to calculate hourly average chloride concentrations and compared hourly concentrations to the threshold value. The number of hourly averaged data points below the 110 mg/L chloride threshold were summed, converted to days (i.e., 24 one-hour intervals below the threshold became one “equivalent” day), and averaged by water year type.

4.4. Salinity calculations

The electrical conductivity (EC, a measure of salinity) of freshwater inflows to the Delta is lower than that of water that enters the estuary from San Francisco Bay, and 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 flows. For example, in 2015, averaged measured EC in the Sacramento River at Freeport was 168 µS/cm (equivalent to a total dissolved solids [TDS] of 103 mg/L[5]), while the average EC in the San Joaquin River at Vernalis was 595 µS/cm (343 mg/L TDS). The average EC at Martinez (downstream boundary of Delta) in 2015 was 26,384 µS/cm (17,882 mg/L TDS). By contrast, the salinity of seawater is approximately 50,000 µS/cm (35,000 mg/L TDS).[6,7]

4.4.1. EC to chloride conversions

The salinity of water in the Delta has historically been expressed as EC, total dissolved solids (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)[8] derived linear relationships between EC, TDS, and chloride for various locations in the Delta and generated mathematical equations 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 these relationships.[9] For

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

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

[7] 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.

[8] 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

[9] See http://www.water.ca.gov/suisun/facts/salin/index.cfm for additional details.

Stockton, the relationship used to convert EC to chloride for all water years was as follows: chloride [mg/L] = -28.9 + (0.23647*EC [µmhos/cm]). Thus, at Stockton's intake location, a chloride concentration of 110 mg/L (ppm) is assumed to correspond to an EC of approximately 587 µS/cm.

4.4.2. Data averaging

The DSM2 model produces data on 15-minute intervals. The time period modeled in DSM2 for most WaterFix analyses spans from water year (WY) 1975–WY 1991; however, the model results from WY 1975 are considered model "spin-up" time and are excluded from analyses. Exponent's analyses are based on the 16-year record from WY 1976–WY 1991. For this analysis, the 15-minute DSM2 data were averaged on an hourly basis and compared to the 110 mg/L chloride threshold value, as described in Section 4.3.

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

The residence time of water in the Delta was calculated for each water year between 1976 and 1991 under scenarios EBC2, NAA, Boundary 1, Boundary 2, and Alternative 4A using a mass balance procedure that relied upon the total volume of water in the Delta and total Delta inflows for the given water year 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)[10] 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 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

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[10] 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. Volume 10, Issue 5, 323-352. October.

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.

5. WaterFix Operations are not defined

5.1. DWR has not defined WaterFix operations and has not conducted modeling of Alternative 4A for the WaterFix proceedings

The WaterFix operations have remained ill-defined both during the WaterFix proceedings and in the FEIR/EIS. DWR has stated in the WaterFix proceedings that the Project may operate to a range of potential operational scenarios, specifically those represented by the boundary conditions Boundary 1 and Boundary 2. DWR testified before the State Board to evaluating "a range call [sic] Boundary 1 to Boundary 2. And the purpose of that is because… this project also includes the collaborative science and adaptive management program and the ability to make adjustments to the initial operating criteria based on science and monitoring… So Boundary 1 and 2 represent what we think at this time, based on those uncertainties, are the range of potential adjustments that may be made."[11] During cross-examination in the WaterFix Change Petition Proceedings, DWR stated that it is appropriate to "evaluate the effects of Boundary 1 and the effects of Boundary 2" in evaluating potential injury from the WaterFix flow proposal. [12]

5.2. AMMP was not defined in the WaterFix proceedings or in the FEIR

The Adaptive Management and Monitoring Program (AMMP) remained almost wholly undefined in both the WaterFix Petition and the FEIR/EIS, which offer only a broad description of program objectives and the program's conceptual framework. The AMMP is intended to be a project management strategy that allows for wide flexibility in determining the rates, volumes, and timing of water diversion operations from the Sacramento River, and which is expected to be a central component of the Project. DWR has indicated that Project operations may vary within a very wide range of operations, from Scenario Boundary 1 to Scenario Boundary 2;

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[11] See p. 40 of SWRCB. 2016. Transcript of California WaterFix Water Right Change Petition Hearing. Part 1A Testimony, Volume 4, p. 40, Hearing before the State Water Resources Control Board. July 29

[12] See pp. 151-152 of SWRCB. 2016. Transcript of California WaterFix Water Right Change Petition Hearing. Part 1A Testimony, Volume 4, p. 40, Hearing before the State Water Resources Control Board. July 29.

however, DWR has provided almost no documentation to describe how Project operations will be managed under the AMMP, and DWR has not described the logic or rules that will be used to adjust project operations within this broad range.

Instead, DWR states that “detailed monitoring and research plans *will be developed* that identify specific metrics and protocols” (FEIR/EIS p. 3-26, emphasis added) which should govern the AMMP. The FEIR/EIS also states that the AMMP may serve as a means to change Project operations beyond permitted limits.[13] DWR’s testimony at the WaterFix hearings was also consistent with the representation of the AMMP.[14] The specific metrics and protocols by which the Project operations will be managed will determine the impacts of the proposed Project but thus far have not been developed or described. Neither the Petition nor the FEIR/EIS describe which agencies or personnel will be responsible for the research plans, operational protocols, and metric evaluation, or what the respective authorities and limits of the agencies will be. Adding to the confusion surrounding the AMMP, DWR states that “the adaptive management and monitoring program is directly related to several key components of the BDCP” (FEIR p. 3-26), but fails to identify which “key components” are referenced.

In contrast, the requirements of an adaptive management program for the Delta have been defined on multiple occasions. In February 2009, the Independent Science Advisors issued a report entitled “Bay Delta Conservation Plan Independent Science Advisors’ Report on Adaptive Management.”[15] The Independent Science Advisors recommended “more extensive

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[13] The FEIR/EIS (p. 3-287) states that “[t]he collaborative science effort is expected to inform operational decisions within the ranges established by the biological opinion and 2081b permit for the proposed Project. However, if new science suggests that operational changes may be appropriate that fall outside of the operational ranges evaluated in the biological opinion and authorized by the 2081b permit, the appropriate agencies will determine, within their respective authorities, whether those changes should be implemented.”

[14] See, for example, the testimony of Jennifer Pierre on July 29, 2016 (SWRCB. 2016. Transcript of California WaterFix Water Right Change Petition Hearing. Part 1A Testimony, Volume 4, p. 45-46. Hearing before the State Water Resources Control Board. July 29): “The collaborative sciences adaptive management program itself is currently under development. It will be provided as part of Part 2. There is a framework that was included as part of the DWR exhibits that outlines the general points of – that will be included in the adaptive management, but there’s more work to be done to really flesh out the full process that will be available for Part 2. But it will be focused on three important things. First, it will focus on the screen design at the North Delta diversion. … It will also focus on habitat restoration. … And probably most importantly for the Part 1 proceedings is that it will affect and potentially change the initial operating criteria through the process that’s outlined in the framework and that will be expanded on in the full proposal… ”

[15] Bay Delta Conservation Plan Independent Science Advisors’ Report on Adaptive Management. Prepared for the BDCP Steering Committee. February 2009. Available at

and explicit use of models to formalize knowledge about the system and to select, design, and predict outcomes of conservation measures"; the advisors also recommended that "greater attention be given to the learning value of actions, and to establishing a formal process by which new knowledge is used to alter actions or revise goals or objectives."[16] The Delta Plan issued in 2013 also included an appendix entitled "Adaptive Management and the Delta Plan."[17] This document described adaptive management, as defined in the Delta Reform Act, as "a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives (Water Code section 85052)."[18] The document identified a "three-phase and nine-step" adaptive management framework. Additionally, a document entitled, "Improving adaptive management in the Sacramento-San Joaquin Delta"[19] was released in 2016 and provided eight major recommendations. Among them were recommendations to assemble an appropriate mix of "experts, agency leaders, resource managers, practitioners, scientists, stakeholders, and regulators" to develop a coordinating team; to support adaptive management with funding that is dependable and flexible; to design monitoring protocols; to integrate science and regulations to enhance flexibility; and to develop a framework for setting decision points or thresholds that will trigger a management response.

The little information that is provided on the AMMP in the Petition and FEIR/EIS focuses on water supply and water quality outcomes that impact fish survival, rather than those that impact municipal and industrial (M&I) water supply. For example, on page 3-283 of the FEIR/EIS, DWR states that "Under the current BiOps and future operations under California WaterFix, a 'real-time operations' (RTO) mechanism will allow for adjustments of water operations, within established conditions … to benefit covered fish species." The AMMP does not describe efforts

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http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Independent_Science_Advisors_Report_on_Adaptive_Management_-_Final_2-1-09.sflb.ashx.

[16] Ibid at p. ii.

[17] Delta Stewardship Council (2013). The Delta Plan. Appendix C: Adaptive Management and the Delta Plan Available at http://deltacouncil.ca.gov/sites/default/files/documents/files/AppC_Adaptive%20Management_2013.pdf.

[18] Ibid at p. C-3

[19] Delta Independent Science Board (2016). Improving Adaptive Management in the Sacramento-San Joaquin Delta. January 2016. Available at http://deltacouncil.ca.gov/docs/final-delta-isb-adaptive-management-review-report.

or protocols to protect water quality for M&I beneficial uses, does not include metrics, standards, or boundaries that will be used to evaluate water quality impacts, and does not describe any measures that may be implemented to address or mitigate water quality degradation. The fact that water quality apparently will not be considered to protect drinking water beneficial uses within the AMMP leads to still more uncertainty regarding the potential impacts of the proposed Project on the City.

5.3. DWR's long-term averages mask project impacts and do not provide the level of detail needed for the City to plan for the future

Operating the Project to the preferred Alternative 4A will cause salinity to increase substantially at the City's intake. Although DWR shows the projected impact of Alternatives H3, H4, Boundary 1, Boundary 2, and 4A at various locations in the Delta (but not at the City's intake), the water quality data are presented as monthly average concentrations of EC and chloride.[20] Monthly average chloride concentrations cannot be used to evaluate the impacts of the proposed Project on drinking water intakes within the Delta, as long-term average concentrations by definition cannot show shorter-term changes in salinity and water quality levels and have the effect of masking substantial increases that will adversely affect Delta water users, including the City. Thus even if the locations evaluated in the FEIR/EIS were representative of conditions at the City's intake, the decision to present water quality data in terms of long-term monthly average concentrations masks the substantial adverse changes in water quality that will occur.

Although DWR asserts that long-term averaging is appropriate to assess water quality changes, DWR's justification for its use of long-term average concentrations is inadequate and

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[20] The DSM2 model produces output data at 15-minute intervals. For example, the DSM2 model provides a modeled electrical conductivity (used to calculate chloride levels) values for each 15-minute interval in the 16-year modeled record (water years 1976-1991). DWR has aggregated the 15-minute model output data to calculate long-term monthly averages, which was done by first averaging data from each individual month at a specific location, and second, by averaging all data for that month over the full 16-year simulation period. For example, the 16 values of the monthly average chloride concentration for all the months of March at Buckley Cove were averaged to generate the average chloride concentration at Buckley Cove for the month of March (and the same process was followed for other months). Results for scenarios H3, H4, Boundary 1, and Boundary 2 were summarized by DWR in the WaterFix Petition before the SWRCB; results for scenario 4A were summarized in the FEIR/EIS.

inaccurate.[21] Because water intake operations are typically managed on an hourly or sub-hourly basis, hourly or sub-hourly chloride concentrations are needed for drinking water operators to understand the impacts on their operations. DSM2 offers the best available tool for assessing impacts to drinking water operations on a time scale relevant to operations (i.e., daily concentrations), and it is well-established that the DSM2 is suited to simulate the tidally driven hydrodynamics of the Delta, which are, in part, the cause of water quality changes over daily or sub-daily timescales. Although the model is not intended to be used in a predictive fashion, the use of the model's daily (or hourly, or sub-hourly) average concentration output can be employed for comparing and contrasting various operational scenarios. Indeed, hourly DSM2 model output has been widely used to assess changes in water quality and hydrodynamics in the Delta for both CEQA and NEPA purposes.[22] Comparing hourly model output for various operational scenarios provides appropriate and necessary information for gauging water quality impacts to the City's intake.

Although neither the WaterFix Petition nor the FEIR/EIS assessed chloride impacts at the City's intake, impacts at Buckley Cove were assessed. For example, Figure 2 is an excerpt of Table Cl-70 from Appendix 8G of the FEIR/EIS (p. 8G-84) which shows the change in average chloride concentration under Alternative 4A relative to the NAA and EBC1 baselines. The change in chloride concentrations in the table is reported as a monthly average concentration. As shown in Figure 2 (FEIR/EIS Table Cl-70), the maximum reported change in chloride at Buckley Cove relative to the NAA during the month of March is 9 mg/L in drought years (defined as the five year period of water years 1987 to 1991, which consists of both dry and critical water year types); however, DSM2 model output evaluated by Exponent under this scenario shows that the change in chloride concentration in March at Buckley Cove can be much greater than 9 mg/L—

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[21] FEIR/EIS Master Response 14 (pp. 1-123 to 1-124) states, "Given the models used and the associated limitations in interpreting the output, utilizing a shorter time step than monthly average for assessing water quality changes at the City of Antioch and CCWD's intakes would not result in a more accurate assessment of effects of the Project on salinity-related parameters (i.e., EC, chloride, bromide) or organic carbon. While there would be days within a month in which parameter concentrations/levels at a given location would be higher than the monthly average at that location (just as there would be days when it is lower), given the modeling limitations, comparing alternatives and baselines based on the monthly average at those locations is considered appropriate for the purposes of NEPA and CEQA."

[22] Ascent Environmental (2014) Final Environmental Impact Report for the Sacramento Regional County Sanitation District EchoWater Project. September 12.

for example, the difference in daily chloride concentration at Buckley Cove between Alternative 4A and NAA during March of 1981 (a dry water year) is over 25 mg/L (Figure 3).

DWR’s use of long-term average monthly concentrations in the FEIR/FEIS serves to mask increases in chloride concentrations that are simulated to occur under various operational scenarios; as such, the use of long-term monthly average simulated chloride concentrations is inappropriate for assessing water quality impacts in the Delta. The use of hourly or daily average salinity is more appropriate for evaluating water quality impacts at drinking water intakes.

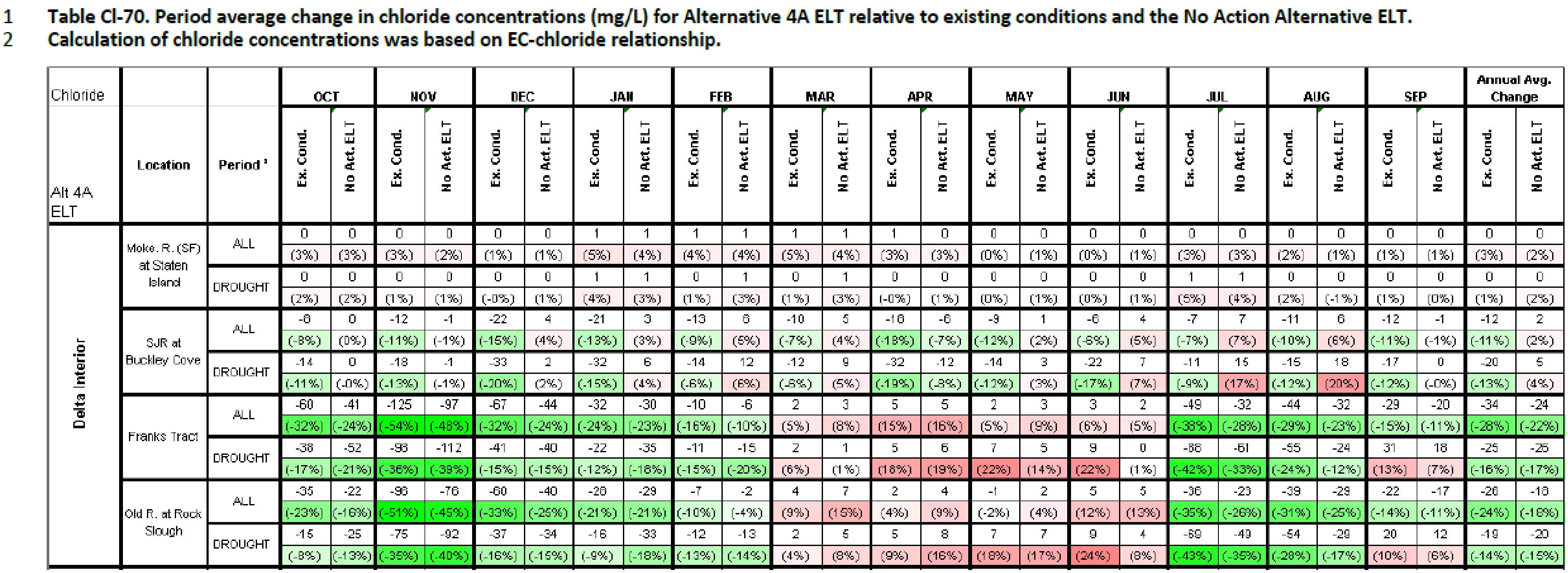

Table CI-70. Period average change in chloride concentrations (mg/L) for Alternative 4A ELT relative to existing conditions and the No Action Alternative ELT. Calculation of chloride concentrations was based on EC-chloride relationship.

Chloride Alt 4A ELT	Location	Period ¹	OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		Annual Avg. Change	
			Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT
Delta Interior	Moke. R. (SF) at Staten Island	ALL	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
			(3%)	(3%)	(3%)	(2%)	(1%)	(1%)	(5%)	(4%)	(4%)	(4%)	(5%)	(4%)	(3%)	(3%)	(0%)	(1%)	(0%)	(1%)	(3%)	(3%)	(2%)	(1%)	(1%)	(1%)	(3%)	(2%)
		DROUGHT	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
			(2%)	(2%)	(1%)	(1%)	(-0%)	(1%)	(4%)	(3%)	(1%)	(3%)	(1%)	(3%)	(-0%)	(1%)	(0%)	(1%)	(0%)	(1%)	(5%)	(4%)	(2%)	(-1%)	(1%)	(0%)	(1%)	(2%)
	SJR at Buckley Cove	ALL	-6	0	-12	-1	-22	4	-21	3	-13	6	-10	5	-16	-6	-9	1	-6	4	-7	7	-11	6	-12	-1	-12	2
			(-8%)	(0%)	(-11%)	(-1%)	(-15%)	(4%)	(-13%)	(3%)	(-9%)	(5%)	(-7%)	(4%)	(-18%)	(-7%)	(-12%)	(2%)	(-6%)	(5%)	(-7%)	(7%)	(-10%)	(6%)	(-11%)	(-1%)	(-11%)	(2%)
		DROUGHT	-14	0	-18	-1	-33	2	-32	6	-14	12	-12	9	-32	-12	-14	3	-22	7	-11	15	-15	18	-17	0	-20	5
			(-11%)	(-0%)	(-13%)	(-1%)	(-20%)	(2%)	(-15%)	(4%)	(-6%)	(6%)	(-6%)	(5%)	(-19%)	(-8%)	(-12%)	(3%)	(-17%)	(7%)	(-9%)	(17%)	(-12%)	(20%)	(-12%)	(-0%)	(-13%)	(4%)
	Franks Tract	ALL	-60	-41	-125	-97	-67	-44	-32	-30	-10	-6	2	3	5	5	2	3	3	2	-49	-32	-44	-32	-29	-20	-34	-24
			(-32%)	(-24%)	(-54%)	(-48%)	(-32%)	(-24%)	(-24%)	(-23%)	(-16%)	(-10%)	(5%)	(8%)	(15%)	(16%)	(5%)	(9%)	(6%)	(5%)	(-38%)	(-28%)	(-29%)	(-23%)	(-15%)	(-11%)	(-28%)	(-22%)
		DROUGHT	-38	-52	-98	-112	-41	-40	-22	-35	-11	-15	2	1	5	6	7	5	9	0	-68	-61	-55	-24	31	18	-25	-26
			(-17%)	(-21%)	(-36%)	(-39%)	(-15%)	(-15%)	(-12%)	(-18%)	(-15%)	(-20%)	(6%)	(1%)	(18%)	(19%)	(22%)	(14%)	(22%)	(1%)	(-42%)	(-33%)	(-24%)	(-12%)	(13%)	(7%)	(-16%)	(-17%)
	Old R. at Rock Slough	ALL	-35	-22	-96	-76	-60	-40	-28	-29	-7	-2	4	7	2	4	-1	2	5	5	-36	-23	-39	-29	-22	-17	-26	-18
			(-23%)	(-16%)	(-51%)	(-45%)	(-33%)	(-25%)	(-21%)	(-21%)	(-10%)	(-4%)	(9%)	(15%)	(4%)	(9%)	(-2%)	(4%)	(12%)	(13%)	(-35%)	(-26%)	(-31%)	(-25%)	(-14%)	(-11%)	(-24%)	(-18%)
		DROUGHT	-15	-25	-75	-92	-37	-34	-16	-33	-12	-13	2	5	5	8	7	7	9	4	-69	-49	-54	-29	20	12	-19	-20
			(-8%)	(-13%)	(-35%)	(-40%)	(-16%)	(-15%)	(-9%)	(-18%)	(-13%)	(-14%)	(4%)	(8%)	(9%)	(16%)	(18%)	(17%)	(24%)	(8%)	(-43%)	(-35%)	(-28%)	(-17%)	(10%)	(6%)	(-14%)	(-15%)

Figure 2. Excerpt of Table CI-70 from Appendix 8G of the FEIR/EIS (p. 8G-84) showing the change in average chloride concentration under Alternative 4A relative to the NAA and EBC1 baselines

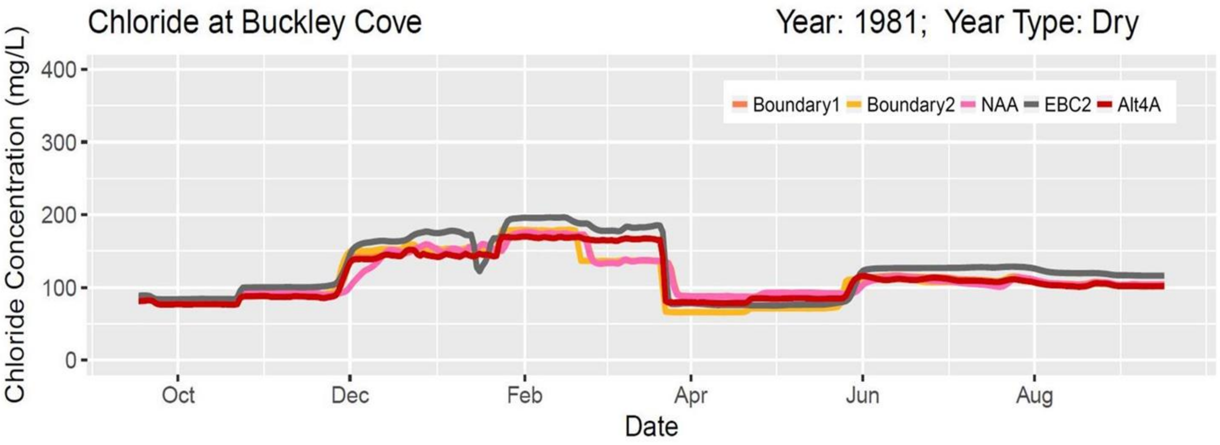

Figure 3. Daily mean concentration of chloride at Buckley Cove under various operational scenarios during water year 1981

6. DWR has not evaluated water quality at Stockton's Intake

6.1. Source water fingerprints show different sources of water at Buckley Cove and Stockton's intake

The Petition and FEIR do not assess the expected water quality impacts at the City's drinking water supply intake from the proposed operation of the Project. Rather, DWR discusses model results describing water quality at Buckley Cove in the San Joaquin River and purports to use model results from Buckley Cove to assess the range of water quality impacts expected at the City's intake.[23] However, the City's intake is located more than eight miles downstream of Buckley Cove, and a number of sloughs and waterways join the San Joaquin River downstream of Buckley Cove. These sloughs and waterways (see **Error! Reference source not found.**) carry water from the Mokelumne River, the Sacramento River, and other sources to the San Joaquin River in the vicinity of the City's intake. For this reason, water supply and water quality conditions are significantly different at the City's drinking water intake than at Buckley Cove.

As described in the Section 4 (Methods) of this report, Exponent used the DSM2 model and DWR's model input files to evaluate the "source fingerprints" of water at Buckley Cove and the City's drinking water intake. The DSM2 model results indicate that water at Buckley Cove has a markedly different composition than water at the City's intake. For example, source water fingerprints describing existing conditions (NAA and EBC2 scenarios) show that San Joaquin River water is the dominant source (up to 95 percent) of water at Buckley Cove during all months of dry water years, while Sacramento River water is absent at this location in all but about three months, when it is present at low concentrations (up to 20 percent) (Figure 5). In contrast, Sacramento River water is the dominant source of water (up to 90 percent) at the City's intake in dry years, with San Joaquin River water comprising no more than about 50 percent of the water at the City's intake for relatively short periods of time (Figure 4).

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[23] For example, the FEIR/EIS states, "For municipal intakes located in the Delta interior, assessment locations at Contra Costa Pumping Plant No. 1 and Rock Slough are taken as representative of Contra Costa's intakes at Rock Slough, Old River and Victoria Canal, and the assessment location at Buckley Cove is taken as representative of the City of Stockton's intake on the San Joaquin River" (FEIR/EIS, p. 8-165).

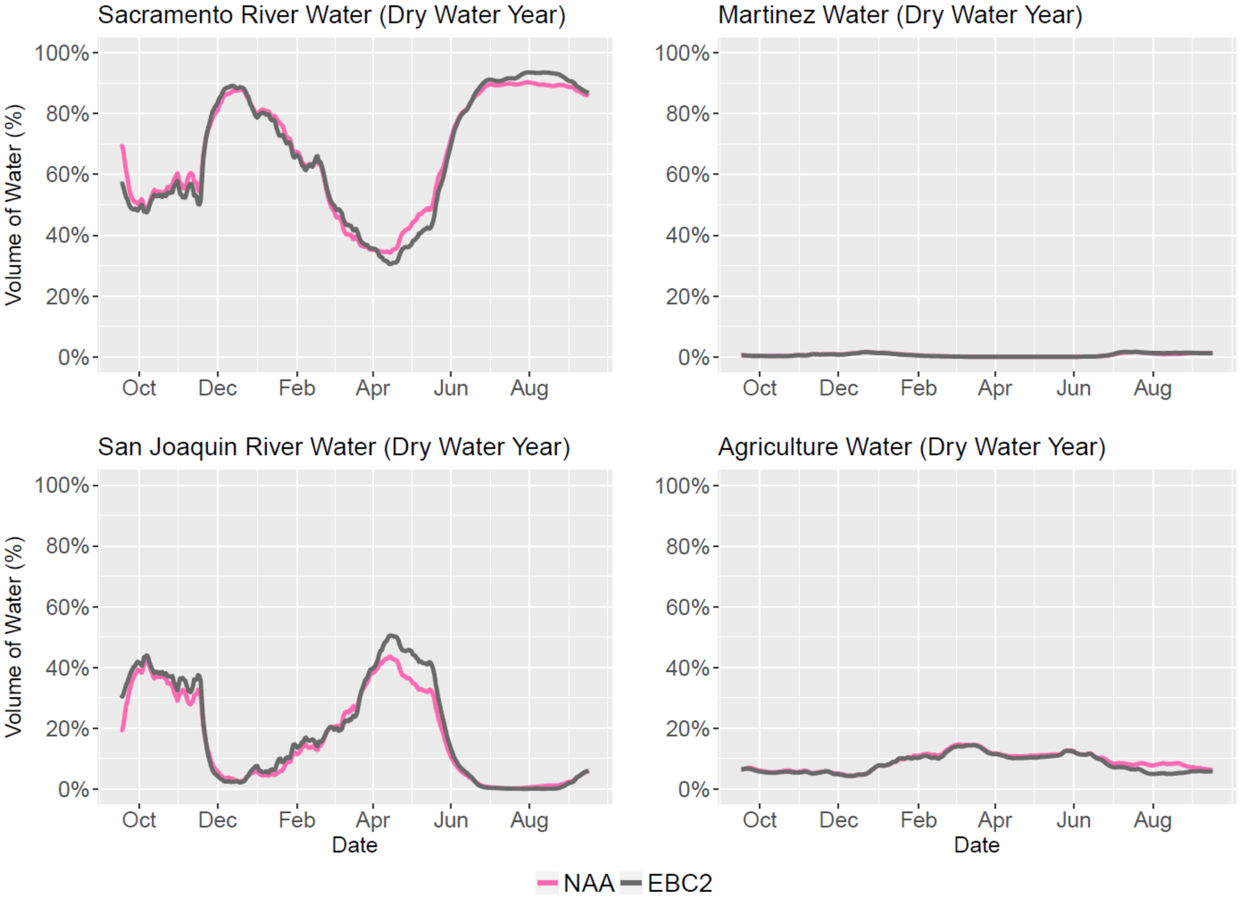

Figure 4. Source water fingerprint at Stockton's intake under the NAA and EBC2 baseline conditions during dry water years (average)

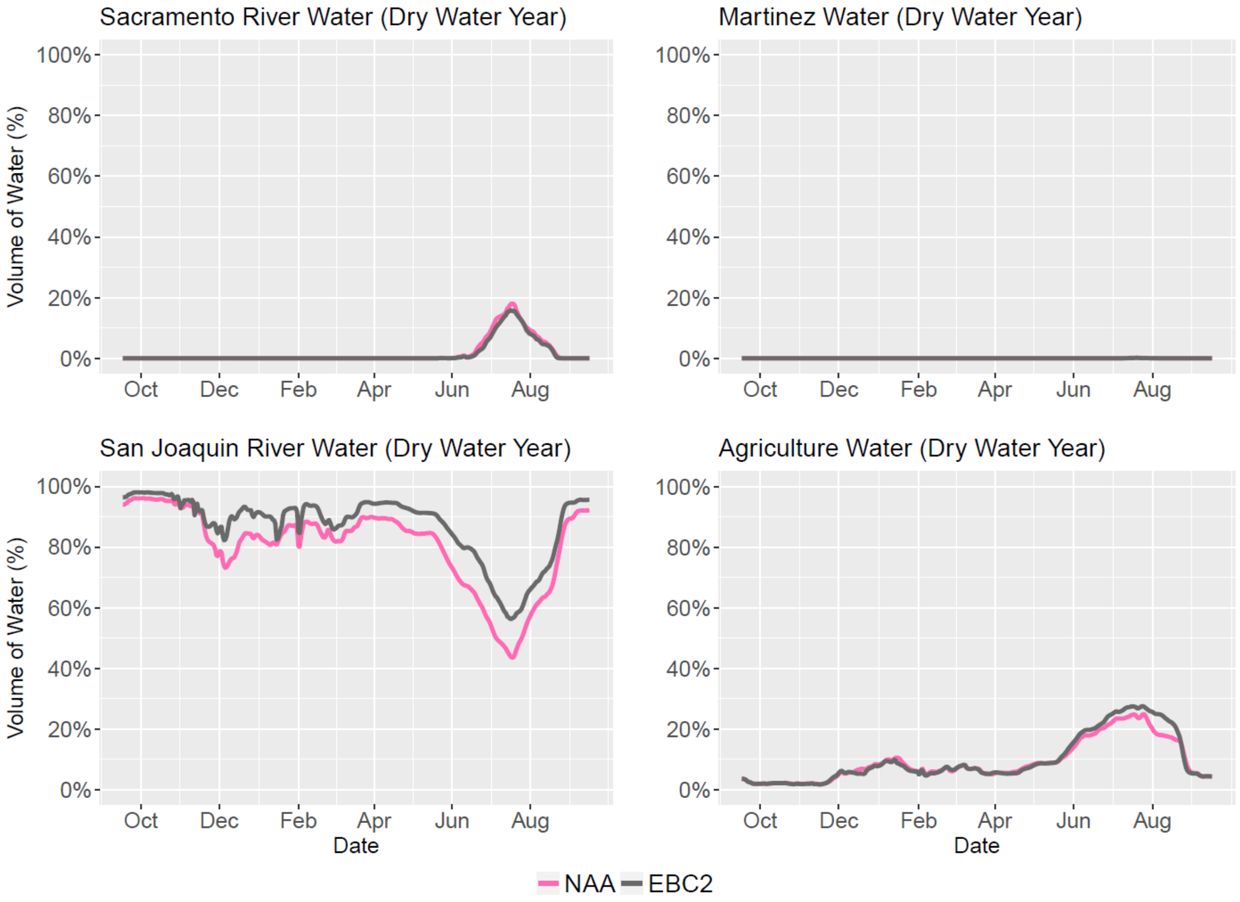

Figure 5. Source water fingerprint at Buckley Cove under the NAA and EBC2 baseline conditions during a dry water year

The differences in source water between Buckley Cove and the City’s intake are observed in all water year types. In every water year during the modeled period (1976 to 1991), the modeled percentage of Sacramento River water at the City’s intake (up to 95 percent) was significantly greater than at Buckley Cove (where it constituted only up to 40 percent and was frequently entirely absent) (Figure 6). Source fingerprints at the City’s intake and Buckley Cove for all other water year types are presented in Appendix B.

The source of water at the City’s intake is important because Sacramento River water is typically higher in quality (lower in salinity) than San Joaquin River water (see Section 4.4). Source water fingerprints obtained using DWR’s DSM2 model input files definitely indicate that the source of water and water quality at Buckley Cove are not representative of water at the City’s intake.

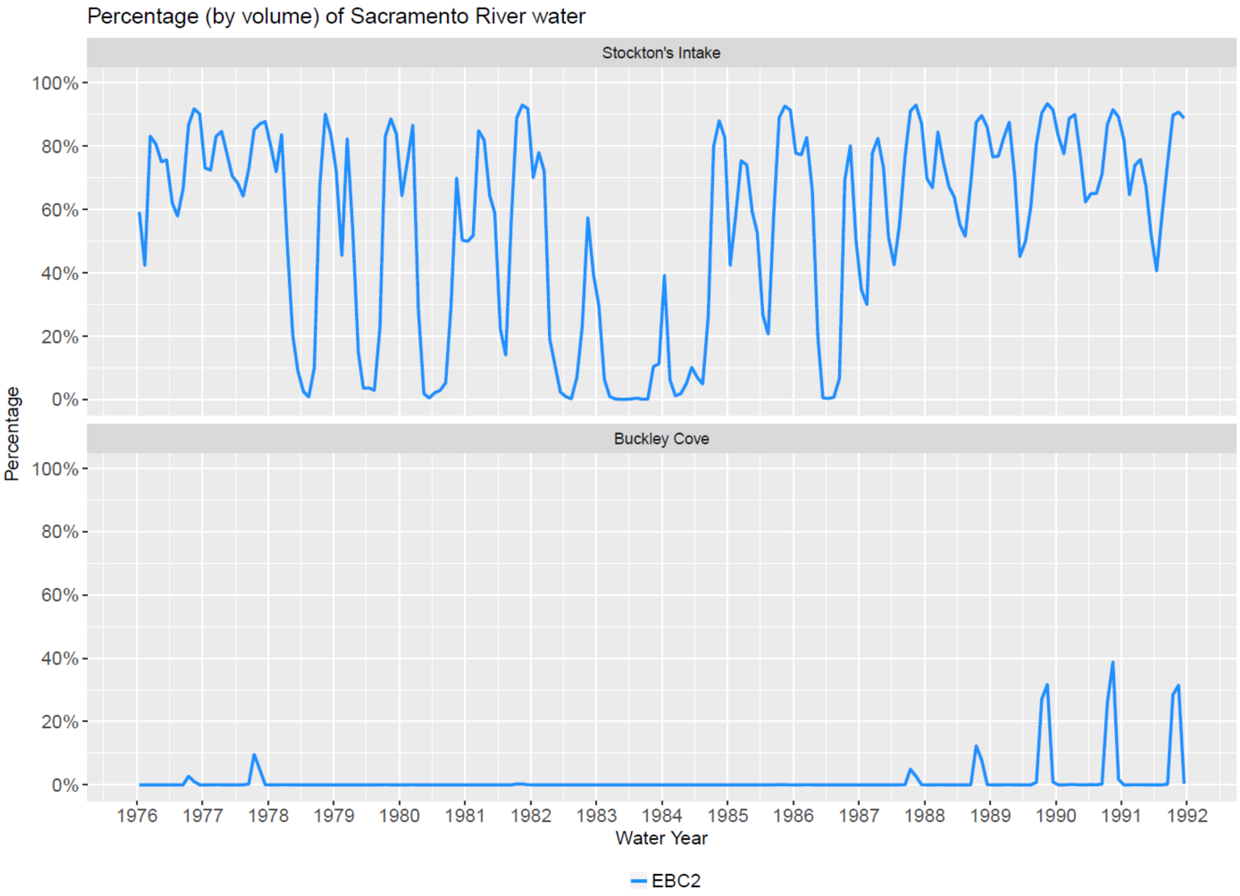

Figure 6. Percentage (by volume) of Sacramento River water at Stockton's intake (top panel) and Buckley Cove (bottom panel) from 1976 to 1991 under existing condition (EBC2)

6.2. Salinity is substantially different at Buckley Cove and Stockton's intake

As expected, water quality is also notably different at the City's intake than at Buckley Cove. As discussed in the methods section above, the yearly average salinity of the San Joaquin River is higher (343 mg/L TDS in 2015) than the Sacramento River (103 mg/L TDS in 2015); because the Sacramento River represents a larger fraction of the water at the City's intake (up to 95 percent), the salinity at the City's drinking water intake is generally lower than at Buckley Cove. Figure 7 and Figure 8 show the average simulated chloride concentration at the City's intake and at Buckley Cove, respectively, during dry water years under the EBC2 baseline. During dry water years, the simulated daily average chloride concentration at the City's intake varied from a low of 25 mg/L (June) to 100 mg/L (March) (Figure 7). In contrast, the daily average simulated chloride concentration at Buckley Cove varies from approximately 80 mg/L (October) to 180 mg/L (February and March) (Figure 8). Chloride concentration model results for other water year types are presented in Appendix C.

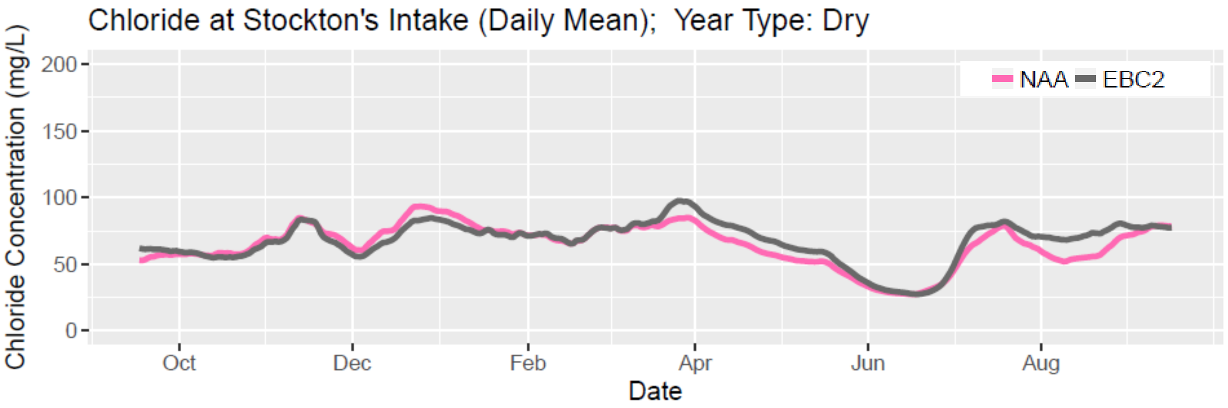

Figure 7. Simulated daily concentration of chloride at the City's intake during dry water year under baseline conditions NAA and EBC2

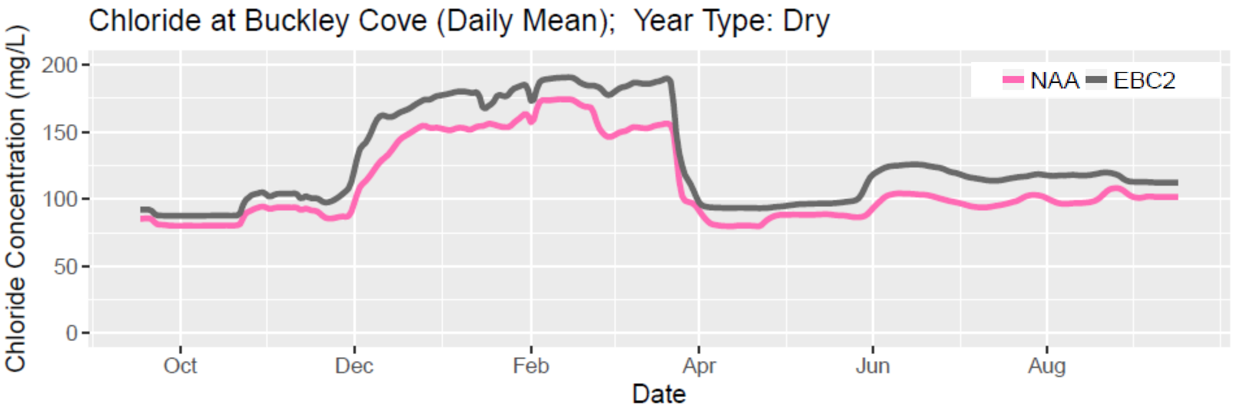

Figure 8. Concentration of daily chloride at the Buckley Cove during a dry water year under baseline conditions NAA and EBC2

DWR's response to the City's comments on the RDEIR/EIS[24] and DEIR/EIS[25], where the City pointed out the location discrepancy, states that "the effects of alternatives at the locations assessed are considered representative of the effects of the alternatives in various portions of the Delta as a whole," and DWR asserted that water quality conditions at Buckley Cove are representative of the "eastern Delta, where the City's intake is located."[26] As discussed above, DWR's analysis is incorrect, as DSM2 modeling performed using DWR's model input files demonstrates that the conditions at Buckley Cove and within other portions of the eastern Delta interior can and do vary significantly from conditions at the City's intake location. As a result, water quality data modeled at Buckley Cove do not represent the range of impacts that are expected at the City's water supply intake under the proposed Project.

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[24] Exhibit STKN-003.

[25] Exhibit STKN-004.

[26] FEIR/EIS, RECIRC Comment Responses Letters 2400-2499, pp. 156–157

7. WaterFix does not use appropriate Delta baseline conditions or characterize the expected range of Project operations

7.1. WaterFix does not use the appropriate Delta baseline condition or accurately describe the existing condition

While DWR's WaterFix Petition and testimony use only a future no action alternative (NAA) scenario as the baseline to assess project impacts for Scenarios H3, H4, Boundary 1, and Boundary 2, the FEIR/EIS analysis utilizes an existing condition scenario known as EBC1 to evaluate Project impacts under the preferred Alternative 4A scenario. While we agree with DWR's decision in the FEIR/EIS to include an existing condition scenario to evaluate project impacts, we disagree with the choice of the baseline condition used in the evaluation. Specifically, the EBC1 scenario is flawed and inappropriate because it does not include the Fall X2 provision of the 2008 U.S. Fish and Wildlife Service Biological Opinion (2008 BiOp) that governs CVP/SWP operations.[27] Failing to include the Fall X2 provision in EBC1 increases the modeled salinity of the existing condition, particularly during the fall period in certain modeled years, which in turn makes the water quality impacts of Alternative 4A appear less significant than they would with the appropriate baseline. Because the 2008 BiOp presents the requirement to manage Delta outflows and operate water storage and releases to achieve the Fall X2 provision, and because current project operations include the Fall X2 requirement, the existing

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[27] On p. 4-6, the FEIR/EIS states that the Fall X2 salinity requirement was not included in the existing condition baseline since "[a]s 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."

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, 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 requirements should have been included (together with the other BiOp requirements that were included) in the baseline existing condition.

condition should include the Fall X2 requirement. DWR previously released modeling that utilized a baseline condition designed to meet Fall X2: the EBC2 scenario, presented in the 2013 Revised Administrative Draft. However, the 2013 DEIR/EIS, the 2015 RDEIR/EIS, and the 2016 FEIR/EIS used only the EBC1 scenario.

Table 1 shows that the number of days existing source water at Stockton's intake exceeds a chloride concentration of 110 mg/L is greater under the EBC1 scenario than under the EBC2 scenario for most water year types. For example, the average number of days in dry water years that the chloride concentration at the City's intake exceeds 110 mg/L is 58 under the EBC1 baseline and 31 under the EBC2 scenario (Table 1). Thus, the baseline water quality condition used by DWR in the FEIR/EIS (EBC1) is more saline because EBC1 is not operated to meet Fall X2 conditions. Because the EBC2 scenario more appropriately represents an accurate baseline condition by adhering to the Fall X2 requirement, Exponent has evaluated Project impacts using the EBC2 baseline condition.

Because they did not use the EBC2 scenario as the existing conditions scenario in the FEIR/EIS, DWR has not accurately disclosed the magnitude of water quality impacts that would occur from the Project relative to existing conditions. Also, because DWR did not present an existing conditions scenario in the WaterFix Petition and testimony, impacts to the City cannot be adequately assessed. In addition, the NAA scenario did not include operations to meet Fall X2 while the project scenarios (H3, H4, Boundary 1, and Boundary 2) did operate to meet Fall X2, again creating a situation where the baseline condition results in higher salinity than would otherwise occur, making the impact of the proposed project appear smaller.

Table 1. Number of days that water at Stockton's intake exceeds 110 mg/L chloride under three modeled baseline scenarios according to water year type

	No. of days per year that water at Stockton's intake exceeds a chloride threshold of 110 mg/L		
Water Year Type	EBC1 Existing Condition **Does not** include Fall X2 **No** sea-level rise	EBC2 Existing Condition **Includes** Fall X2 **No** sea-level rise	NAA baseline condition **Includes** Fall X2 **15-cm** sea-level rise
Critical	50	35	50
Dry	58	31	36
Normal	44	36	44
Wet	11	11	11

7.2. DWR Did Not Fully Characterize the Entire Range of Expected Project Operations or Associated Water Quality Impacts.

While DWR presented summary analyses for the Boundary 1 and Boundary 2 scenarios in the WaterFix Petition and testimony, the FEIR/EIS did not include a full analysis of these scenarios. Thus, the FEIR/EIS for the proposed project did not characterize the water quality and water supply impacts that would be expected over the full range of the Project's proposed operational scenarios.

The FEIR/EIS did not fully evaluate the water quality impacts of Boundary 1 or Boundary 2, which are representative of proposed operations of the Project, as DWR has indicated in testimony to the SWRCB in the WaterFix water rights change petition proceedings.[28] In the water rights proceedings before the SWRCB, DWR disclosed that under its AMMP, Project diversion and conveyance facility operations could fall anywhere from the Boundary 1 scenario (characterized by low Delta outflow and high exports) to the Boundary 2 scenario (characterized by high Delta outflow). DWR assessed more than 18 different Project alternatives (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A) within the body of the

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[28] The FEIR/EIS states that "operation of the future conveyance facility under a possible adaptive management range represented by Boundary 1 and Boundary 2 will be consistent with the impacts discussed for the range of alternatives considered in this document" (FEIR/EIS, p. 3-288) and "Boundaries 1 and 2 were presented to the State Water Board during the water rights petition process as a means to represent a potential range of operations that could occur as a result of the proposed Adaptive Management Program" (FEIR/EIS, p. 5E-1).

FEIR/EIS; Alternative 4 was also evaluated as Alternatives H1 through H4. DWR has stated that Boundary 1 and Boundary 2 are operational scenarios that fall outside the range of H1 to H4;[29] according to DWR, Boundary 1 impacts can be assessed by examining impacts from Alternatives 1A and 3, while Boundary 2 impacts can be assessed by examining impacts from Alternatives 4H3+ and 8.[30] Table 2 shows operational scenarios that were released by the DWR in various model files in support of the Project and reviewed by Exponent.[31] Although this list is not an exhaustive list of all files released by DWR, it points to the number and types of operational scenarios that were assessed and released by DWR over time.

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[29] The FEIR/EIS states on p. 3-288 (Section 3.6.4.4) that "As shown in Appendix 5E, the operation of the future conveyance facility under a possible adaptive management range represented by Boundary 1 and Boundary 2 will be consistent with the impacts discussed for the range of alternatives considered in this document (see Appendix 5E, Section 5E.2, for additional information on these boundaries). Boundary 1 and Boundary 2 also encompass the full range of impacts found in the analysis prepared for H1 and H2(as well as H3 and H4)."

[30] The FEIR/EIS states that "[c]onsistent with the goals of this analysis, the nature and severity of the impacts generally fall within the range of impacts disclosed under Alternatives 1A and 3 for Boundary 1, Alternative 4H3, Alternative 4H3+, and Alternative 8 for Boundary 2" (FEIR/EIS, p. 5E-170).

[31] Model results for operational scenarios not listed in Table 2 were not made available by DWR.

Table 2. Exponent's record of model files released by the California Department of Water Resources in support of the California WaterFix Project

Accompanying Document	Model Files Acquired by Exponent
March 2013 Revised Administrative Draft BDCP	EBC1, EBC2, NAA (ELT, LLT), all Project alternatives, including Alternative 4 (H1, H2, H3, H4) at LLT and ELT
2013 Draft EIR/EIS	EBC1, NAA (ELT, LLT), all Project alternatives, including Alternative 4 (H1, H2, H3, H4) at LLT and ELT
2015 RDEIR/SDEIS	Updated 2013 Draft EIR/EIS model files and sensitivity analyses released. Alternative 4A (or H3+) introduced as the preferred alternative but not modeled. NAA evaluated as ELT and LLT.
Draft BA model files (released January 2016, before document release)	NAA (ELT), Preferred Alternative (Alternative 4A)
Final FEIR/EIS model files (released March 2016, before document release)	NAA (ELT), Alternative 2D, Alternative 4A, Alternative 5A
WaterFix Petition (May 2016)	B1, B2, NAA, H1, H2, H3, H4

B1 = Boundary 1
B2 = Boundary 2
EBC1 = existing baseline condition without the Fall X2 standard
EBC2 = existing baseline condition including the Fall X2 standard
ELT = early long term (i.e., 2025 with 15 cm of sea level rise)
LLT = later long term (i.e., 2060 with 45 cm of sea level rise)
NAA = no action alternative

DWR found that Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 would have significant adverse impacts with respect to chloride concentrations at the Contra Costa Pumping Plant #1 (FEIR/EIS Figure 8-0a). Only Alternatives 4A, 2D, and 5A were found to have no significant impact/no adverse effects (FEIR/EIS Figure 8-0a). Thus, operation of the Project to Boundaries 1 and 2, which DWR states are represented by scenarios 1A, 3, and 8, would also have significant/adverse impacts.

Although Appendix 5E of the FEIR/EIS contains a highly generalized summary of modeling DWR performed to evaluate the water quality impacts (including salinity impacts) of Boundary 1 and Boundary 2, these impacts are not assessed in the same comprehensive manner as the preferred Alternative 4A and other alternatives (including Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A) (see FEIR/EIS Chapter 8). (In addition, the Boundary 1 and Boundary 2 scenarios are not presented in the Executive Summary for the

FEIR/EIS, including FEIR/EIS Table ES.4.2, which summarizes the findings for eighteen (18) individual scenarios, and which finds that chloride impacts for all scenarios are both “significant and unavoidable (any mitigation not sufficient to render impact less than significant)” and “adverse.”) In contrast with the information presented in Chapter 8 of the FEIR/EIS, Appendix 5E presents water quality results for a more limited number of Delta locations, for fewer water quality constituents, and in much less detail. The model results of Appendix 5E were also not used to make the final impact assessment of the Project.[32]

An additional point of concern is that DWR evaluated conditions in the “late long term” (LLT) timeframe, which corresponds to the year 2060 and includes 45 cm of sea level rise, only in the Administrative Draft EIR, DEIR/EIS, and RDEIR/EIS. DWR did not evaluate the LLT timeframe in either the WaterFix Petition and testimony or the FEIR/EIS, despite the fact that DWR does not anticipate the project operations will begin prior to 2025, the date that corresponds to the “early long term” (ELT) timeframe. Thus, it is not possible to discern the impacts of the project during the full range of anticipated environmental and operating conditions from the information presented by DWR to the SWRCB as part of the WaterFix petition or from information in the FEIR/EIS.

In summary, DWR presented different information in the WaterFix Petition and testimony than in the FEIR/EIS, and at times that information appears to be inconsistent. Of particular concern to the City of Stockton’s analysis of water quality impacts at its intake are the inconsistent treatment of “baseline” conditions (e.g., inclusion of Fall X2, comparison to the NAA or to a present-day existing condition), the time horizon of DWR’s evaluation (ELT v. LLT), and the apparently inconsistent determinations of water quality impacts in the WaterFix Petition and testimony and in the FEIR/EIS. As a result of these inconsistencies and DWR’s failure to analyze water quality at the City’s intake (see Section 6), it is difficult to determine the impacts of the proposed WaterFix project on water quality at the City’s intake.

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[32] Appendix 5E comprises additional modeling requested by the State Water Board for the Boundary scenarios and an additional scenario, “Scenario 2.” The impact calls made in Chapter 8 are specific to each Alternative presented in the main body of the text (i.e., 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A), which does not include the Boundary scenarios.

8. The boundary scenarios and Alternative 4A show water quality impacts at Stockton’s intake and these impacts are significant

8.1. Source water fingerprinting shows large shifts in source water at the City’s intake during different operational scenarios

As described in Section 6, DWR has not evaluated the impacts of any of the Project alternatives (including Alternative 4A, the preferred alternative, or Alternatives H3, H4, Boundary 1, and Boundary 2) at the location of the City’s intake. To assess impacts at the City’s intake, Exponent used the DSM2 model together with DWR’s model input files to evaluate the impact of these project alternatives on the City’s water source and water quality (see Section 4 for methodology). Exponent’s DSM2 modeling demonstrates that water quality under the project scenarios is expected to be markedly different from either existing conditions (EBC2) or the future no action alternative (NAA).

Modeling demonstrates that during dry water years and under existing conditions the volume of Sacramento River water at the City’s intake varies from approximately 30 to 93 percent. However, this volume would fall to 20 to 90 percent under the Alternative 4A scenario, to 30 to 90 percent under the Boundary 1 scenario, and to 9 to 85 percent under the Boundary 2 scenario (Figure 9). The decrease is as much as 50 percent in January of dry years (under Boundary 2 scenario). For the most part, the higher quality Sacramento River water at the City’s intake is replaced by lower quality (e.g., more saline) San Joaquin River water. The volume of Sacramento River water at the City’s intake also decreases under Alternative 4A for all other water year types. The water source fingerprints under the various operational scenarios for all water year types is presented in Appendix D. As discussed in Section 5.1 above, DWR testified in the 2016 SWRCB water rights change petition hearings that Boundary 1 and Boundary 2 represent the range of potential Project operational outcomes that may result from implementation of the AMMP. Boundary 1 (characterized by a high volume of exported water) and Boundary 2 (characterized by high Delta outflow) represent a broad range of potential Project operations that is substantially different from any alternative evaluated in any of the

Project environmental documents (DEIR/EIS, RDEIR/EIS, FEIR/EIS)[33] and a broad range of potential impacts to the City's water supply that should have been evaluated fully within one of the draft environmental documents and circulated for public review and comment.

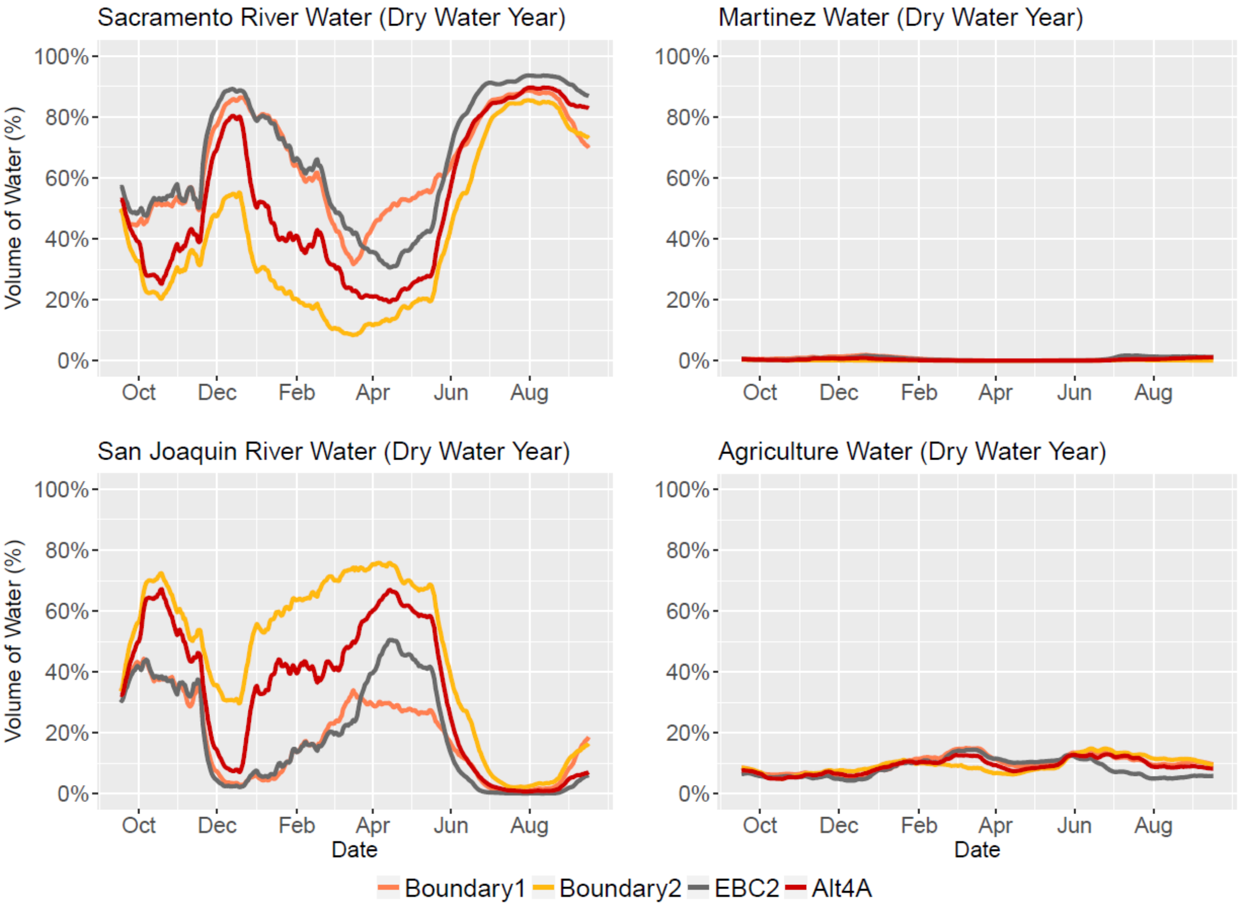

Figure 9. Source water fingerprint at Stockton's intake under the proposed California WaterFix Project scenarios during dry water year years (1981, 1985, 1987, and 1989)

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[33] Model results show more water will be exported from the Delta under the Boundary 1 scenario than scenario Alternative 4A in all but critical water years. During wet and normal years, Boundary 1 results in 622 thousand acre-feet (TAF) and 638 TAF of additional exports, respectively. Note that Boundary 1 and Boundary 2 are presented in a highly generalized fashion in Appendix 5E of the FEIR/EIS, but water quality impacts were not evaluated for the City's intake, and the impacts of these two scenarios were not presented in detail or included in the summary impact tables in either the Executive Summary of the FEIR/EIS or in Chapter 8.

As shown in Figure 9 and Appendix D, DSM2 modeling performed using DWR's model input files shows that the amount of high quality Sacramento River water at the City's intake will decrease under most of the project operational scenarios, by as much as 50 percent. This trend is seen in all water year types (Appendix D). Under each water year type and operational scenario, the Sacramento River water is replaced by lower quality San Joaquin River water.

8.2. Scenarios Boundary 1, Boundary 2, and Alternative 4A result in higher salinity at the City's intake

Water quality impacts at the City's intake were evaluated for three scenarios (Alternative 4A, Boundary 1, and Boundary 2), as well as for the EBC2 and NAA conditions, using the DSM2 model as described in Section 4.[34] DSM2 results show that the average number of days that chloride will exceed the City's 110 mg/L threshold will increase, relative to existing conditions (EBC2), for all simulated scenarios in critical and dry years (Table 3); in critical and dry years, the Boundary 2 scenario is expected to have the greatest water quality impacts, with the number of days in excess of the 110 mg/L threshold increasing by 112% and 151%, respectively. In normal year types, the NAA and Boundary 1 scenarios show a significant increase in the number of days that exceed this threshold, while the Boundary 2 scenario shows water quality improvement (Table 3).

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[34] DWR has asserted that complying with D-1641 water quality objectives will assure that water users in the Delta are not harmed. See, for example, DWR-53, p. 13, lines 18-20 ["A reduction in water quality that is within the objectives contained in D-1641 would not interfere with the ability of other legal users to put water to beneficial use"]. However, not all the proposed operations scenarios will be operated to meet D-1641 criteria. The Boundary 1 scenario, for example, "represents an operational scenario with most of the existing regulatory constraints… but does not include additional spring Delta outflow, additional OMR flows, existing I/E ratio, and the existing Fall X2 flow requirement imposed in the existing BiOp for Delta Smelt" (DWR-51, p. 13 lines 18-21). More importantly, the D-1641 water quality criteria are not evaluated at or near Stockton's intake, and Exponent's analysis shows significant water quality impacts at Stockton's intake that appear to be unrelated to D-1641 water quality objectives.

Table 3. Number of equivalent days per year that water at Stockton's intake *exceeds* 110 mg/L chloride under various modeled baseline scenarios according to water year type

Water Year Type	No. of days per year water at Stockton's intake exceeds chloride threshold of 110 mg/L					Percentage increase from EBC2 to B1	Percentage increase from EBC2 to B2	Percentage increase from EBC2 to Alt4A
	EBC2	NAA	B1	B2	Alt 4A			
Critical	35	50	47	75	53	35%	112%	52%
Dry	31	36	46	77	58	49%	151%	87%
Normal	36	44	57	18	32	60%	-49%	-11%
Wet	11	11	8	4	2	-28%	-61%	-79%

Table 4 shows the number of days per year that water at the City's intake exceeds 110 mg/L chloride for every year during the 16-year model period (1976 to 1991). As shown in Table 4, all operational scenarios cause daily average chloride concentration at the City's intake to exceed the 110 mg/L threshold more often than EBC2 for the modeled period as a whole, with increases relative to EBC2 from 33 percent (Alternative 4A scenario) to 67 percent (Boundary 2 scenario).

Table 4. Number of equivalent days per year that water at Stockton's intake *exceeds* 110 mg/L chloride under various modeled baseline scenarios for each water year between 1976 and 1991

Water year	Water Year Type	Total Days	No. of days per year water at Stockton's intake exceeds chloride threshold of 110 mg/L EBC2	NAA	B1	B2	Alt 4A	Percentage increase from EBC2 to B1	Percentage increase from EBC2 to B2	Percentage increase from EBC2 to Alt4A
1976	Critical	366	25	0	11	87	25	-55%	248%	-1%
1977	Critical	365	9	76	56	71	57	513%	685%	526%
1978	Normal	365	45	82	105	24	72	131%	-46%	60%
1979	Normal	365	12	29	33	31	18	171%	150%	45%
1980	Normal	366	50	23	34	1	6	-32%	-98%	-88%
1981	Dry	365	12	14	5	82	38	-58%	602%	223%
1982	Wet	365	20	23	30	4	4	49%	-82%	-81%
1983	Wet	365	0	0	0	0	0	NA	NA	NA
1984	Wet	366	0	0	0	0	0	NA	NA	NA
1985	Dry	365	7	1	7	76	42	-8%	921%	469%
1986	Wet	365	26	20	4	15	7	-86%	-42%	-74%
1987	Dry	365	11	6	63	81	44	465%	627%	291%
1988	Critical	366	15	10	18	88	22	19%	487%	44%
1989	Dry	365	93	125	109	71	107	17%	-24%	15%
1990	Critical	365	54	24	11	57	37	-79%	5%	-32%
1991	Critical	365	75	139	143	72	129	92%	-3%	72%
Summary	(all)		455	572	627	759	606	38%	67%	33%

During dry water years, higher chloride concentrations during Alt 4A operation (relative to existing condition EBC2) will occur at the intake from January to May, while during normal and wet water years, higher chloride concentrations will occur during June and December (Figure 9 and Appendix E). During critical water years, higher chloride concentrations will occur from January into June, and again in September. The DSM2-simulated chloride concentrations at the City's intake under the various operational scenarios are provided in Appendix E for all water year types and during every year in the modeled period (1976 to 1991).

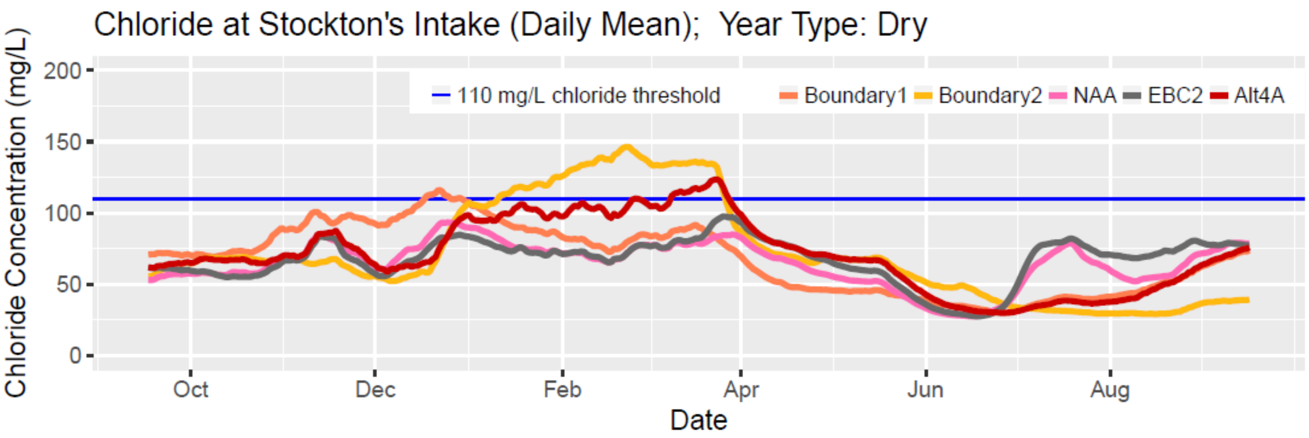

Figure 10 Concentration of chloride at Stockton's intake under various operational scenarios during dry water years (1981, 1985, 1987, and 1989). The 110 mg/L chloride threshold is also shown as a blue horizontal line.

Additionally, the number of days per year the chloride concentration at the City's intake exceeds the 110 mg/L usability threshold would also be greater under the Boundary 1 scenario than existing condition EBC2 during normal (57 and 36 for Boundary 1 and EBC2), dry (46 and 31), and critical years (47 and 35) (Table 3). The number of days per year the chloride threshold is exceeded would be greater under the B2 scenario than EBC2 during dry (77 and 31 for Boundary 2 and EBC2) and critical years (75 and 31) (Table 3). Not only do the Boundary 1 and Boundary 2 operational scenarios generate water quality and source water changes that are significantly different from each other, they also generate impacts that are significantly different from the preferred Alternative 4A.

Figure 10 shows that during a dry water year under Boundary 2 operations, the 110 mg/L threshold would most frequently be exceeded from January to April, and chloride concentrations up to 150 mg/L are simulated to occur. Compared to Alternative 4A, operating to the Boundary 1 scenario during a dry water year would cause higher chloride concentrations at the City's intake during the months of September through December; and operating to the Boundary 2 scenario would cause chloride concentrations to increase during the months of January through March (Figure 10). Compared to existing conditions (EBC2), operating to Alternative 4A during a dry water year causes chloride concentrations at the City's intake to increase during the months of January through March, May, October, and November (Figure 10). Thus, there are sizable impacts to the City's water quality during the operations of Project scenarios Boundary 1, Boundary 2, and Alternative 4A. These impacts have not been properly evaluated or disclosed in WaterFix Petition or testimony or in the FEIR/EIS.

8.3. Longer water residence times will occur in the Delta under all operational scenarios relative to the existing condition

Exponent used information from DWR's model input files to compute the average monthly residence time of inflows to the Delta. As described in Section 4.5, residence time was calculated as the volume of water within the Delta divided by the monthly average inflow rate of major inflows. DSM2 modeling shows that the residence time of water entering the Delta during a dry water year will increase for scenarios Boundary 1, Boundary 2, and Alternative 4A relative to the existing condition EBC2 and NAA (Table 5). Although DWR determined average residence times for Delta flows using the DSM2 particle tracking model (Table 8-60a in the FEIR/FEIS, p. 8-198), the residence times calculated by DWR are long-term seasonal averages (i.e., summer, fall, winter, spring) for the entire 16-year model period. DWR's residence times did not consider hydrologic variations observed in different water year types.

Exponent calculated monthly residence times in order to assess the impacts of the proposed WaterFix project on Delta flows and residence times as well as the potential effects on *Microcystis* blooms. Table 5 presents calculated average monthly residence times for dry years for Alternative 4A, the Boundary 1 and Boundary 2 scenarios, and existing conditions (EBC2). As shown in Table 5, the greatest change in residence times from the existing baseline condition (EBC2) will occur during the months of July to December, and that residence times for Alternative 4A and the Boundary 1 and 2 scenarios will increase markedly with respect to existing conditions (EBC2). For example, residence times will be 37% longer, on average, during the month of August in dry years for the Boundary 2 scenario relative to existing conditions. Table 5 also shows that residence times will be similar for the no action alternative (NAA) and the existing condition (EBC2), demonstrating that the increase in residence times is caused primarily by the proposed WaterFix project and not by sea level rise or climate change. Residence times for other water year types are presented in Appendix F and show similar trends.

Our detailed analysis of residence times indicates that the proposed WaterFix project will result in longer Delta residence times in all water year types. Longer residence times in the Delta can lead to increased water temperatures that are conducive to growth of *Microcystis* and other harmful microorganisms, as discussed in Section 8.4 below.

Table 5 Residence times of inflows to the Delta under a dry water year

	Monthly average residence time (days)					Percent increase from EBC2 to B1	Percent increase from EBC2 to B2	Percent increase from EBC2 to Alt4A
Month	EBC2	NAA	B1	B2	Alt 4A			
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%

8.4. Increased *Microcystis* growth may result from the WaterFix project

Increases in *Microcystis* blooms are a concern in the Delta, as these cyanobacteria are 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.[35] To evaluate the possibility of increased risk

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

from this organism, the FEIR/EIS attempted to categorize the proposed alternatives (i.e., operational scenarios) on a relative scale.

Overall, DWR's description of the factors known to control *Microcystis* growth in the Delta identified in the FEIR/EIS seems consistent with the state of the science. An increase in temperature and a decrease in flow rates were identified by DWR as the two most important influences on *Microcystis* growth in the Delta, with smaller potential impacts from changes in turbidity and nutrient concentrations (FEIR/EIS at p. 8-196 to 8-197). However, the FEIR/EIS provided only a qualitative analysis of the potential impact of each remedy on the likelihood that an increase in *Microcystis* blooms may occur. No detail is given on the criteria used to generate these results, which include a numerical rating proportional to the extent of the predicted impact, and which are presented on a whole-Delta basis (Figure 8.0-b of the FEIR/EIS). The use of a whole-Delta approach is inappropriate, as it does not consider area-specific changes as they relate to beneficial uses. On a whole-Delta basis, it would be possible to maintain a constant frequency of *Microcystis* blooms, while increasing ecological and human health risk, simply by altering the likely locations or timing of the blooms such that blooms are likely to be present at or near a drinking water intake for a longer period of time or more frequently.

Lower streamflows that result in higher residence times correlate with an increased likelihood of *Mycrocystis* blooms in the Delta,[36] and the FEIR/EIS should consider not just average changes, but changes in specific locations, which may drastically alter residence times. Likewise, because studies have shown a sharp increase in the likelihood of *Microcystis* blooms in the Delta based on only moderate increases in temperature (from a likelihood of 10 percent at 20 ºC to 50 percent at 25 ºC[37]), the effect of temperature at locations throughout the Delta should be addressed explicitly in the FEIR/EIS. It is important to examine both the relative increases and decreases in temperature at specific locations, but also the absolute temperature predictions in relation to known thresholds (e.g., *Microcystis* blooms can occur when temperatures are greater

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[36] 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.

[37] Mioni, C. 2012. What Controls Harmful Algal Blooms and Toxicity in the Sacramento-San Joaquin Delta? Research Summaries, California Sea Grant College Program, U.C. San Diego. Available: http://escholarship.org/uc/item/3qf633v9.

than 19 ºC[38]). Increased residence time in the Delta may increase the likelihood of a *Microcystis* bloom by several mechanisms.[39] 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 water column where irradiance is higher, leading to higher growth. Additionally, water temperatures may increase as a result of increased residence times. This could both increase the growth rates of *Microcystis* and increase the length of time that the water temperature remains above the 19 ºC threshold, effectively extending the blooming season for the cyanobacteria.

All of the proposed Alternatives evaluated in the FEIR/EIS result in an increase in predicted summer mean residence times for all subregions of the Delta, with the exception of Suisun Marsh (FEIR/EIS at p. 8-198, Table 8-60a). The FEIR/EIS specifically notes that under proposed Alternative 4A, "residence times may increase in parts of the southern and central Delta."(FEIR/EIS, p. 8-980). However, Alternative 4A is not ranked as more likely to contribute to *Microcystis* blooms than the NAA (Figure 8.0-b of the FEIR/EIS). The reasoning behind this conclusion is not presented.

As shown in Table 5 and Appendix F, residence times in the Delta will increase markedly for Alternative 4A and the Boundary 1 and Boundary 2 scenarios relative to both the EBC2 and NAA. These increases in residence time are greatest during the months of July through October, when water temperatures within the Delta are highest. For this reason, it is likely that the WaterFix Project will cause an increase in *Microcystis* growth within the Delta.

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[38] 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.

[39] Berg M and Sutula M. 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.

Appendix A

Curriculum *vitae* of Susan Paulsen

Exponent®

Susan C. Paulsen, Ph.D., P.E.

Principal Scientist & Practice Director

Professional Profile

Dr. Susan Paulsen is a Principal Scientist and the Director of Exponent's Environmental and Earth Sciences practice. Dr. Paulsen has 24 years of experience with projects involving hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents. She has provided expert testimony on matters involving the Clean Water Act and state water quality regulations, and she also provides scientific and strategic consultation on matters involving Superfund (CERCLA) and Natural Resources Damages (NRD). She has expertise designing and implementing field and modeling studies of dilution and analyzing the fate and transport of organic and inorganic pollutants, including DDT, PCBs, PAHs, copper, lead, and selenium, in surface and groundwater and in sediments.

Dr. Paulsen has designed and implemented field studies in reservoir, river, estuarine, and ocean environments using dye and elemental tracers to evaluate the impact of pollutant releases and treated wastewater, thermal, and agricultural discharges on receiving waters and drinking-water intakes. Dr. Paulsen has designed and managed modeling studies to evaluate transport and mixing, including the siting and design of diffusers, and has evaluated water quality impacts of stormwater runoff, irrigation, wastewater and industrial process water treatment facilities, and desalination brines. Dr. Paulsen has extensive knowledge of California water supply issues, including expertise in California's Bay-Delta estuary, the development of alternative water supplies, and integration of groundwater basins into supply and storage projects.

Dr. Paulsen has designed studies using one-dimensional hydrodynamic models (including DSM2 and DYRESM), three-dimensional CFD modeling, longitudinal dispersion modeling, and Monte Carlo analysis. Dr. Paulsen has participated in multi-disciplinary studies of the fate and transport of organic and inorganic pollutants, including DDT, PCBs, PAHs, copper, lead, selenium, and indicator bacteria in surface waters, groundwaters, and/or sediments. She has worked on matters involving both CERCLA and NRDA, including several involving the fate and transport of legacy pollutants, and she has evaluated the impacts of oil-field operations on drinking-water aquifers.

Dr. Paulsen has broad expertise with water quality regulation through the Clean Water Act and state regulations in California, Washington, Hawaii, and other states, and has worked on temperature compliance models, NPDES permitting, permit compliance and appeals, third-party citizens' suits, and TMDL development. She has evaluated the importance of background and natural sources on stormwater and receiving-water quality and the development of numeric limits for storm flows and process-water discharges. Dr. Paulsen is the author of multiple reports describing the history and development of water quality regulations and has provided testimony on regulatory issues, water quality, and water rights.

Academic Credentials and Professional Honors

Ph.D., Environmental Engineering Science, California Institute of Technology, 1997
M.S., Civil Engineering, California Institute of Technology, 1993
B.S., Civil Engineering, Stanford University (with honors), 1991

Licenses and Certifications

Registered Professional Civil Engineer, California, #66554

Languages

Italian (Conversational)
German (Conversational)

Selected Publications and Presentations

Byard JL, Paulsen SC, Tjeerdema RS, Chiavelli D. DDT, Chlordane, Toxaphene and PCB Residues in Newport Bay and Watershed: Assessment of Hazard to Wildlife and Human Health. Reviews of Environmental Contamination and Toxicology 2015; 235.

California Council for Environmental and Economic Balance (CCEEB); authored by Paulsen SC. A Clear Path to Cleaner Water: Implementing the vision of the State Water Board for improving performance and outcomes at the State Water Boards. CCEEB: San Francisco, CA. 2013. Available at www.cceeb.org.

South Orange Coastal Ocean Desalination (SOCOD) Project; authored by Expert Panel Member Paulsen SC. Expert Panel Report: Offshore Hydrogeology/Water Quality Investigation Scoping, Utilization of Slant Beach Intake Wells for Feedwater Supply. Municipal Water District of Orange County (MWDOC): Fountain Valley, CA. 2012. Available at http://www.mwdoc.com/filesgallery/FINAL_Expert_Panel_Rept_10_9_2012.pdf.

Paulsen SC, Goteti G, Kelly BK, Yoon VK. Automated flow-weighted composite sampling of stormwater runoff in Ventura County, CA. Proceedings, Water Environment Federation 2011.12 (2011): 4186-4203. Also published as automated flow-weighted composite sampling of stormwater runoff. Water Environment Laboratory Solutions 2012; 19(2):1–6.

Paulsen SC, List EJ, Kavanagh KB, Mead AM, Seyfried R, Nebozuk S. Dynamic modeling and field verification studies to determine water quality and effluent limits downstream of a POTW discharge to the Sacramento River, California. Proceedings, Water Environment Federation 2007; 12:5695–5721.

Paulsen SC, List EJ. Potential background constituent levels in storm water at Boeing's Santa Susana Field Laboratory. Report to Expert Panel convened by The Boeing Company and Regional Water Quality Control Board, Los Angeles Region, 2007. Available at http://www.boeing.com/assets/pdf/aboutus/environment/santa_susana/water_quality/tech_reports/2007_background/2007_background_report.pdf.

Paulsen SC, List EJ, Santschi PH. Modeling variability in 210Pb and sediment fluxes near the Whites Point Outfalls, Palos Verdes Shelf, California. Environmental Science & Technology 1999; 33:3077–3085.

Paulsen SC, List EJ, Santschi PH. Comment on "In situ measurements of chlorinated hydrocarbons off the Palos Verd es Peninsula, California." Environmental Science & Technology 1999; 33:3927–3928.

Paulsen SC, List EJ. A study of transport and mixing in natural waters using ICP-MS: Water-particle interactions. Water, Air, and Soil Pollution 1997; 99:149–156.

Paulsen SC, List EJ. Tracing discharges in ocean environments using a rare earth tracer. Presented at the 27th IAHR Congress, San Francisco, CA, August 1997.

Prior Experience

- Various positions including President, Flow Science Incorporated, Pasadena, California, 1997–2014
- Consultant to Flow Science Incorporated, Pasadena, California, 1994–1997
- Staff Engineer, Dames & Moore, Civil Design Group, San Francisco, California, 1990-1992
- Graduate Research and Teaching Assistant, Hydrologic Transport Processes and Fluid Mechanics, California Institute of Technology, Pasadena, California, 1993–1997
- Research Engineer, Fraunhofer Institute for Atmospheric Environmental Research, Garmisch-Partenkirchen, Germany (West), 1989
- Instructor, Technical Communications Program (joint Business School/School of Engineering program), Stanford University, Stanford, CA, 1989–1990

Professional Affiliations

- American Society of Civil Engineers—ASCE
- Member, National Ground Water Association

Depositions (last 4 years)

Robert Bruncati and Maureen Bruncati v. Billy Wayne Andrews, Jr., et al., Case No. CIVDS1309044, in the Superior Court of the State of California, County of San Bernardino, San Bernardino District. August 24, 2015, and September 8, 2015.

City of Cerritos, et al., v. Water Replenishment District of Southern California, Case No. BS128136, in the Superior Court of the State of California, County of Los Angeles. November 24, 2014.

The Boeing Company et al. v. State of Washington, Department of Ecology, Appeal of the 2010 Industrial Stormwater General Permit, Pollution Control Hearings Board, State of Washington. Case No. 09-140. 2011.

Puget Soundkeeper Alliance v. BNSF Railway Co., Case No. C09-1087-JCC, in the United States District Court, Western District of Washington at Seattle. 2011.

Trials and Hearings (last 4 years)

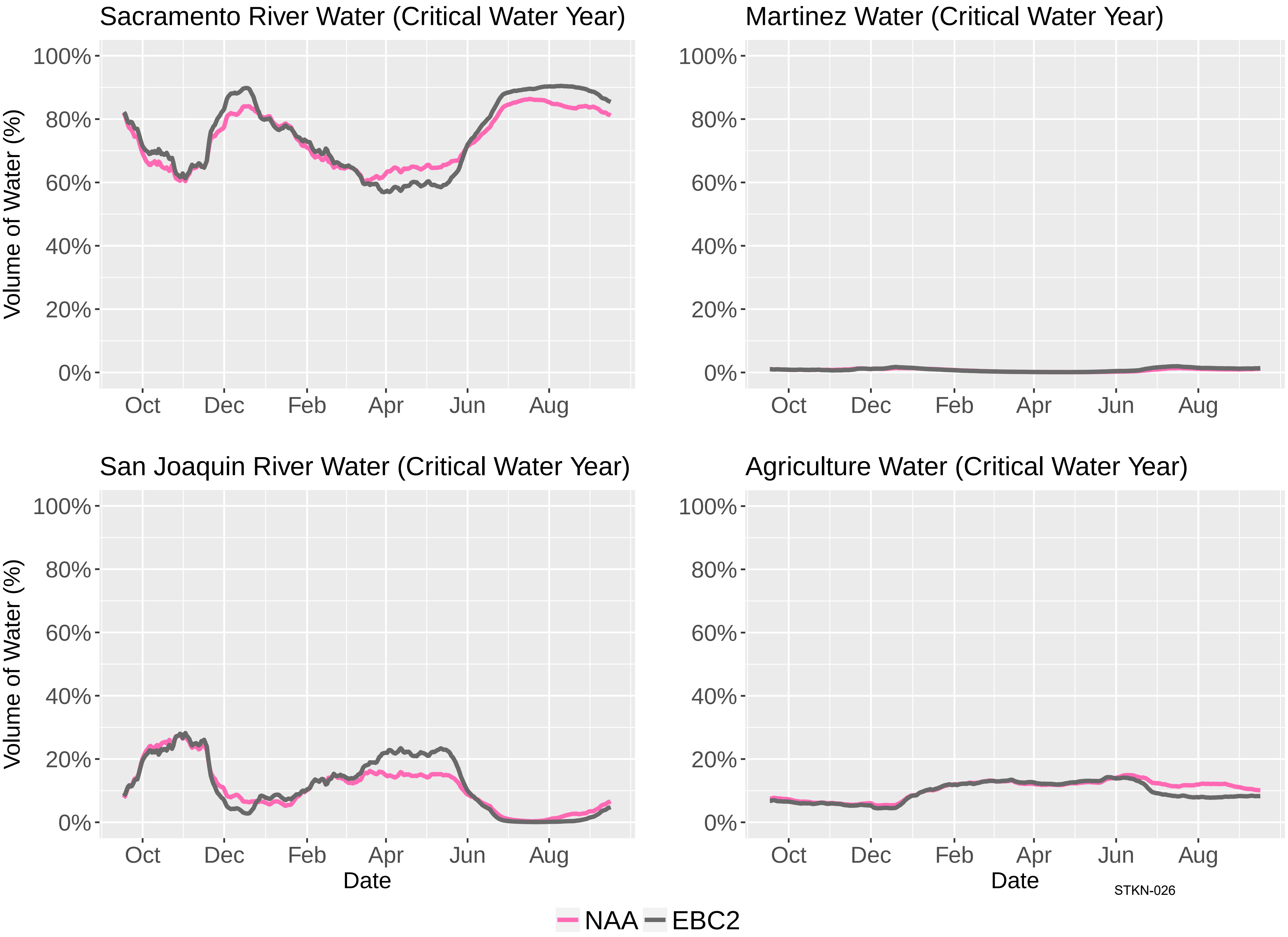
Robert Bruncati and Maureen Bruncati v. Billy Wayne Andrews, Jr., et al., Case No. CIVDS1309044, in the Superior Court of the State of California, County of San Bernardino, San Bernardino District. 2015.

The Boeing Company et al. v. State of Washington, Department of Ecology, Appeal of the 2010 Industrial Stormwater General Permit, Pollution Control Hearings Board, State of Washington. Case No. 09-140. 2011.

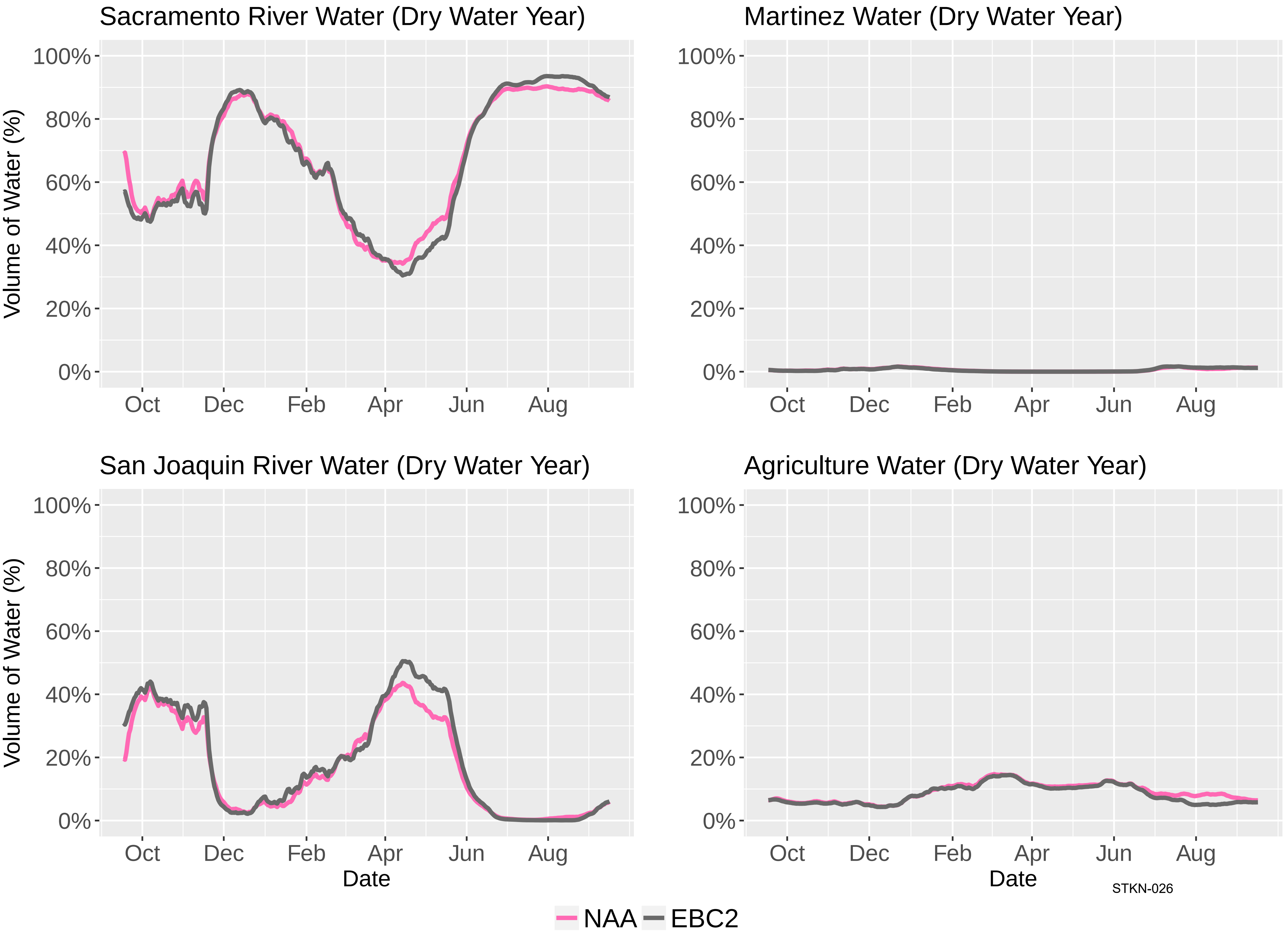
Appendix B

Water source fingerprints under baseline conditions EBC2 and NAA

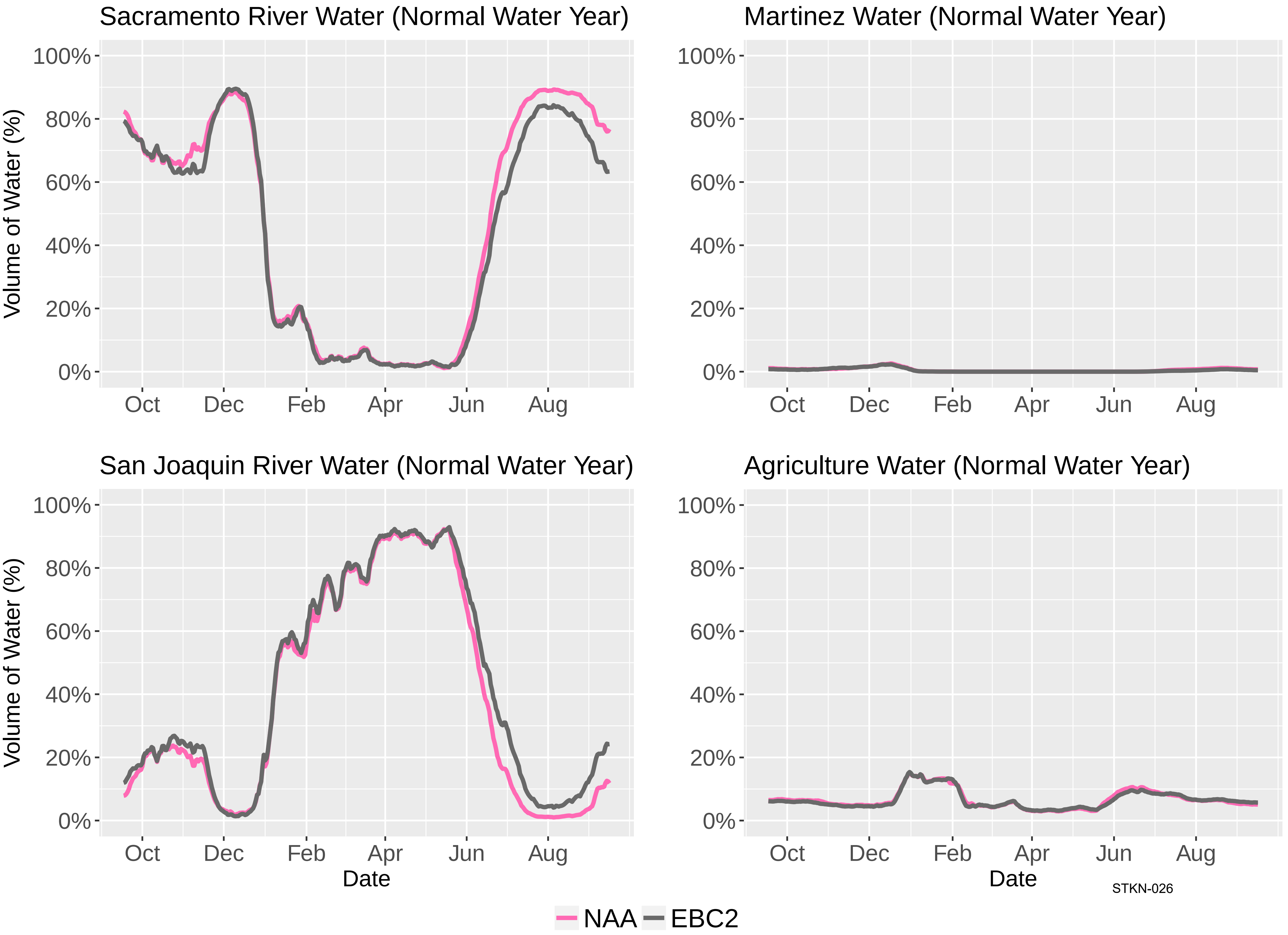
Source-water fingerprints at Stockton’s Intake

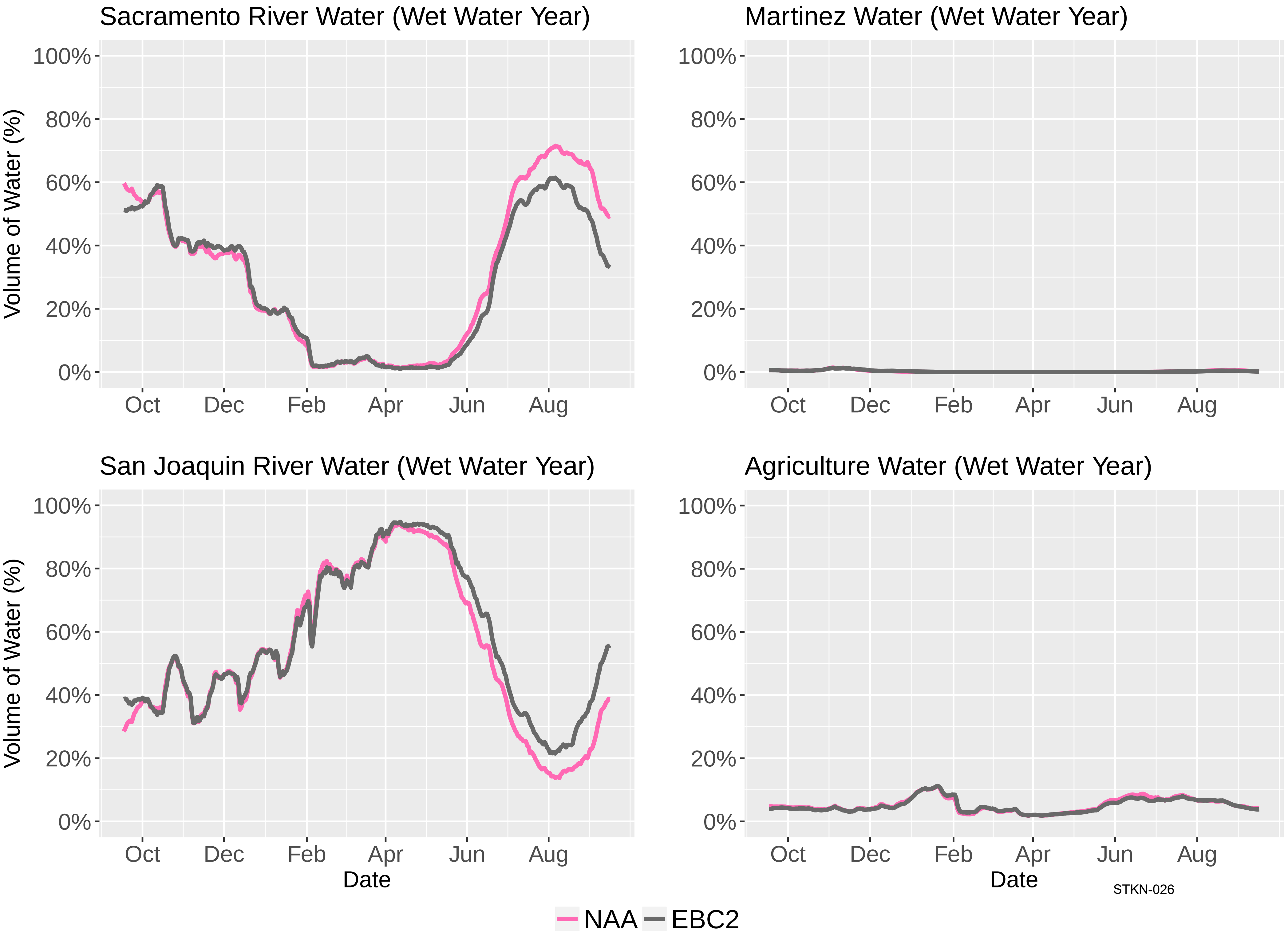

Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

STKN-026


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

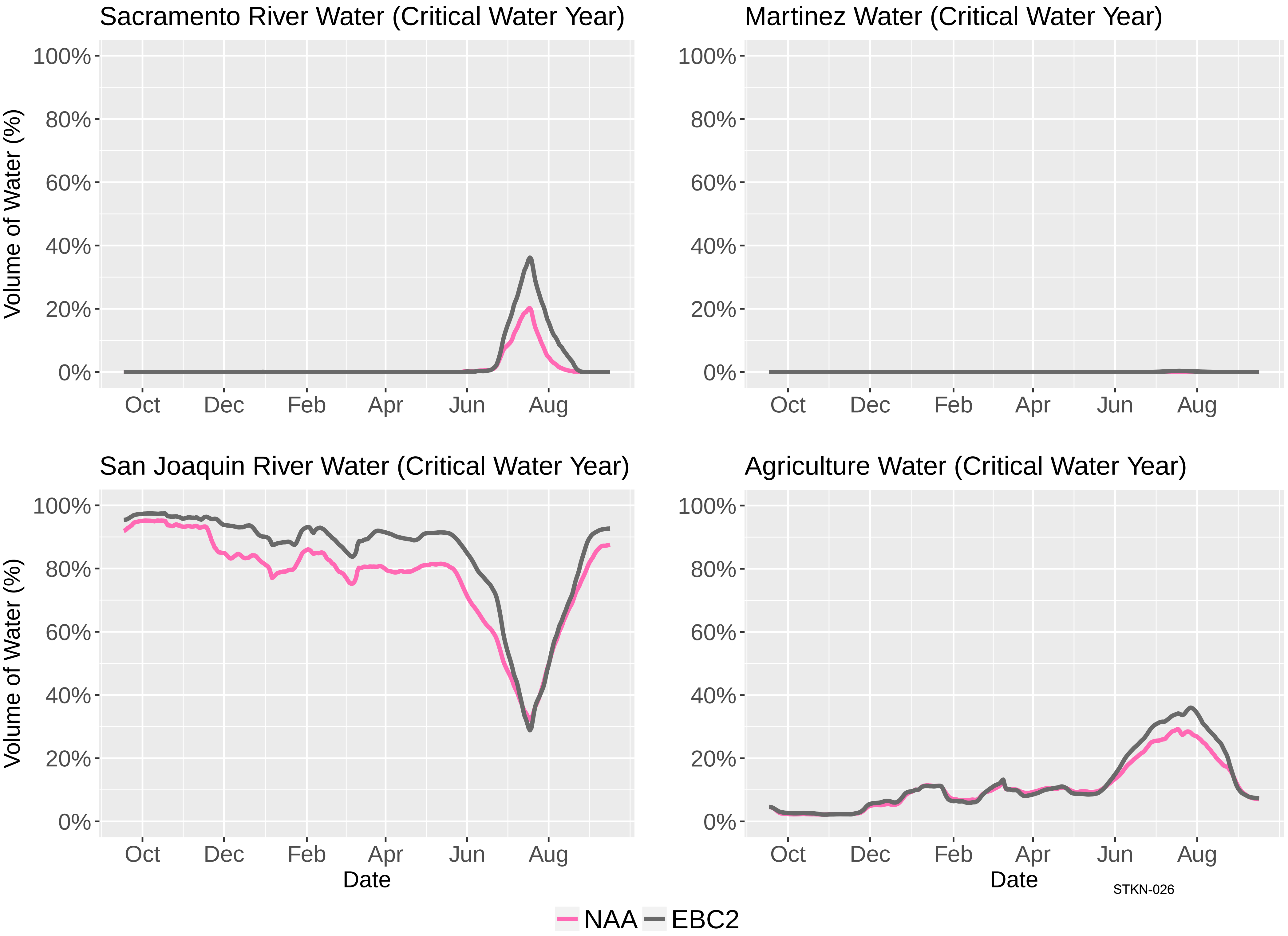
STKN-026

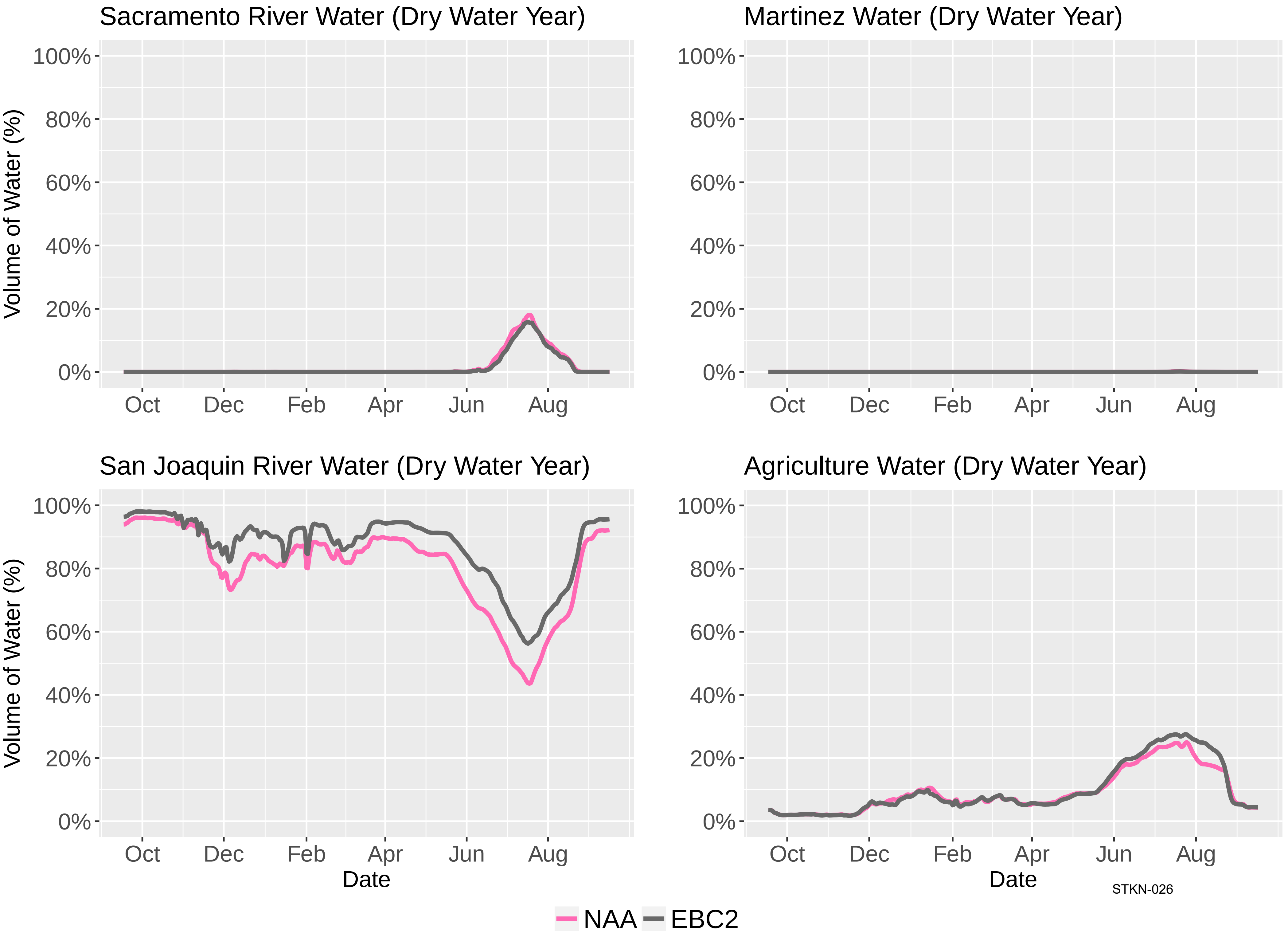

Sacramento River Water (Normal Water Year)
Martinez Water (Normal Water Year)
San Joaquin River Water (Normal Water Year)
Agriculture Water (Normal Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2


Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

STKN-026

Source-water fingerprints at Buckley Cove


Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2



Sacramento River Water (Dry Water Year)

Martinez Water (Dry Water Year)

San Joaquin River Water (Dry Water Year)

Agriculture Water (Dry Water Year)

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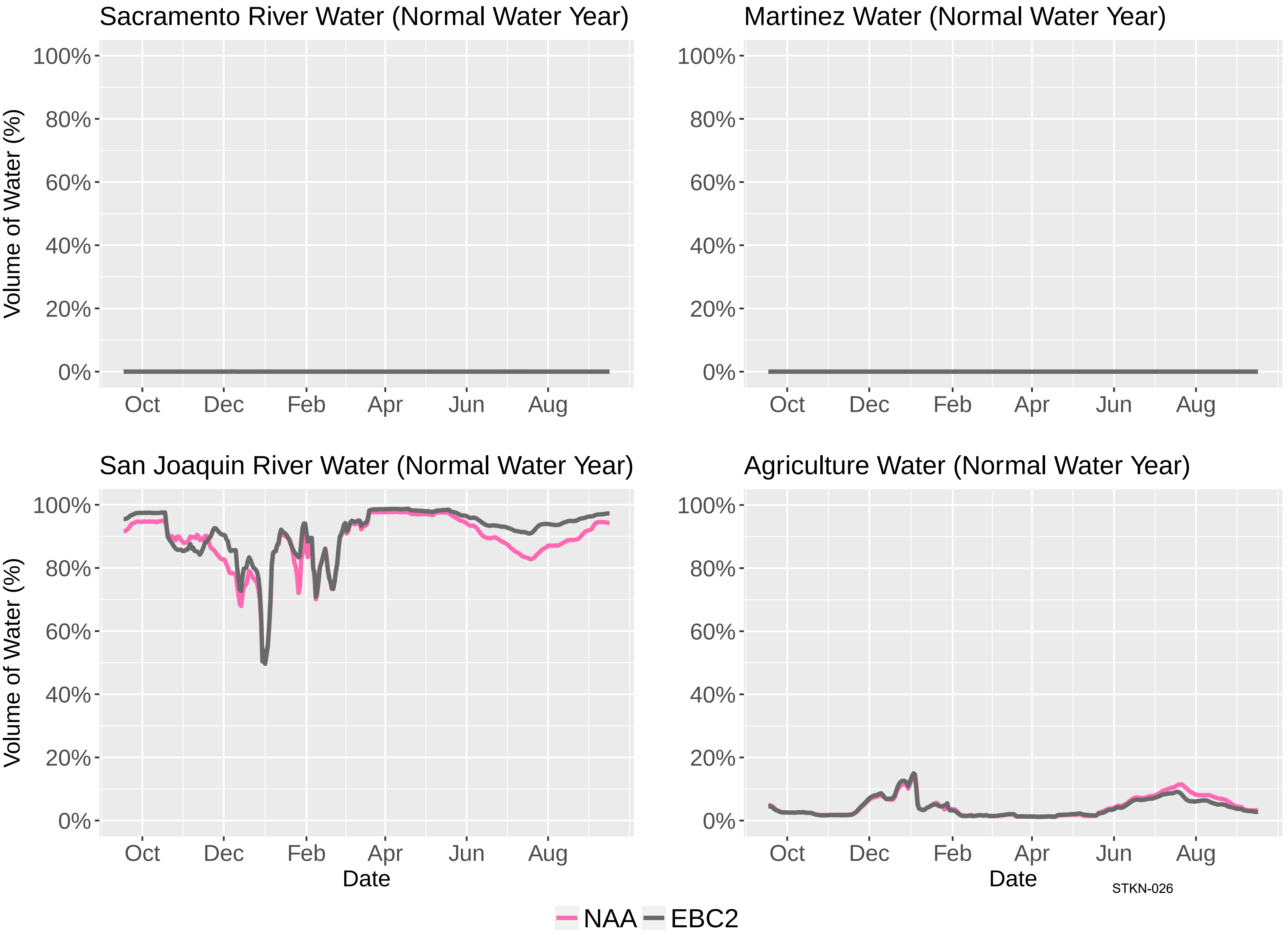
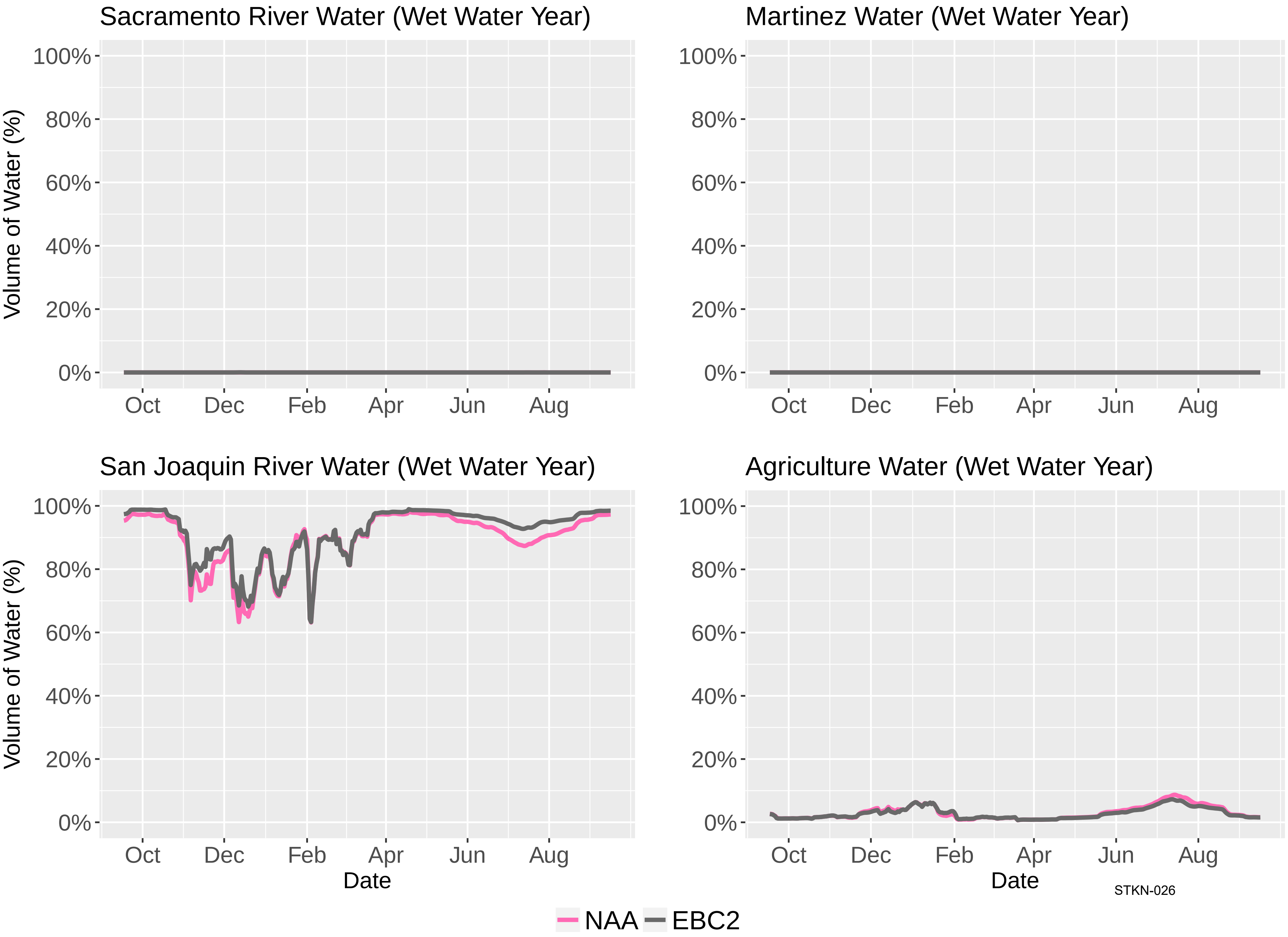
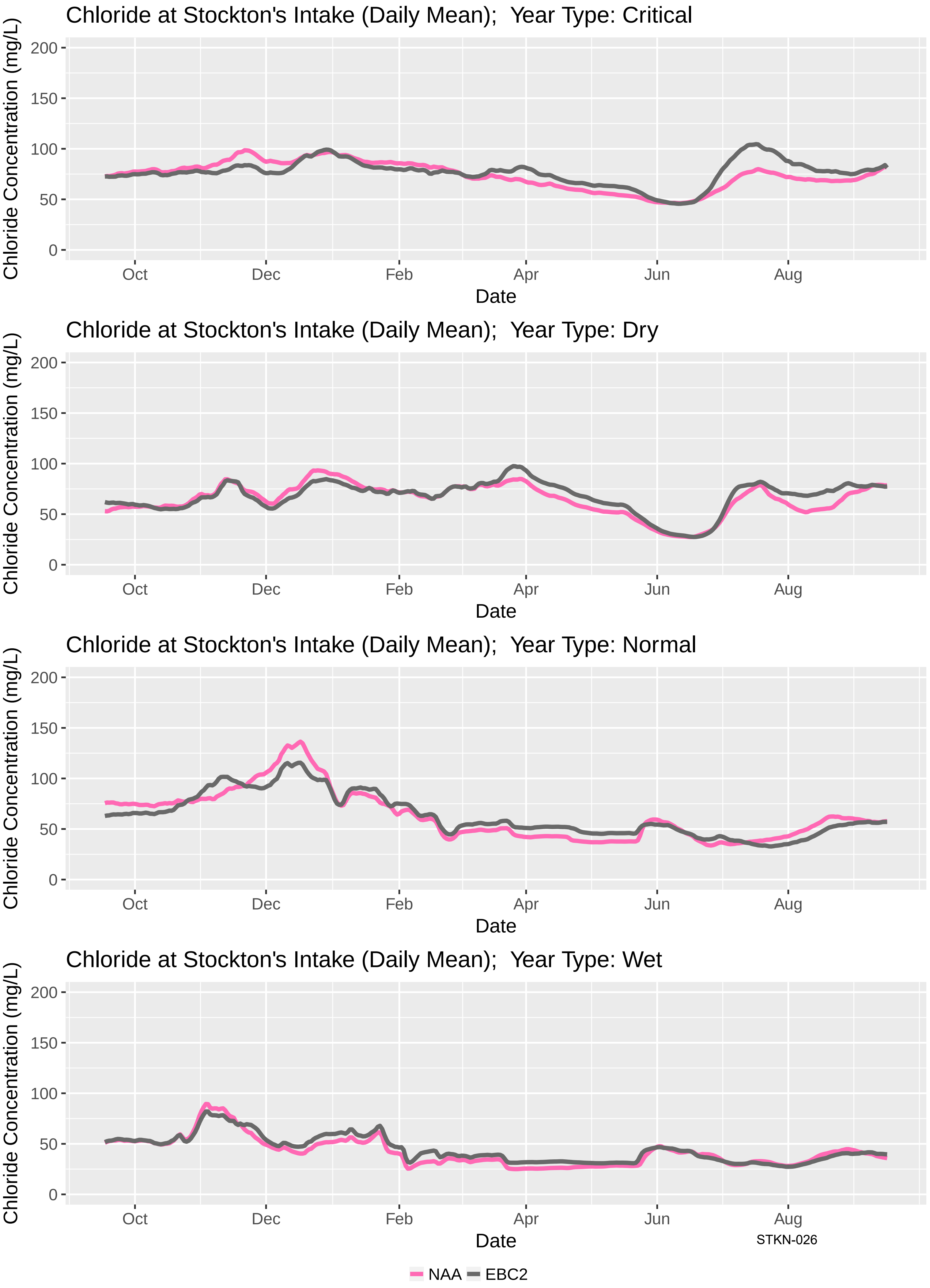

Sacramento River Water (Normal Water Year)
Martinez Water (Normal Water Year)
San Joaquin River Water (Normal Water Year)
Agriculture Water (Normal Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2


Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Date
STKN-026
NAA
EBC2

Appendix C

Chloride concentrations under baseline conditions EBC2 and NAA



Chloride at Stockton's Intake (Daily Mean); Year Type: Critical

Chloride at Stockton's Intake (Daily Mean); Year Type: Dry

Chloride at Stockton's Intake (Daily Mean); Year Type: Normal

Chloride at Stockton's Intake (Daily Mean); Year Type: Wet

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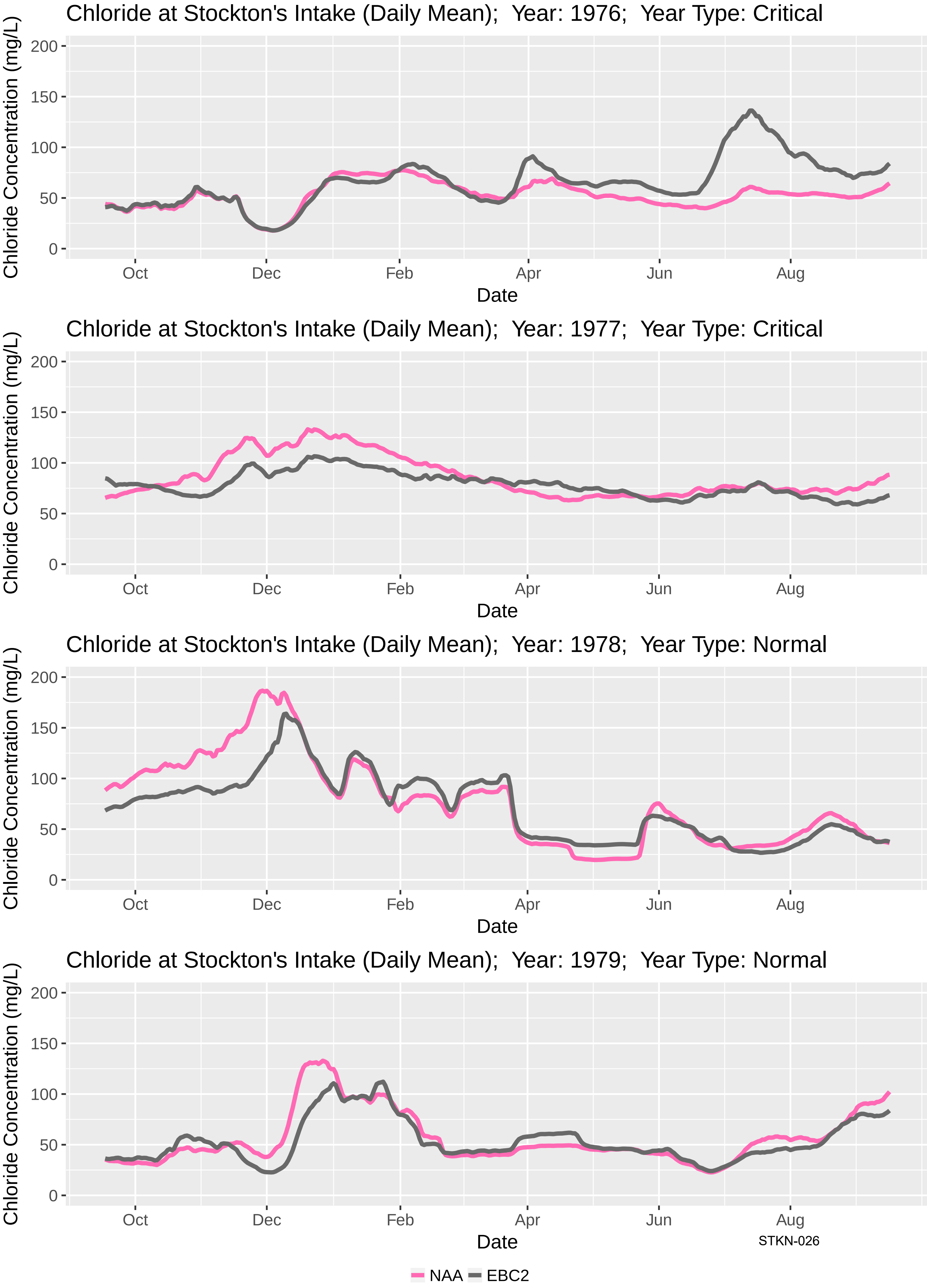
Chloride at Stockton's Intake (Daily Mean); Year: 1976; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1977; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1978; Year Type: Normal
Chloride at Stockton's Intake (Daily Mean); Year: 1979; Year Type: Normal
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

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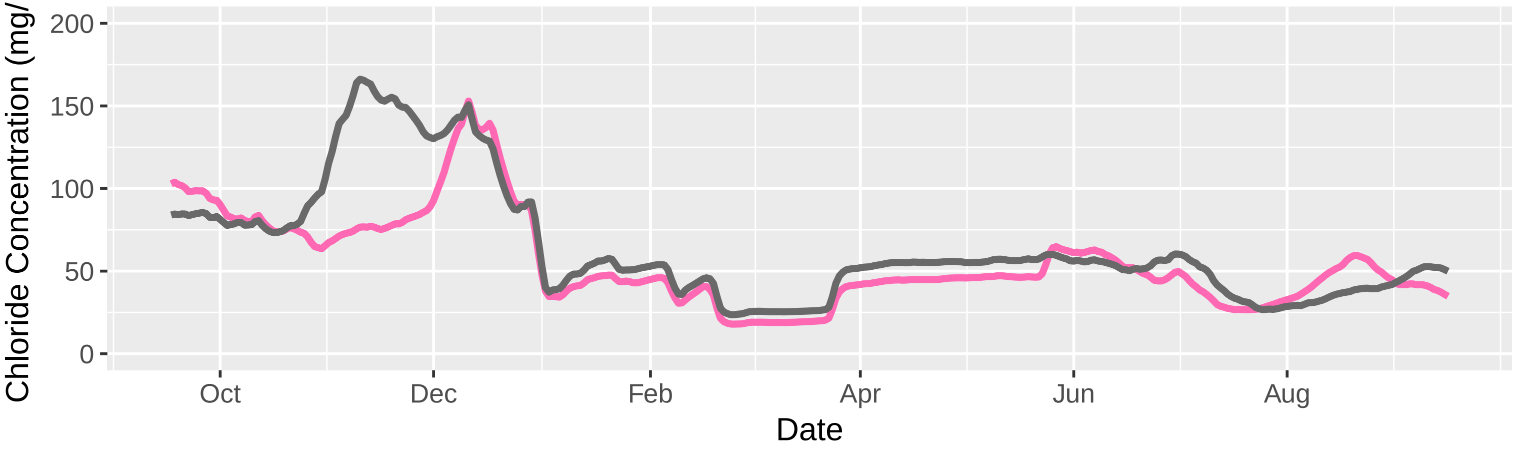
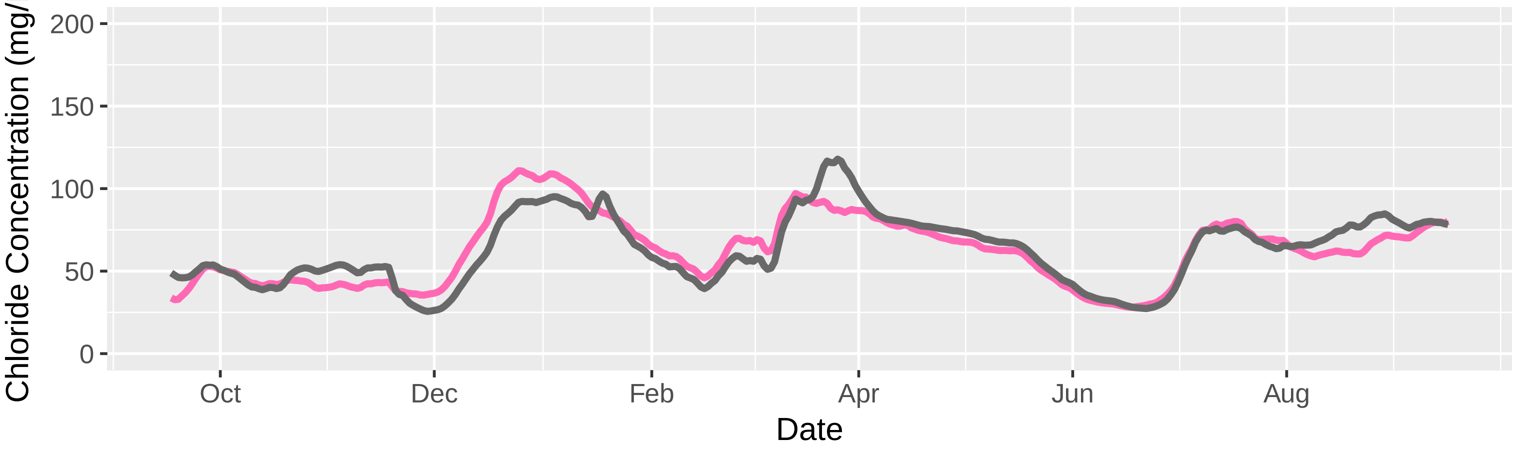
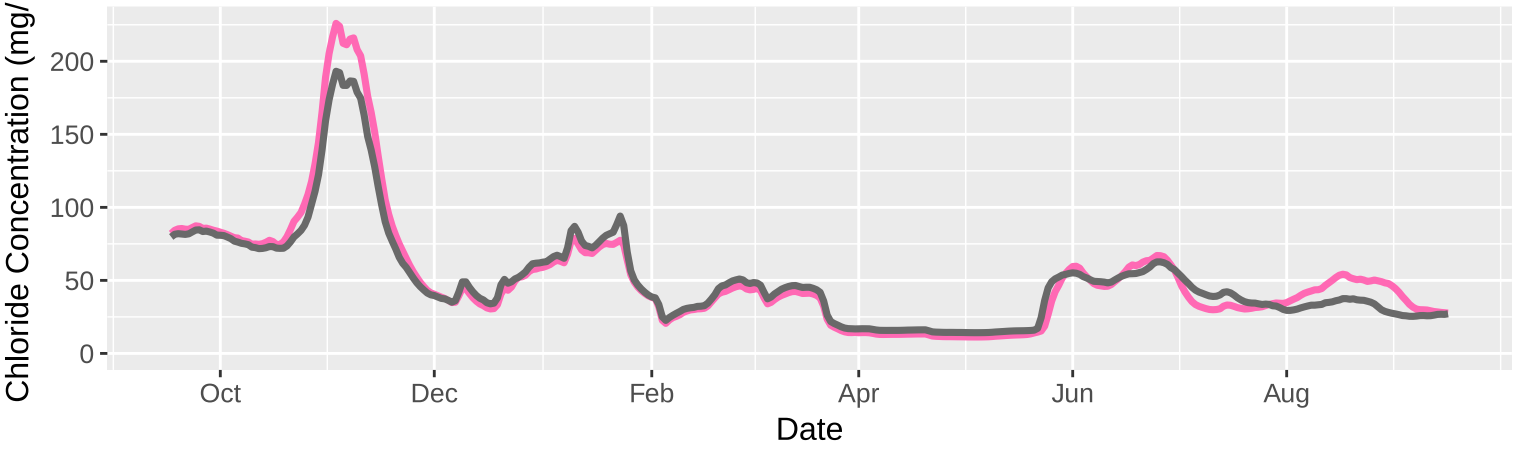
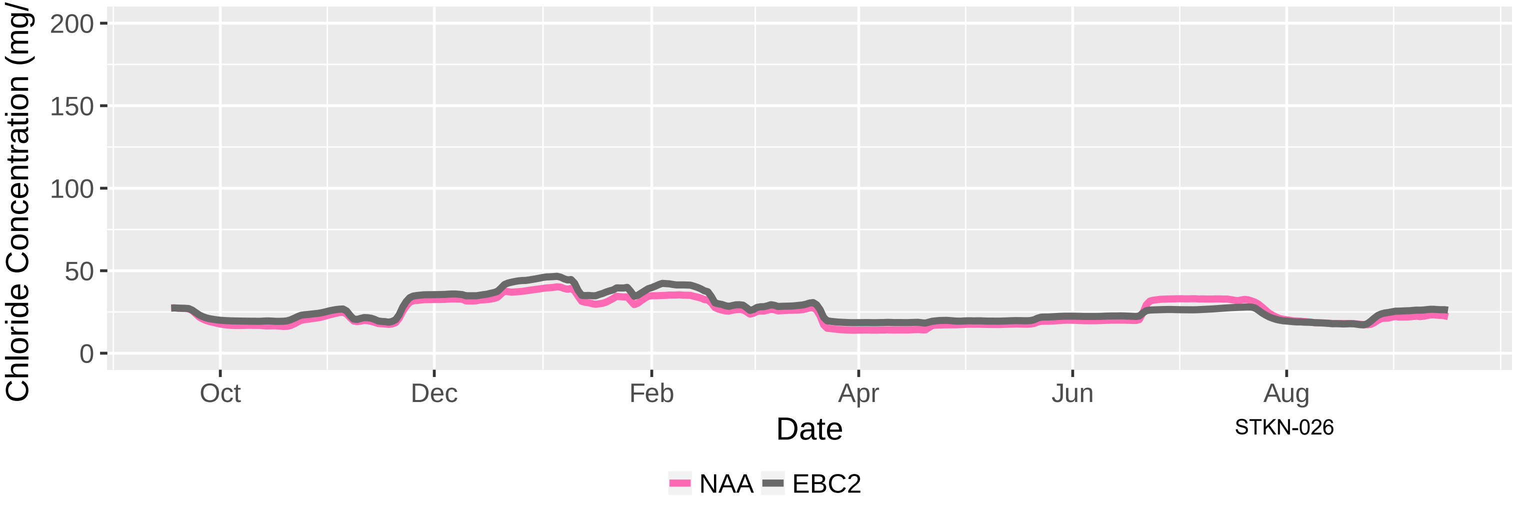
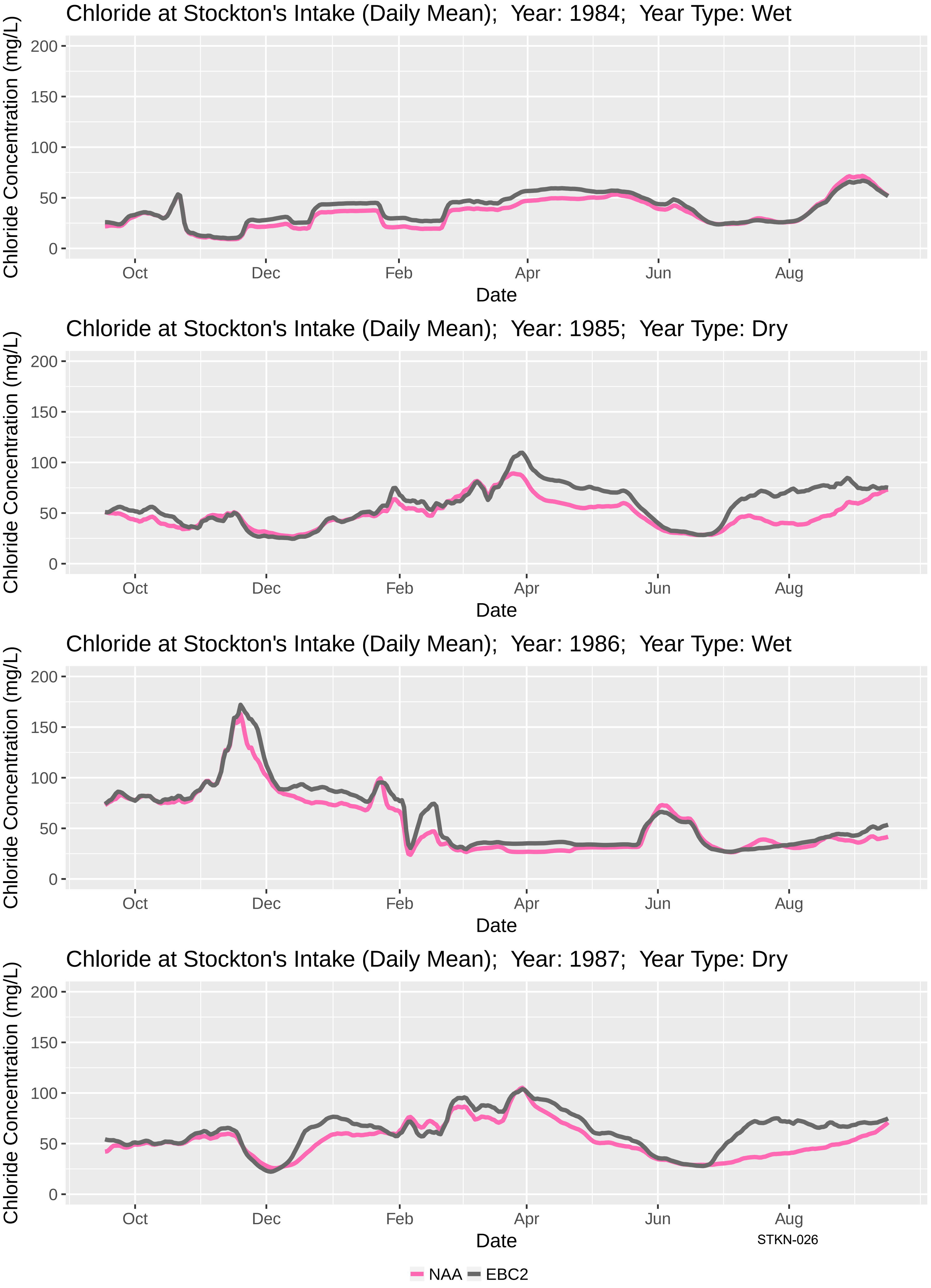

Chloride at Stockton's Intake (Daily Mean); Year: 1980; Year Type: Normal


Chloride at Stockton's Intake (Daily Mean); Year: 1981; Year Type: Dry


Chloride at Stockton's Intake (Daily Mean); Year: 1982; Year Type: Wet


Chloride at Stockton's Intake (Daily Mean); Year: 1983; Year Type: Wet

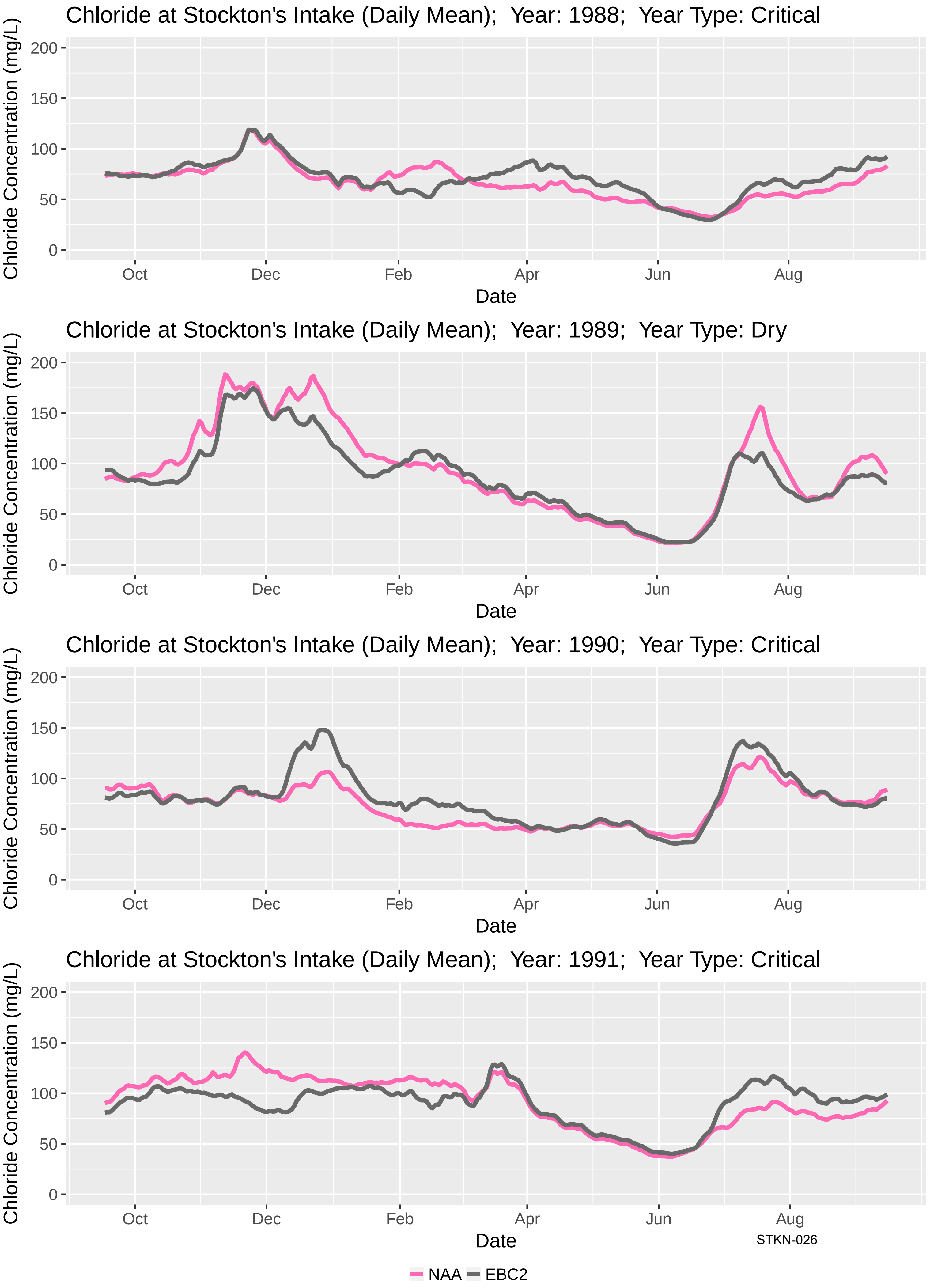


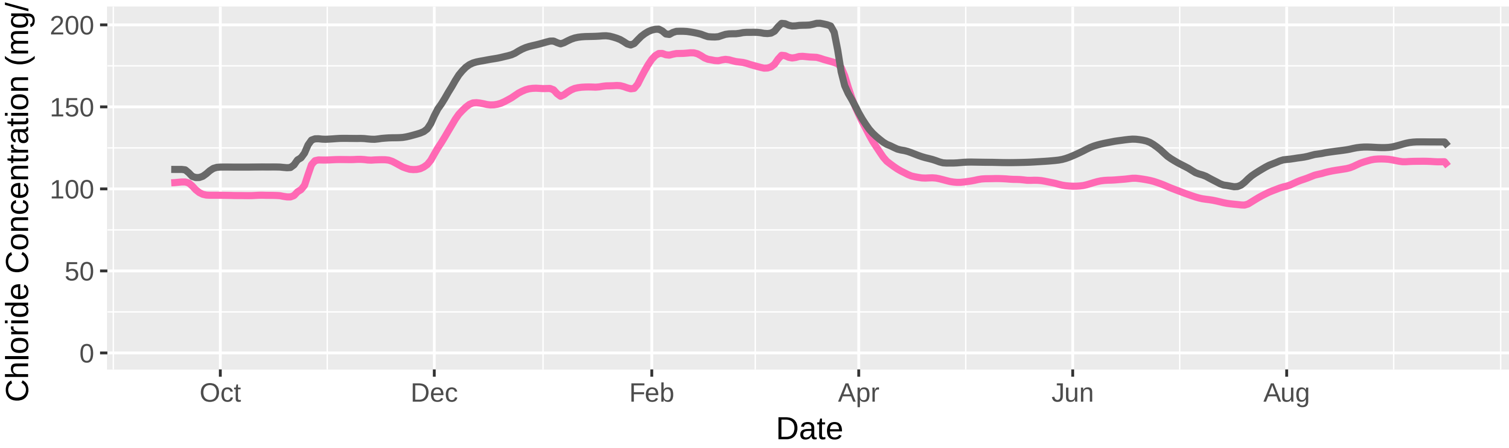
Chloride at Stockton's Intake (Daily Mean); Year: 1984; Year Type: Wet

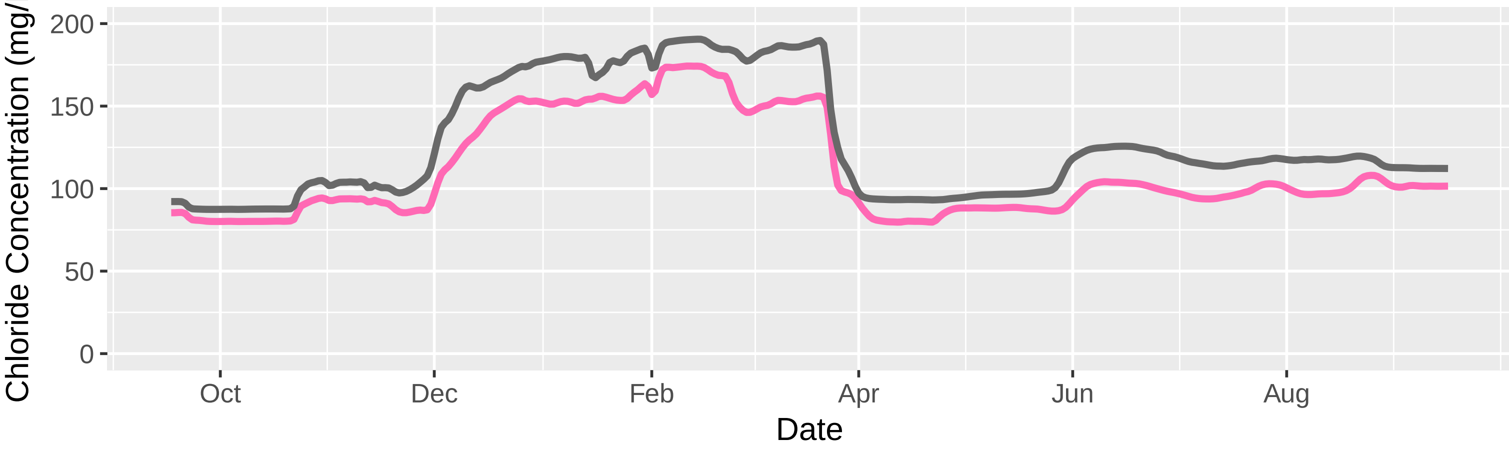
Chloride at Stockton's Intake (Daily Mean); Year: 1985; Year Type: Dry

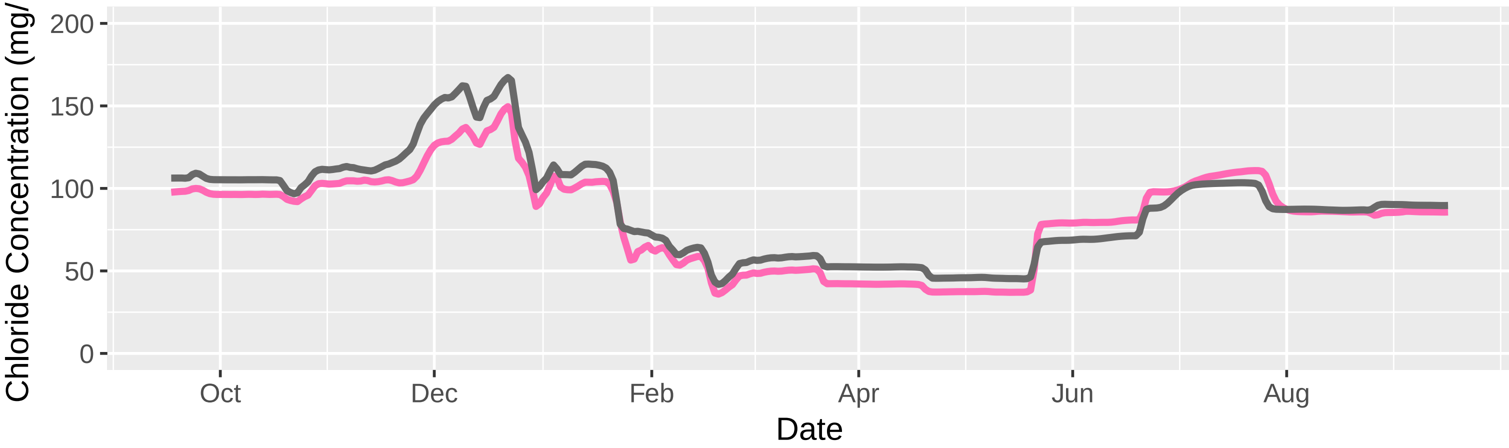
Chloride at Stockton's Intake (Daily Mean); Year: 1986; Year Type: Wet

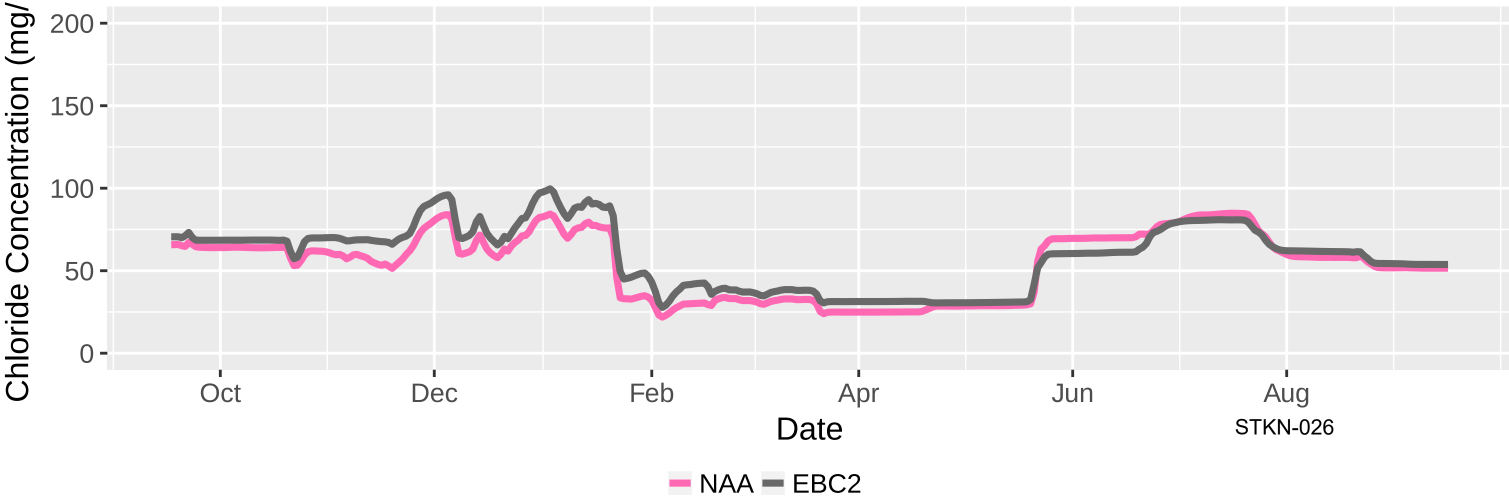
Chloride at Stockton's Intake (Daily Mean); Year: 1987; Year Type: Dry


Chloride at Stockton's Intake (Daily Mean); Year: 1988; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1989; Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year: 1990; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1991; Year Type: Critical
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2


Chloride at Buckley Cove (Daily Mean); Year Type: Critical


Chloride at Buckley Cove (Daily Mean); Year Type: Dry


Chloride at Buckley Cove (Daily Mean); Year Type: Normal


Chloride at Buckley Cove (Daily Mean); Year Type: Wet

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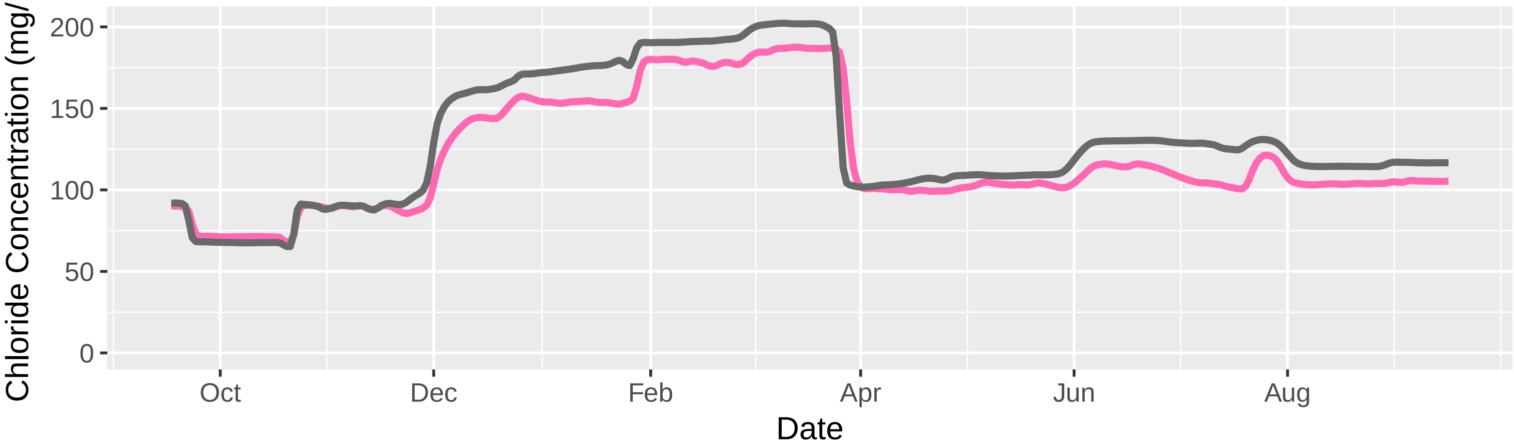
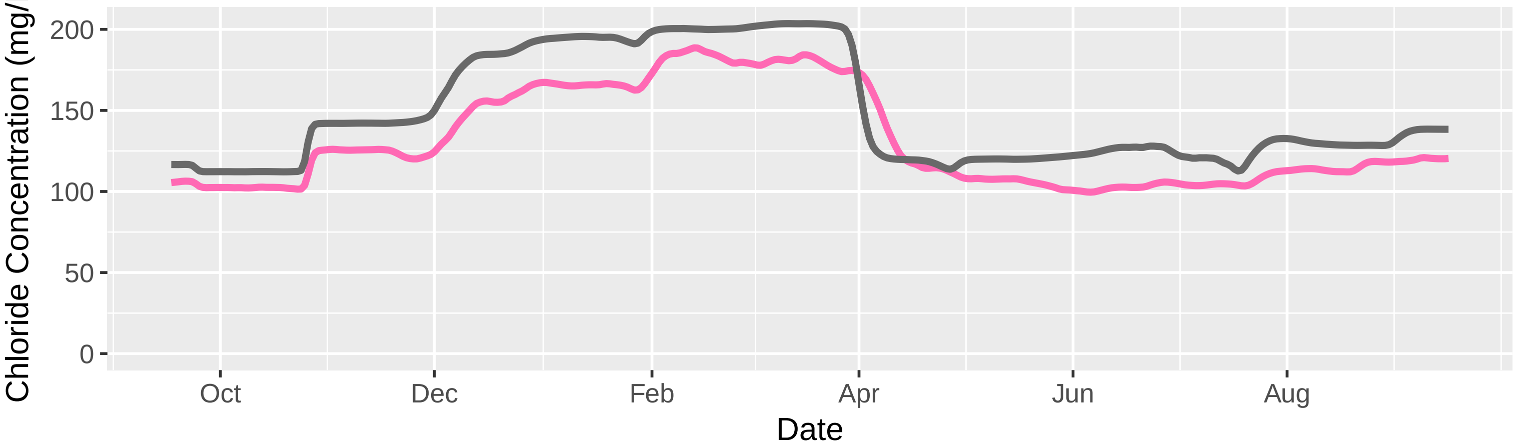
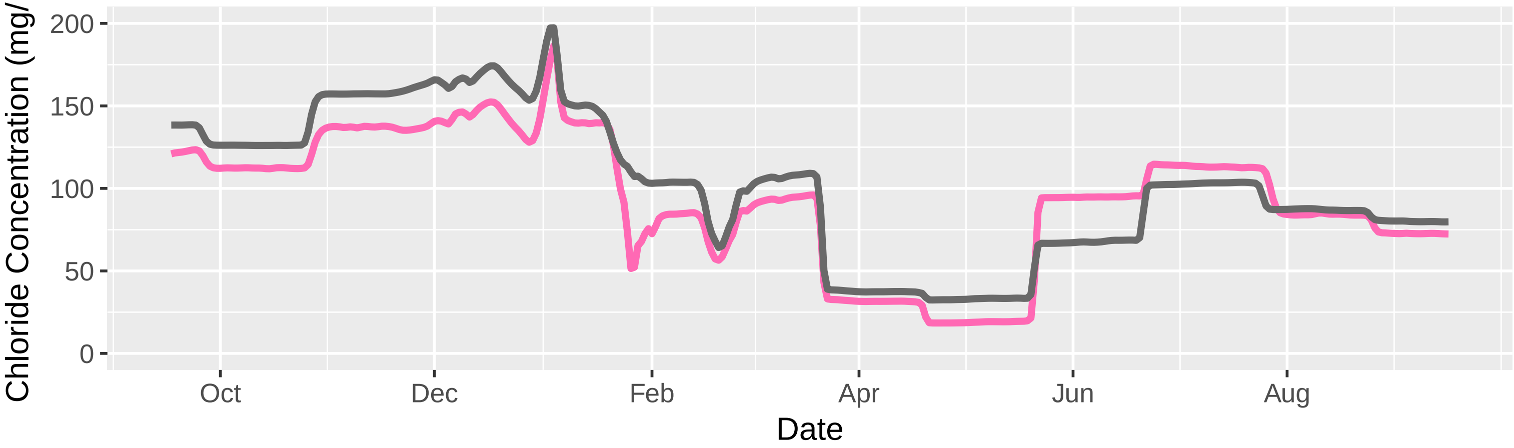
Chloride at Buckley Cove (Daily Mean); Year: 1976; Year Type: Critical



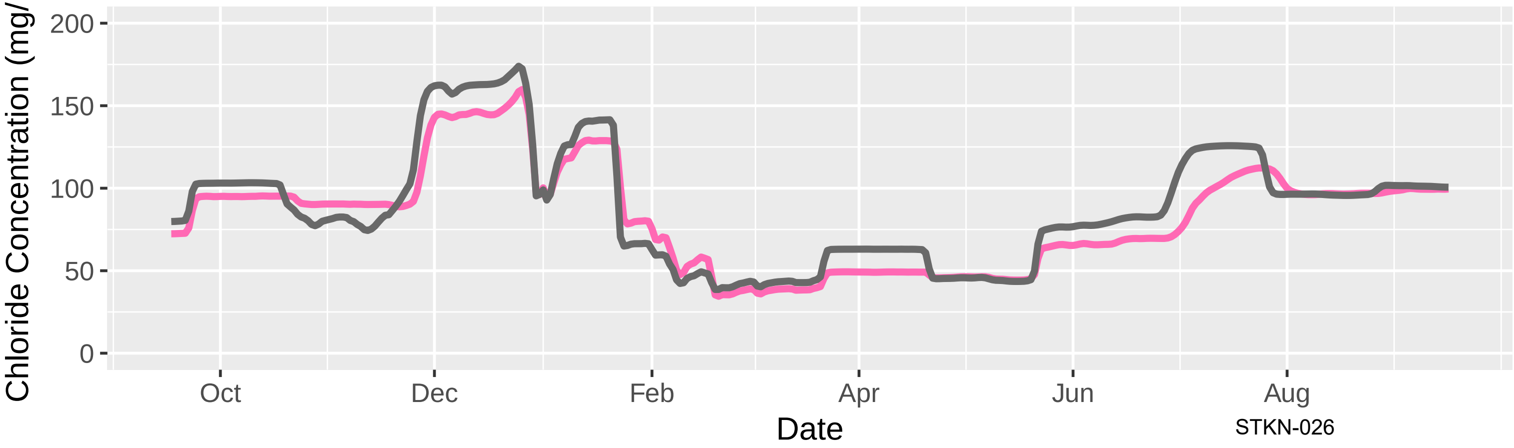
Chloride at Buckley Cove (Daily Mean); Year: 1977; Year Type: Critical



Chloride at Buckley Cove (Daily Mean); Year: 1978; Year Type: Normal



Chloride at Buckley Cove (Daily Mean); Year: 1979; Year Type: Normal



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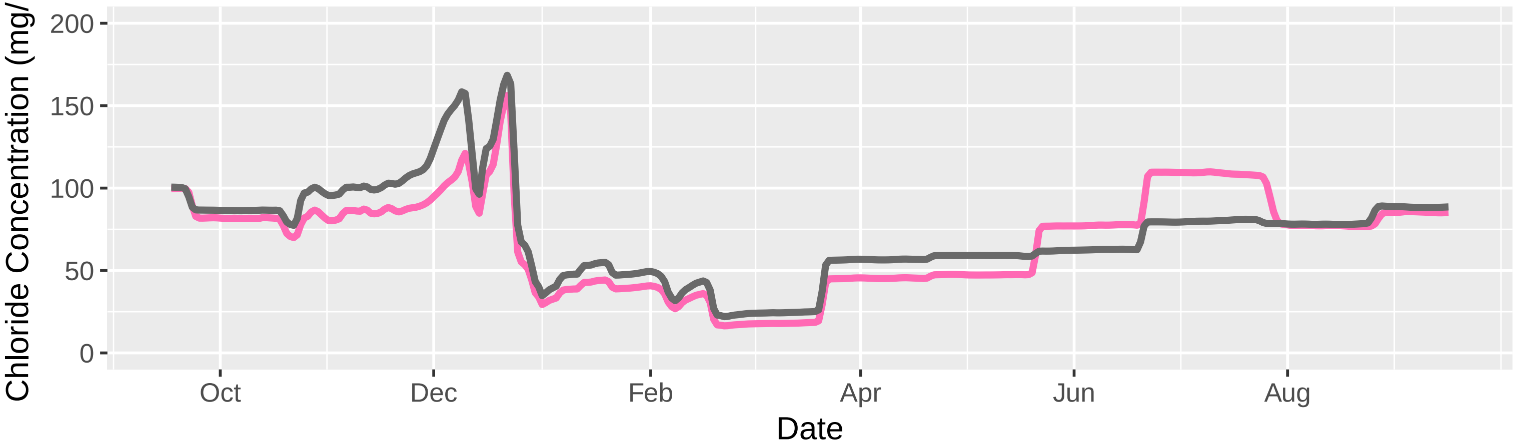
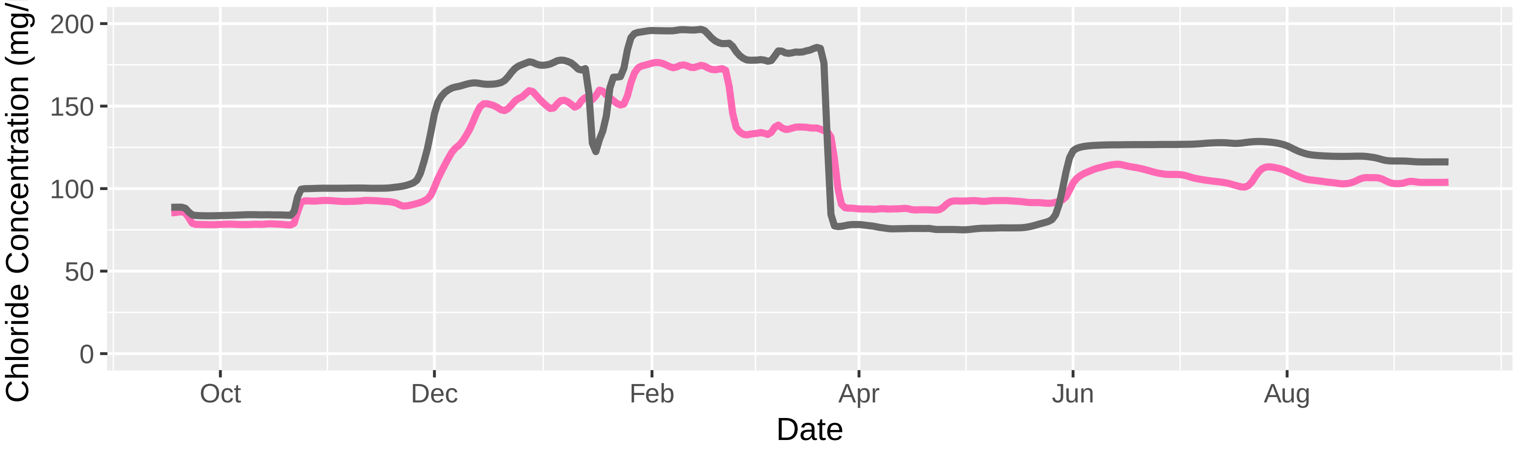
▬ NAA ▬ EBC2

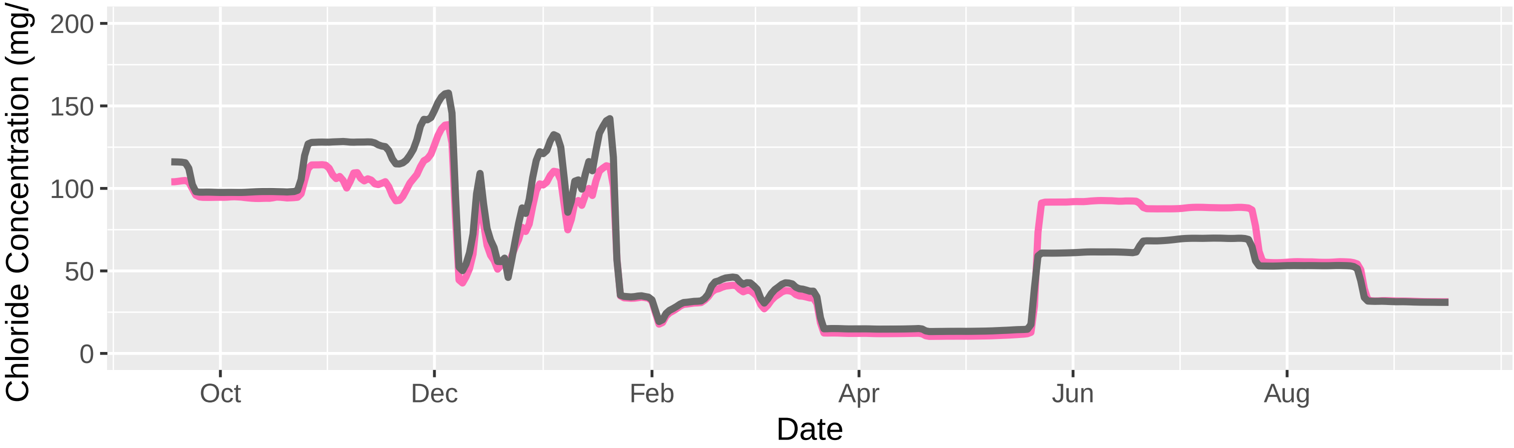
Chloride at Buckley Cove (Daily Mean); Year: 1980; Year Type: Normal



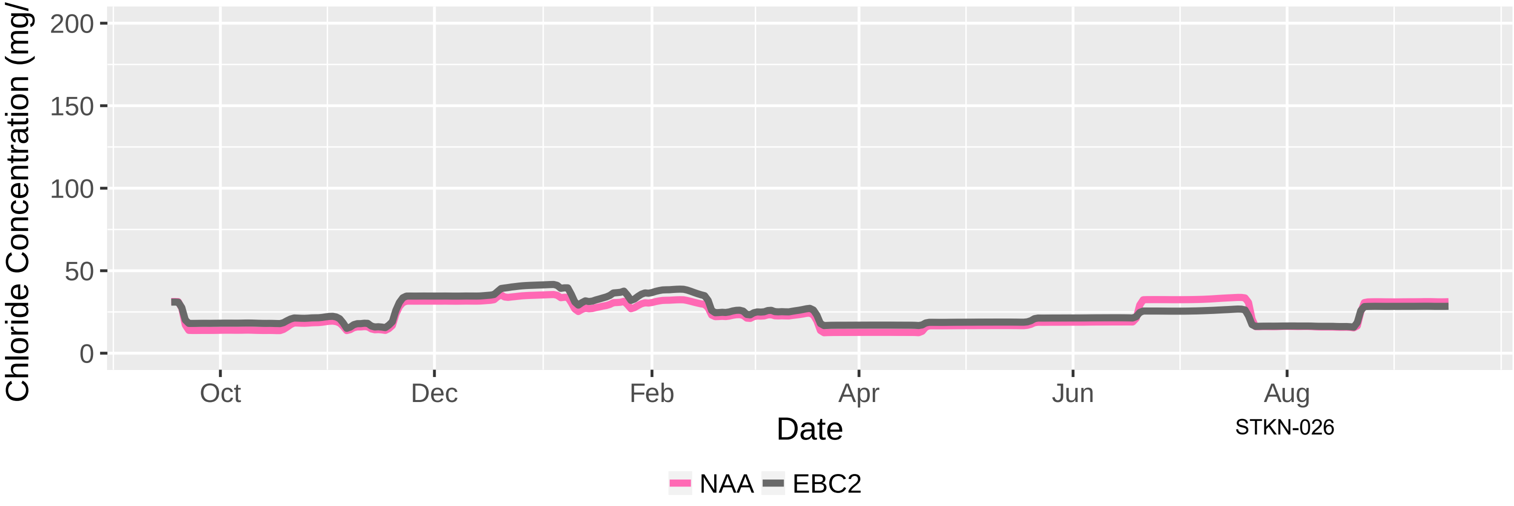
Chloride at Buckley Cove (Daily Mean); Year: 1981; Year Type: Dry



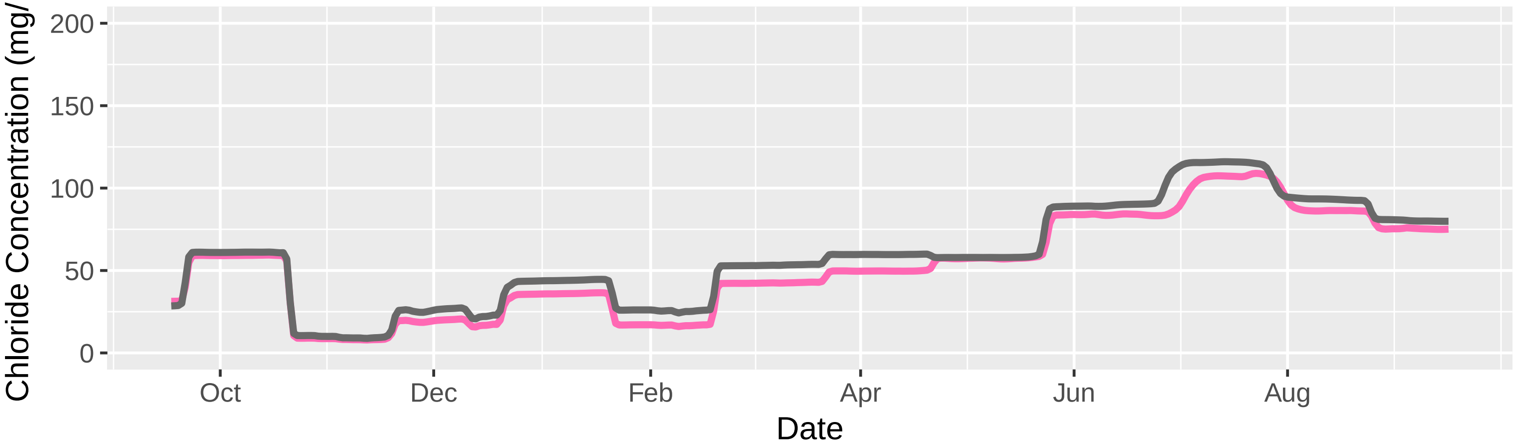
Chloride at Buckley Cove (Daily Mean); Year: 1982; Year Type: Wet



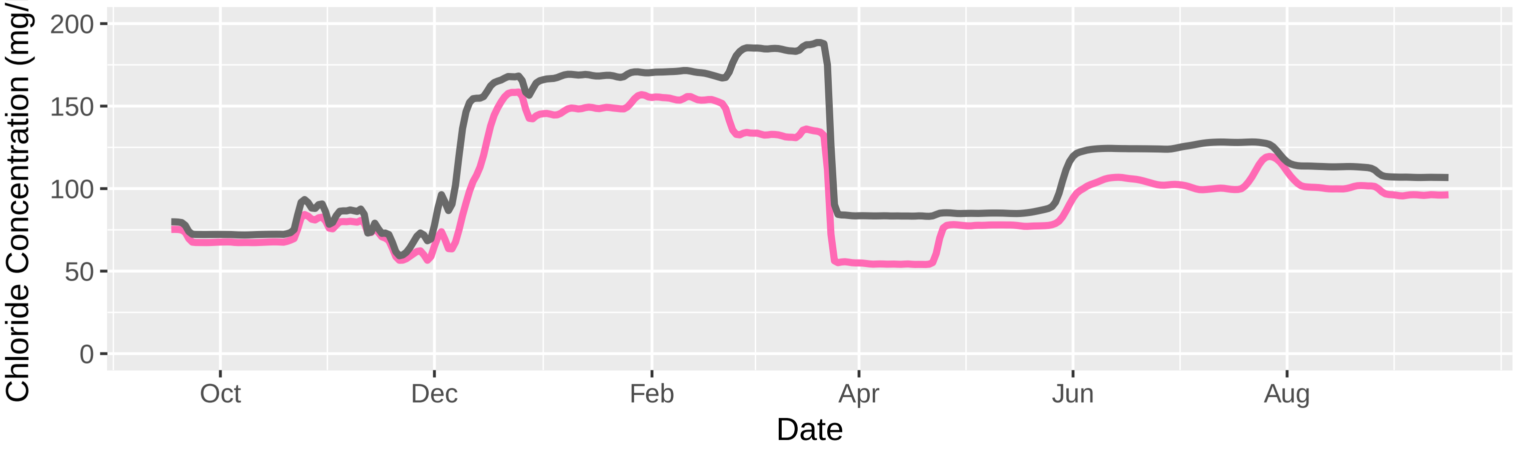
Chloride at Buckley Cove (Daily Mean); Year: 1983; Year Type: Wet



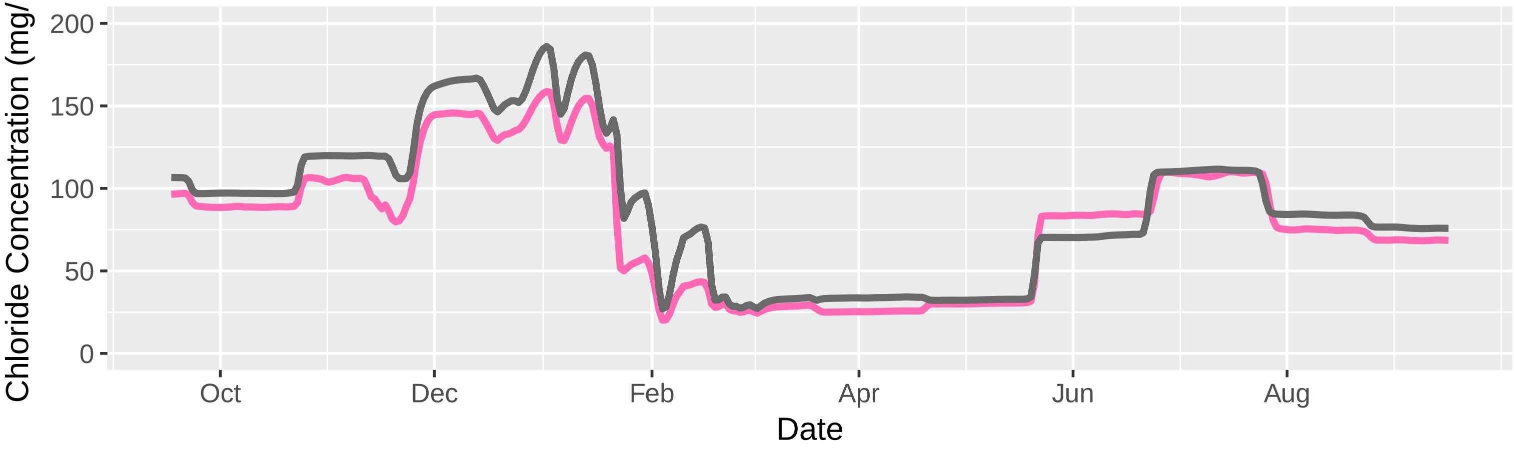
Chloride at Buckley Cove (Daily Mean); Year: 1984; Year Type: Wet



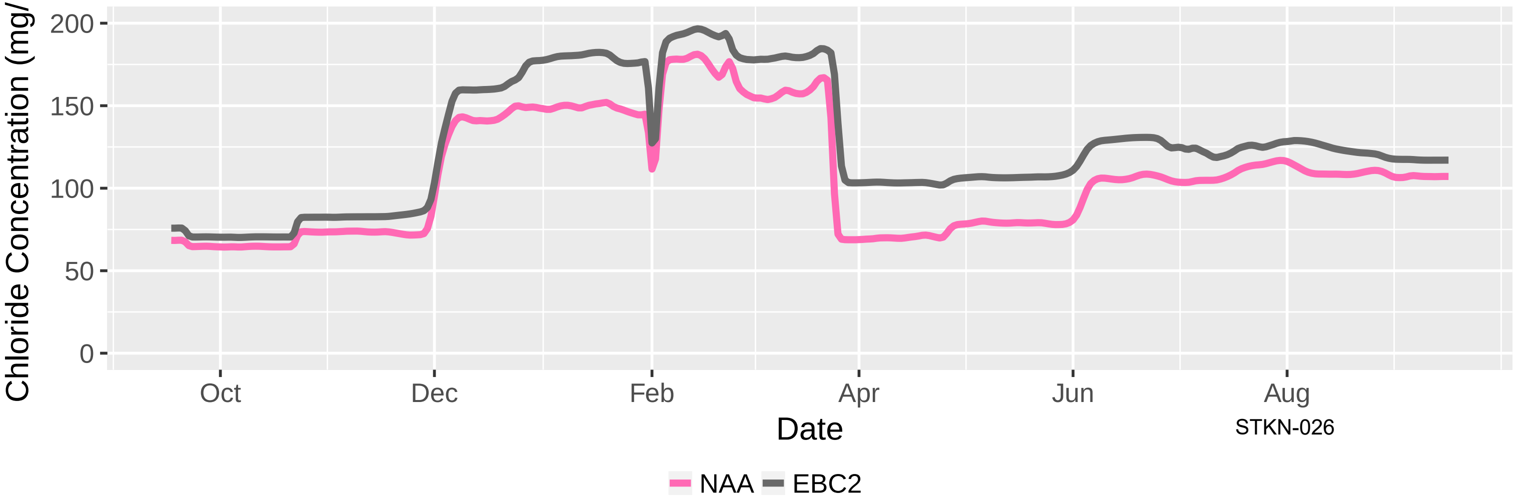
Chloride at Buckley Cove (Daily Mean); Year: 1985; Year Type: Dry



Chloride at Buckley Cove (Daily Mean); Year: 1986; Year Type: Wet



Chloride at Buckley Cove (Daily Mean); Year: 1987; Year Type: Dry



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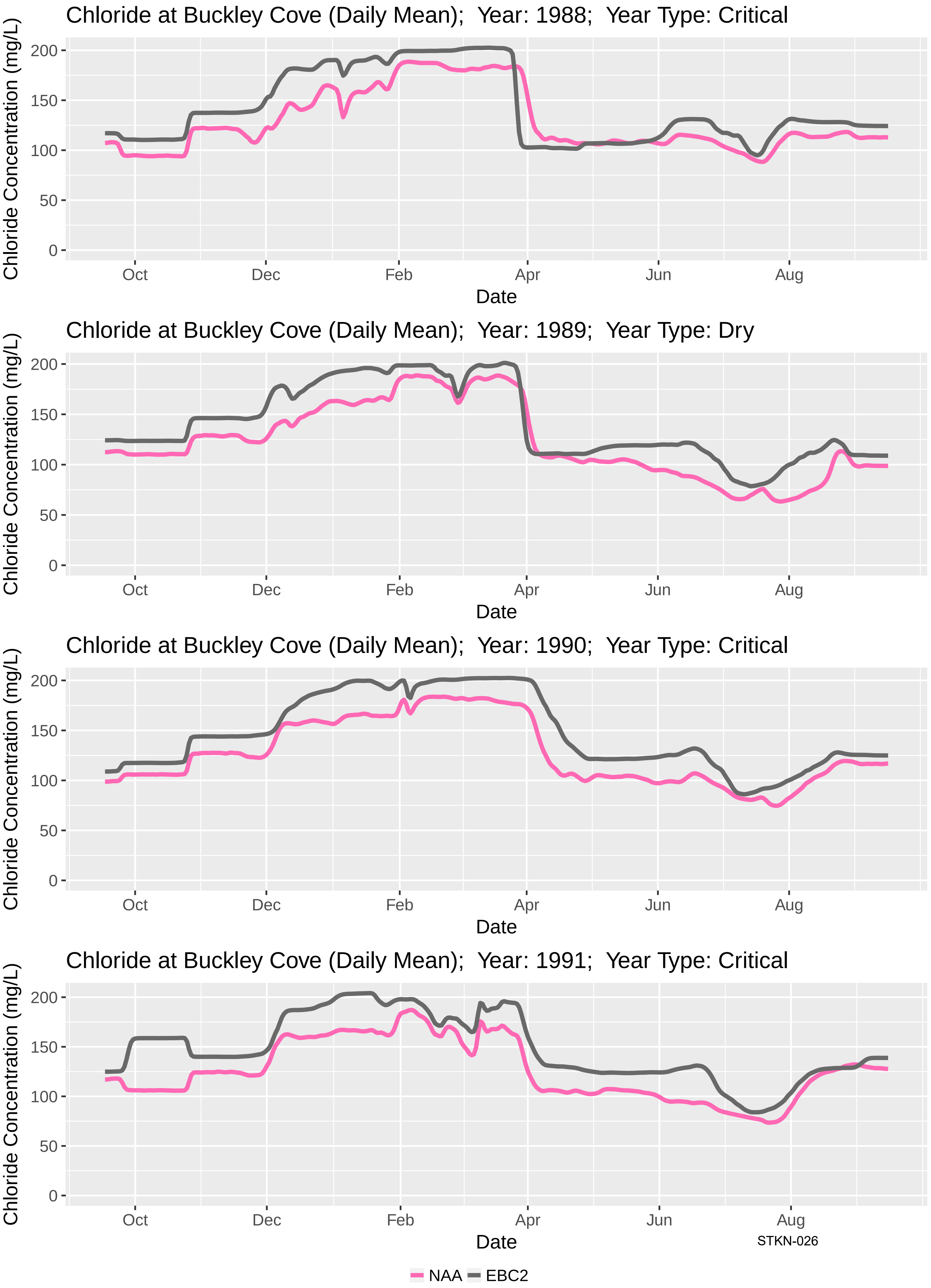
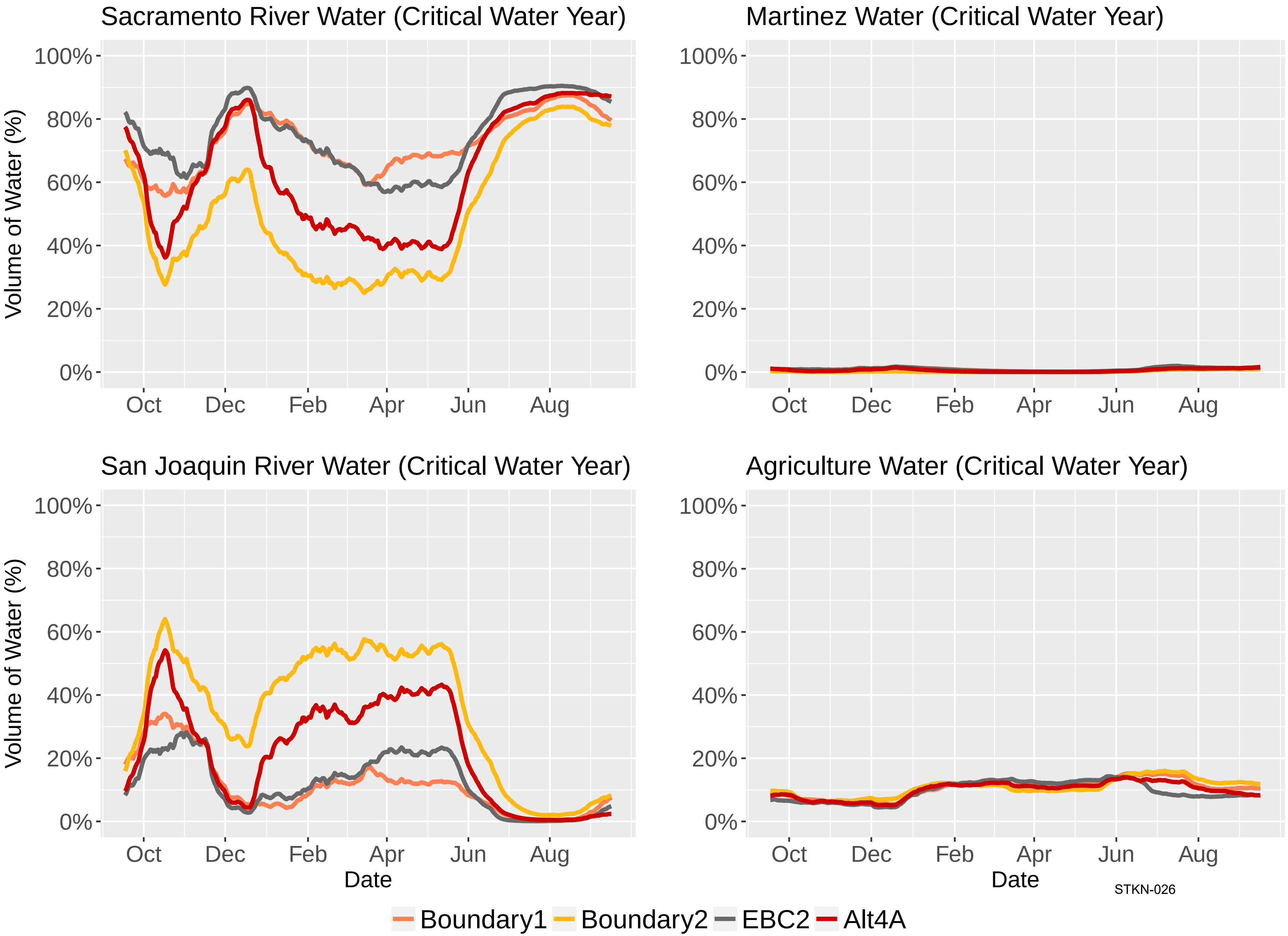

Chloride at Buckley Cove (Daily Mean); Year: 1988; Year Type: Critical
Chloride at Buckley Cove (Daily Mean); Year: 1989; Year Type: Dry
Chloride at Buckley Cove (Daily Mean); Year: 1990; Year Type: Critical
Chloride at Buckley Cove (Daily Mean); Year: 1991; Year Type: Critical
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2

Appendix D

Water source fingerprints under Boundary 1, Boundary 2, and Alternative 4A

Source-water fingerprints at Stockton's Intake


Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A

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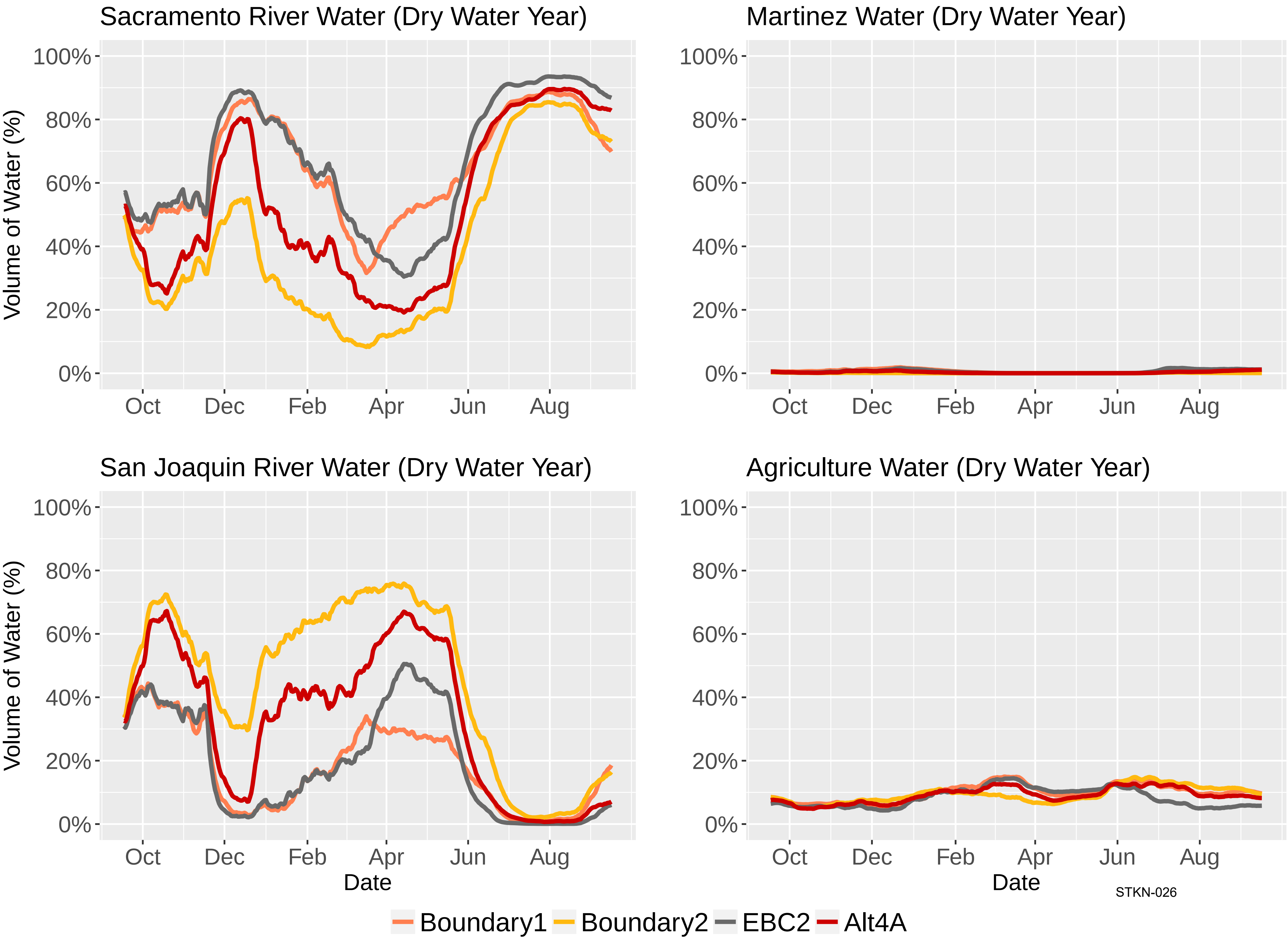
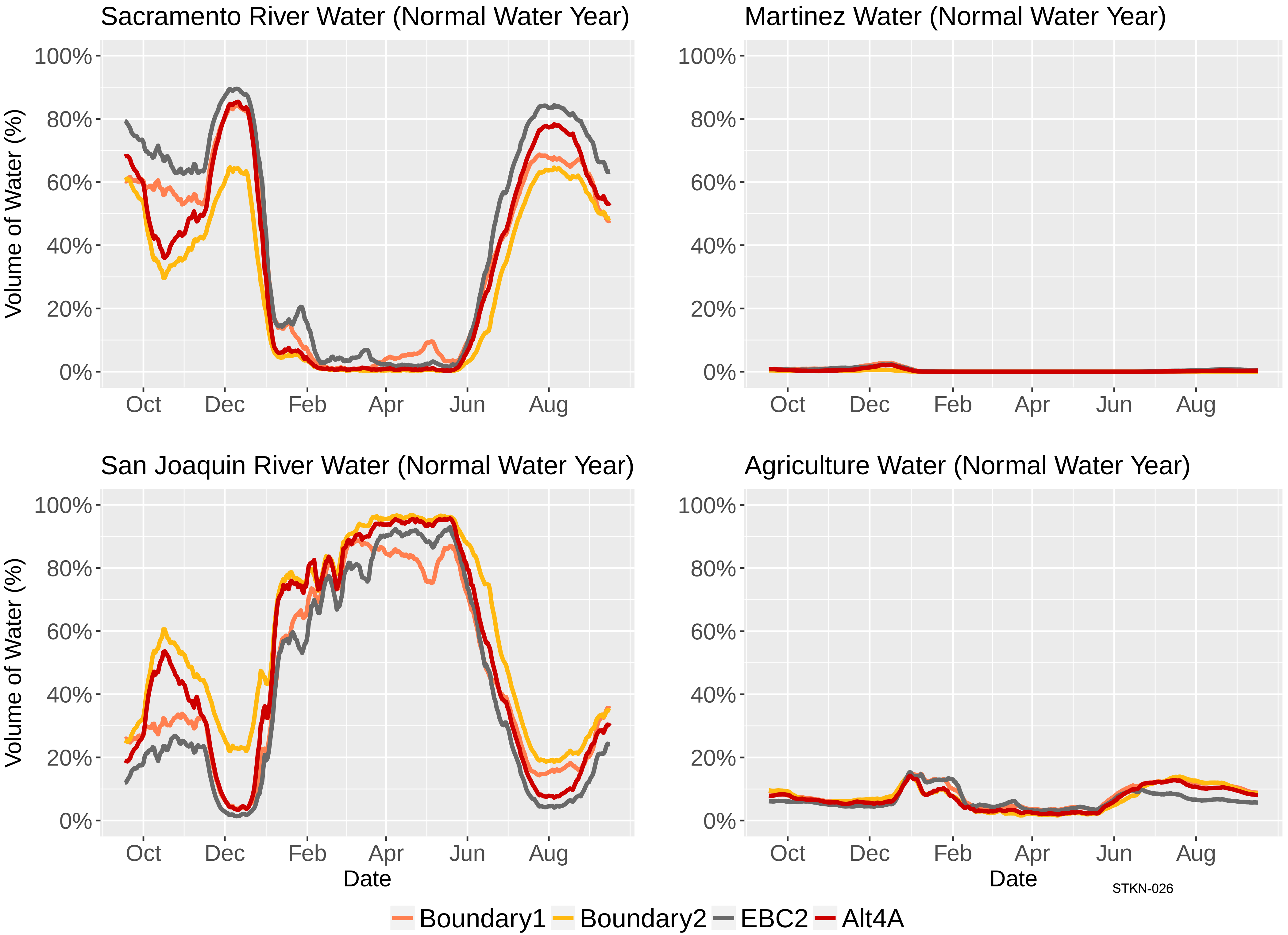

Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A



Sacramento River Water (Normal Water Year)

Martinez Water (Normal Water Year)

San Joaquin River Water (Normal Water Year)

Agriculture Water (Normal Water Year)

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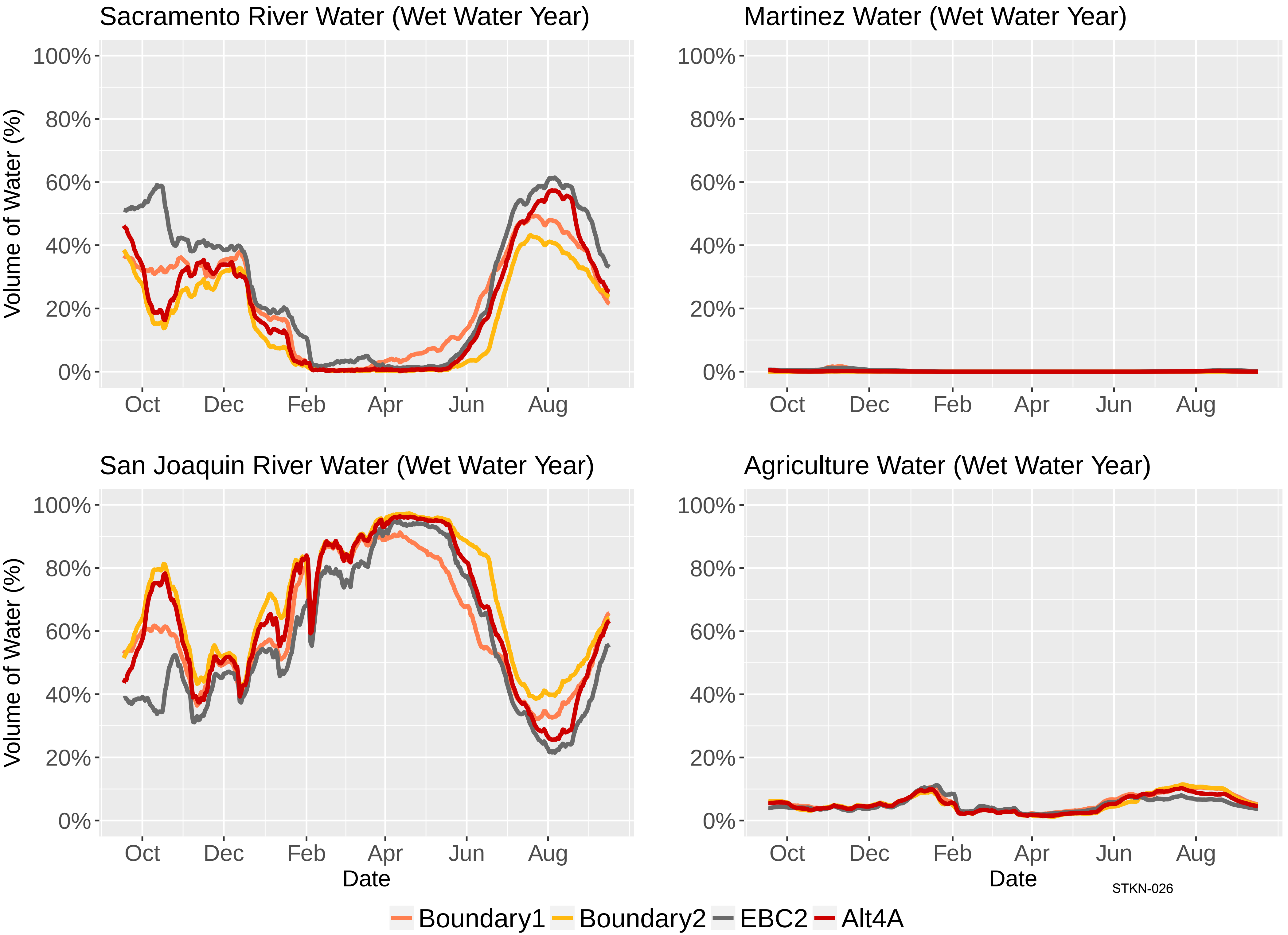
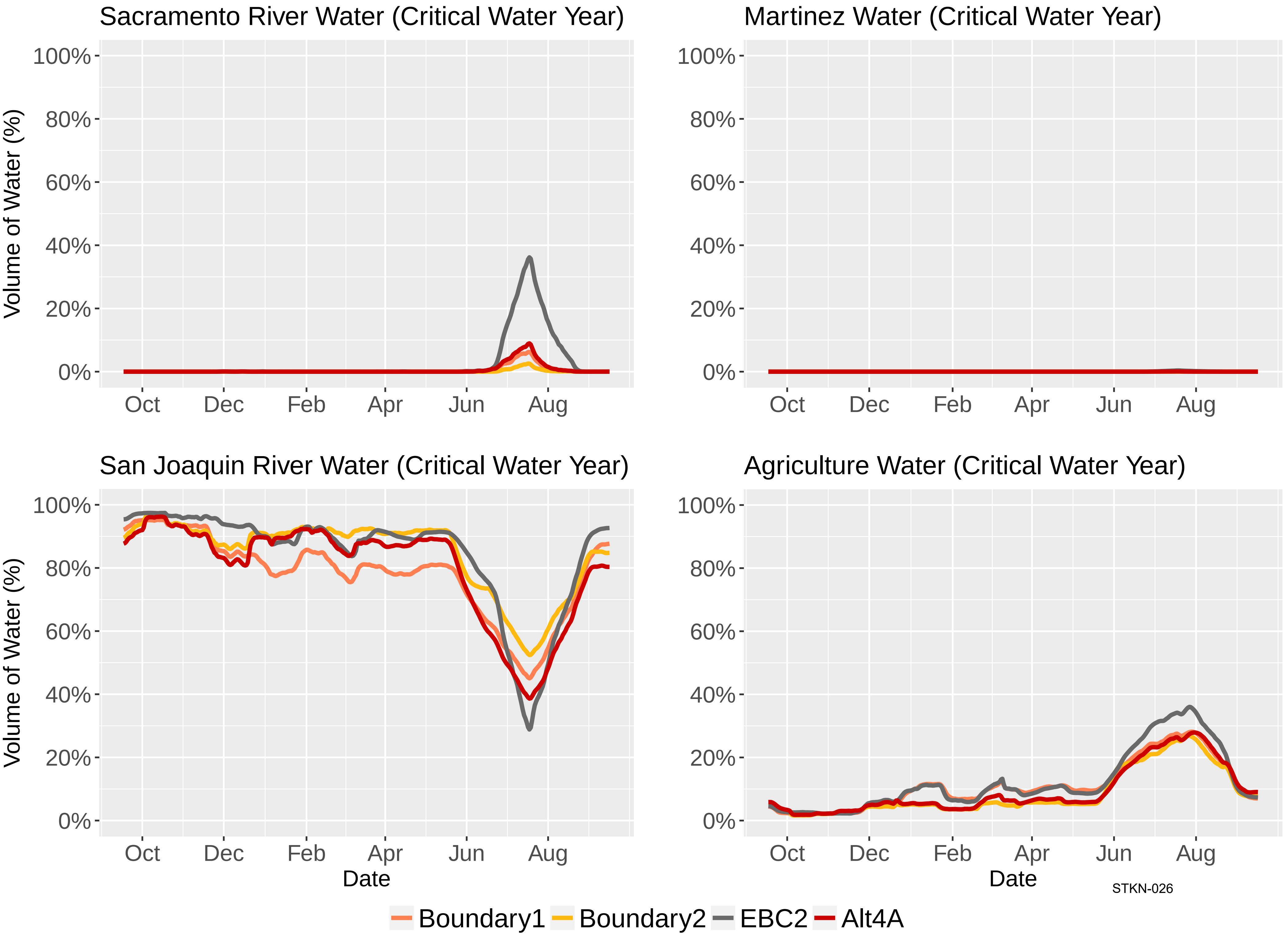

Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A

STKN-026

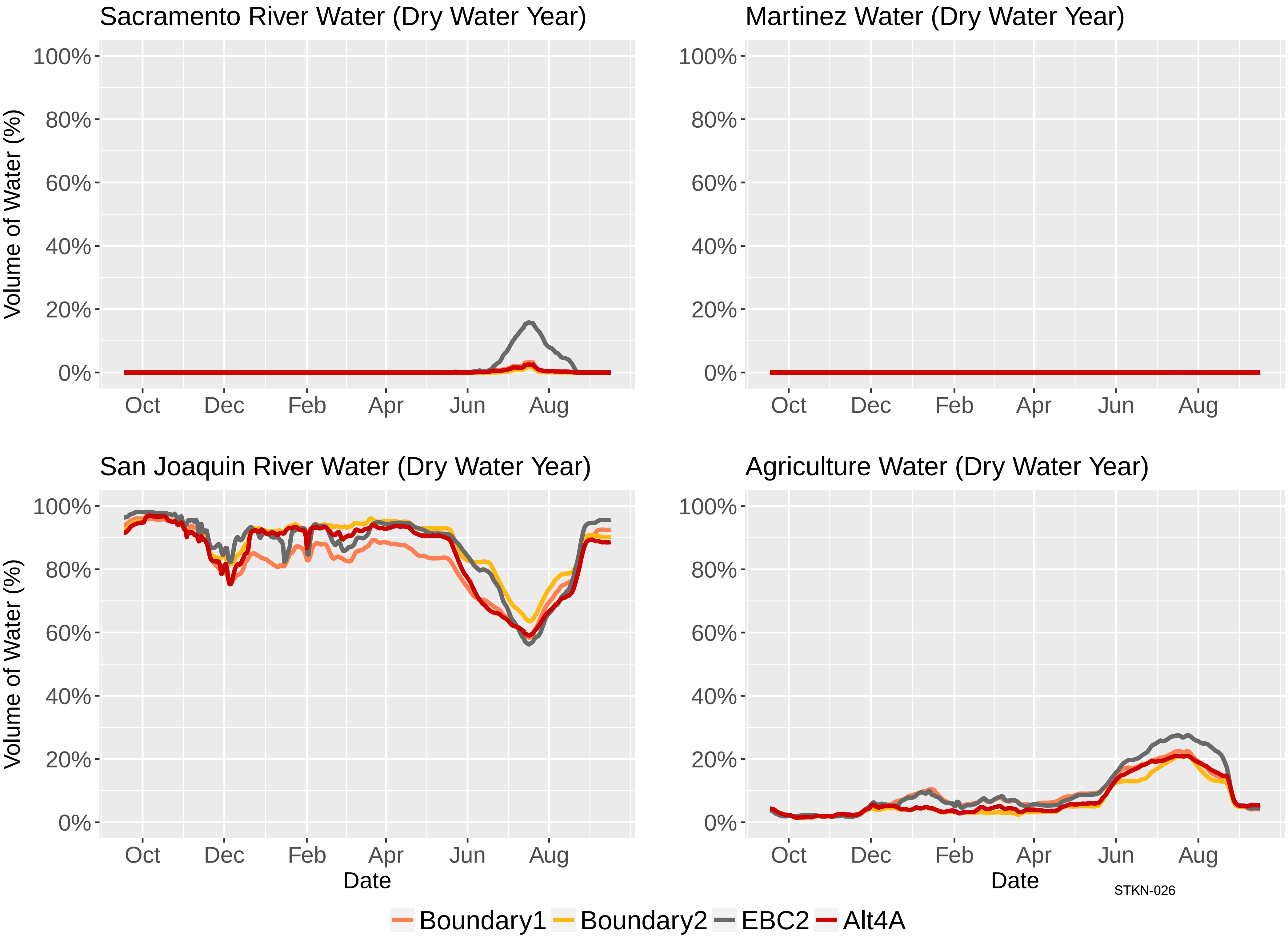
Source-water fingerprints at Buckley Cove

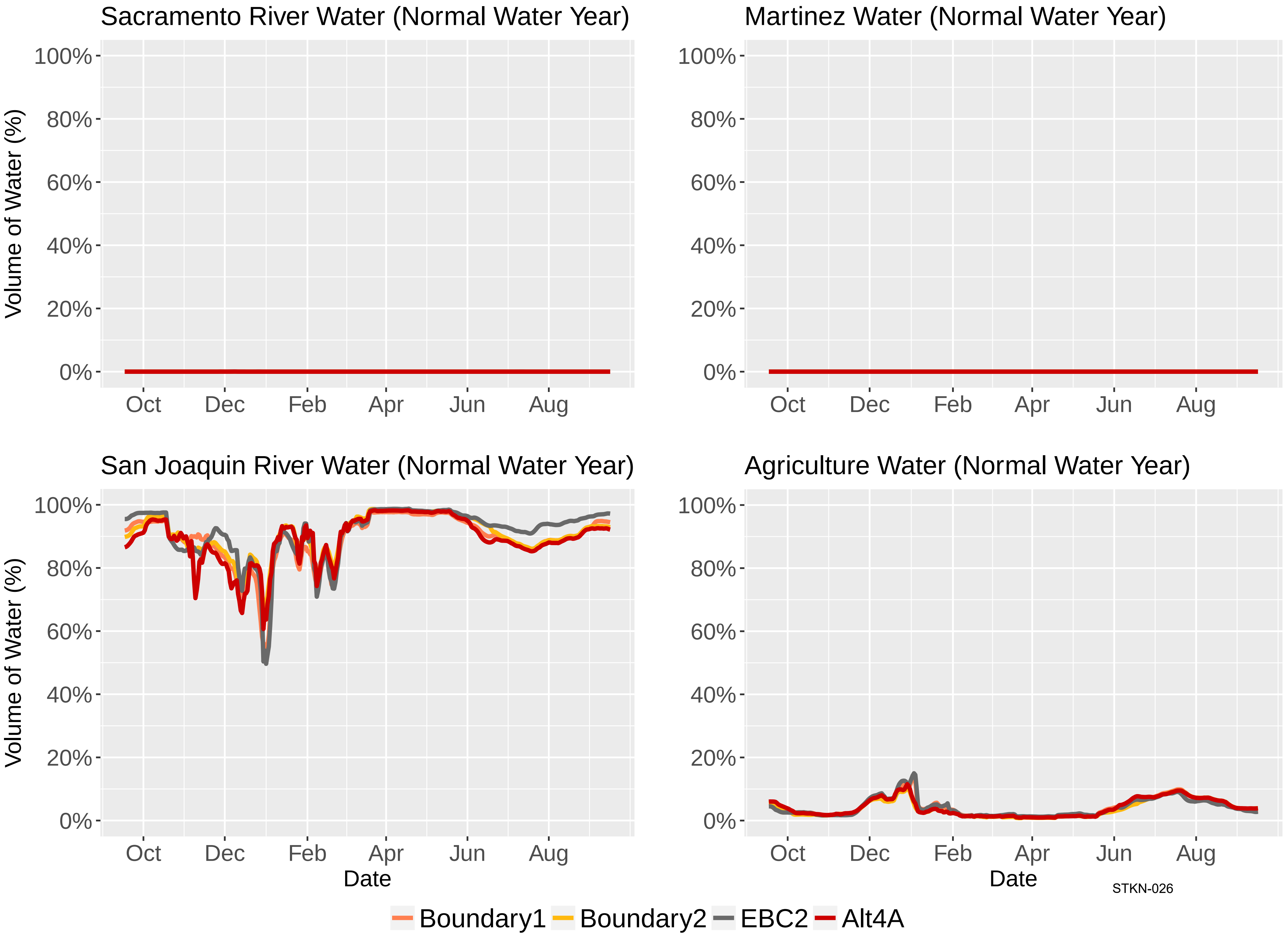

Sacramento River Water (Critical Water Year)

Martinez Water (Critical Water Year)

San Joaquin River Water (Critical Water Year)

Agriculture Water (Critical Water Year)


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A


Sacramento River Water (Normal Water Year)
Martinez Water (Normal Water Year)
San Joaquin River Water (Normal Water Year)
Agriculture Water (Normal Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A

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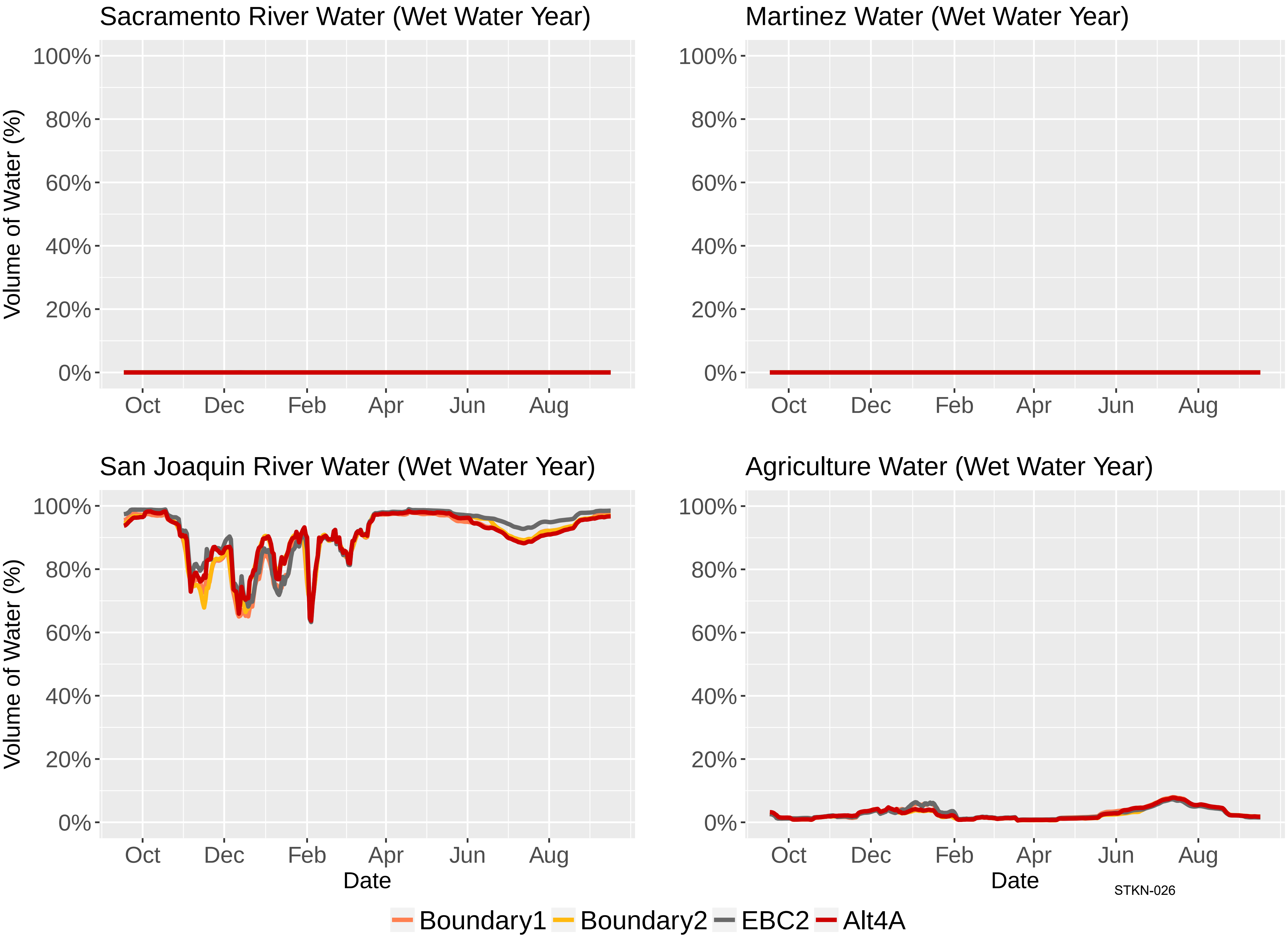
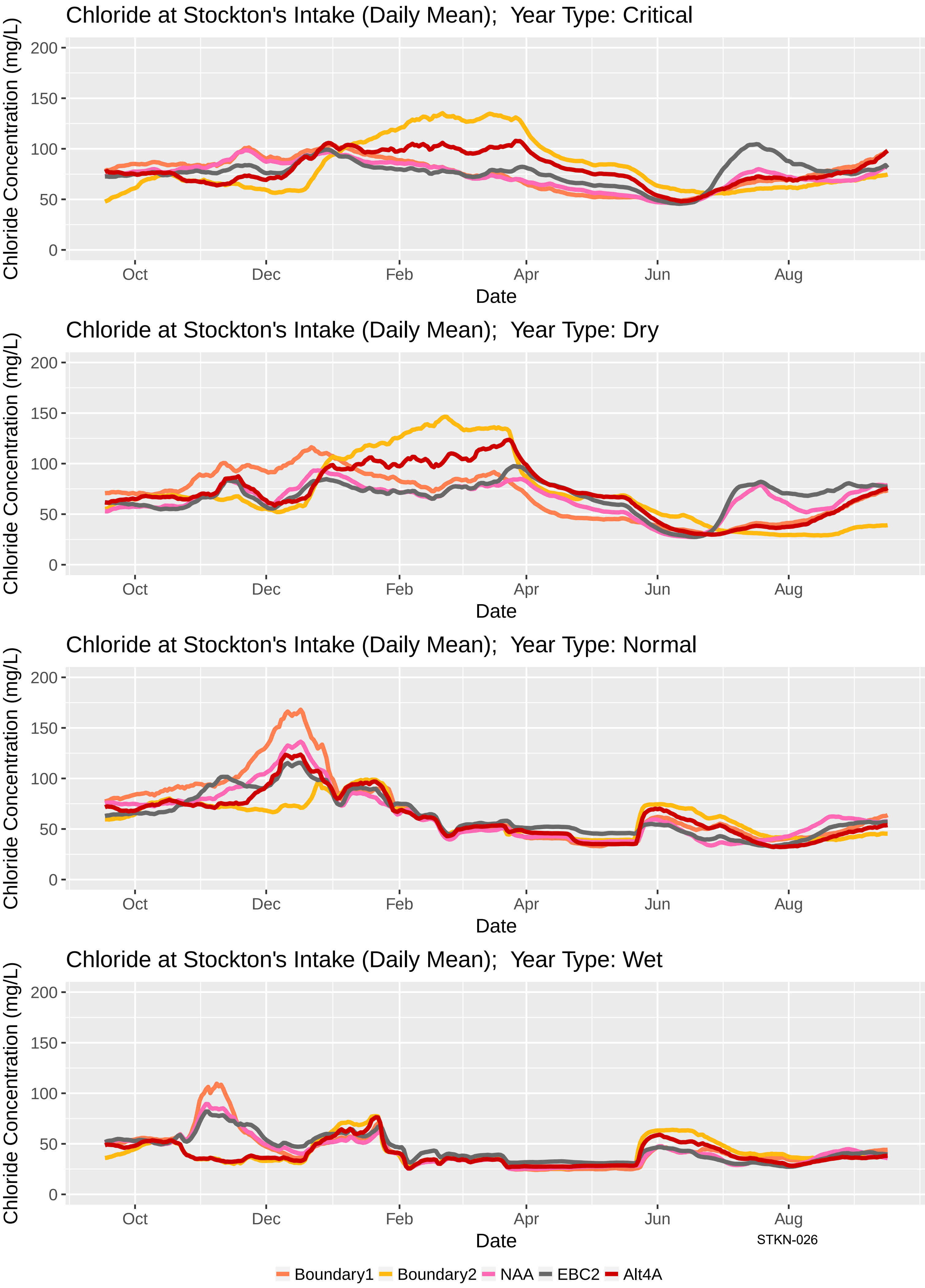

Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A

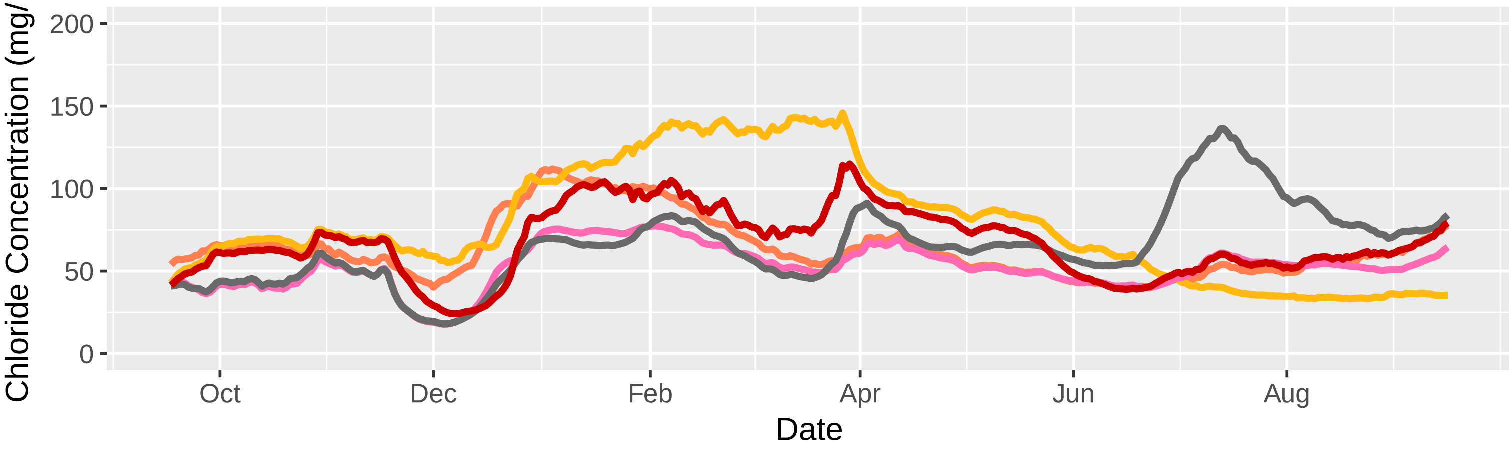
STKN-026

Appendix E

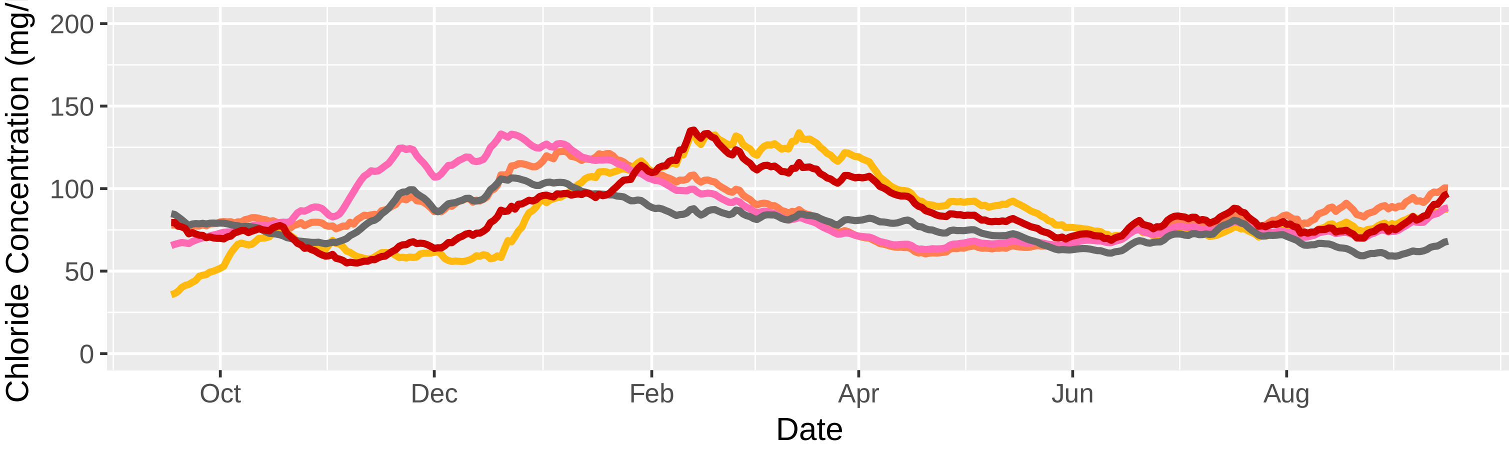
Chloride concentrations under Boundary 1, Boundary 2, and Alternative 4A


Chloride at Stockton's Intake (Daily Mean); Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year Type: Normal
Chloride at Stockton's Intake (Daily Mean); Year Type: Wet
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
Boundary1
Boundary2
NAA
EBC2
Alt4A

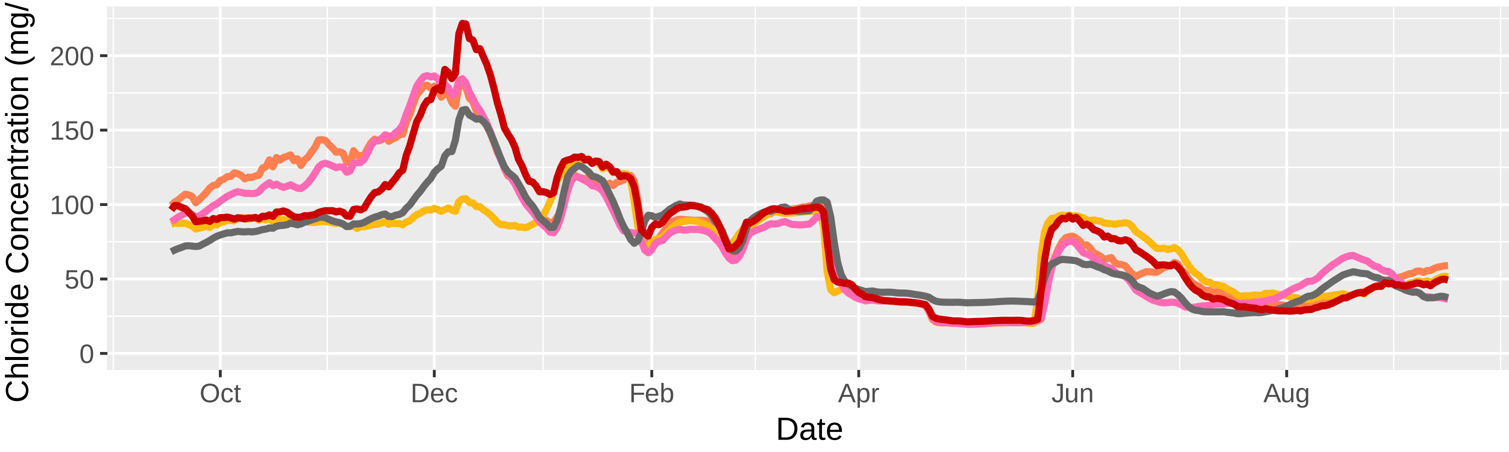
Chloride at Stockton's Intake (Daily Mean); Year: 1976; Year Type: Critical



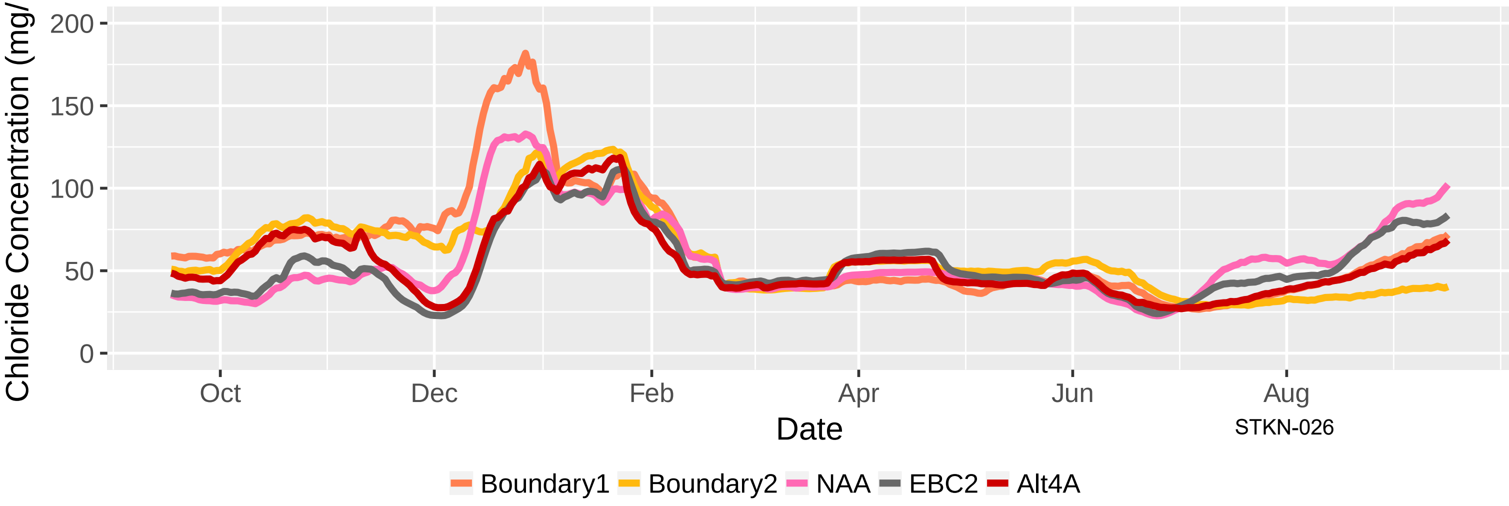
Chloride at Stockton's Intake (Daily Mean); Year: 1977; Year Type: Critical

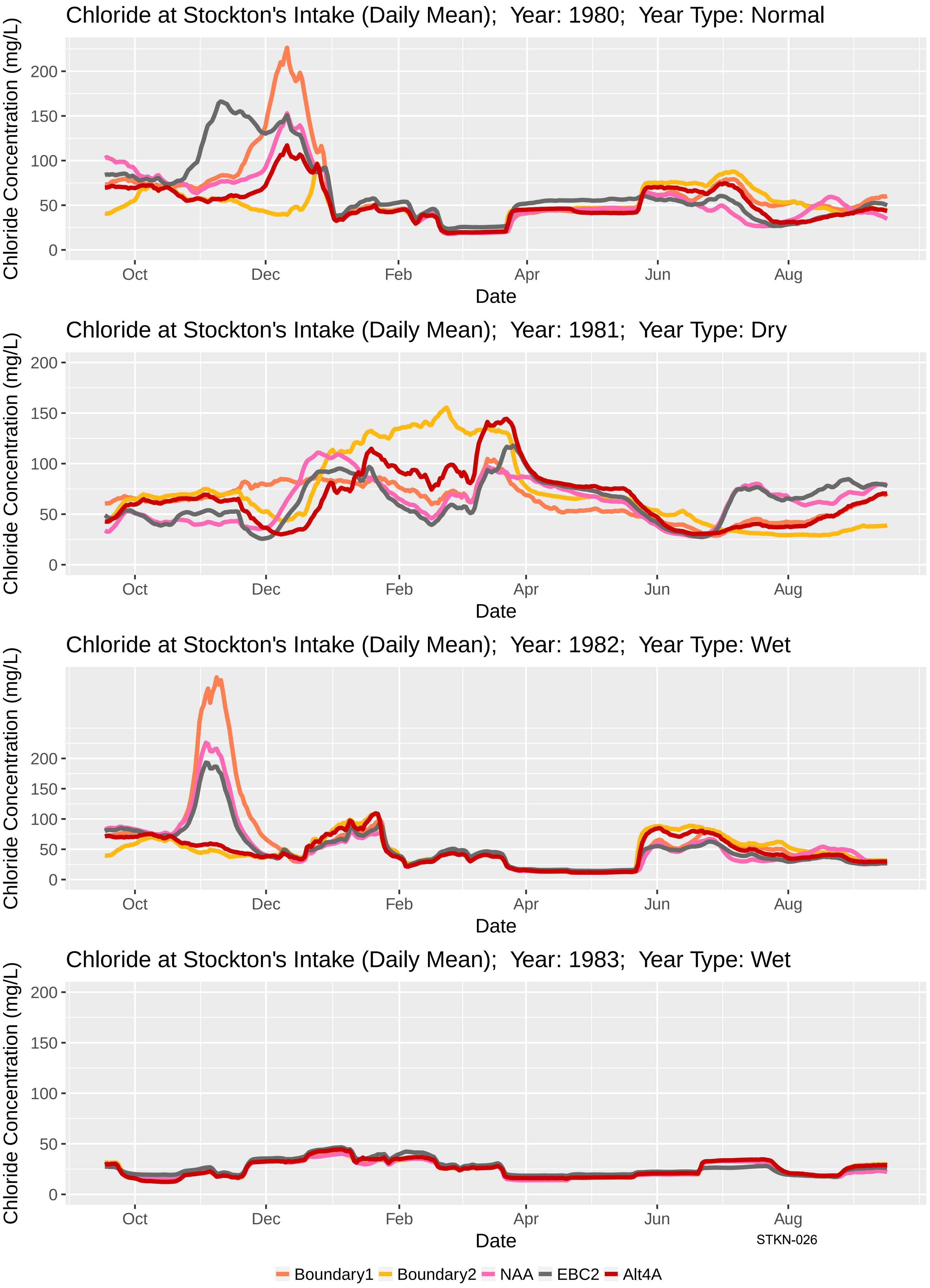


Chloride at Stockton's Intake (Daily Mean); Year: 1978; Year Type: Normal



Chloride at Stockton's Intake (Daily Mean); Year: 1979; Year Type: Normal




Chloride at Stockton's Intake (Daily Mean); Year: 1980; Year Type: Normal

Chloride at Stockton's Intake (Daily Mean); Year: 1981; Year Type: Dry

Chloride at Stockton's Intake (Daily Mean); Year: 1982; Year Type: Wet

Chloride at Stockton's Intake (Daily Mean); Year: 1983; Year Type: Wet

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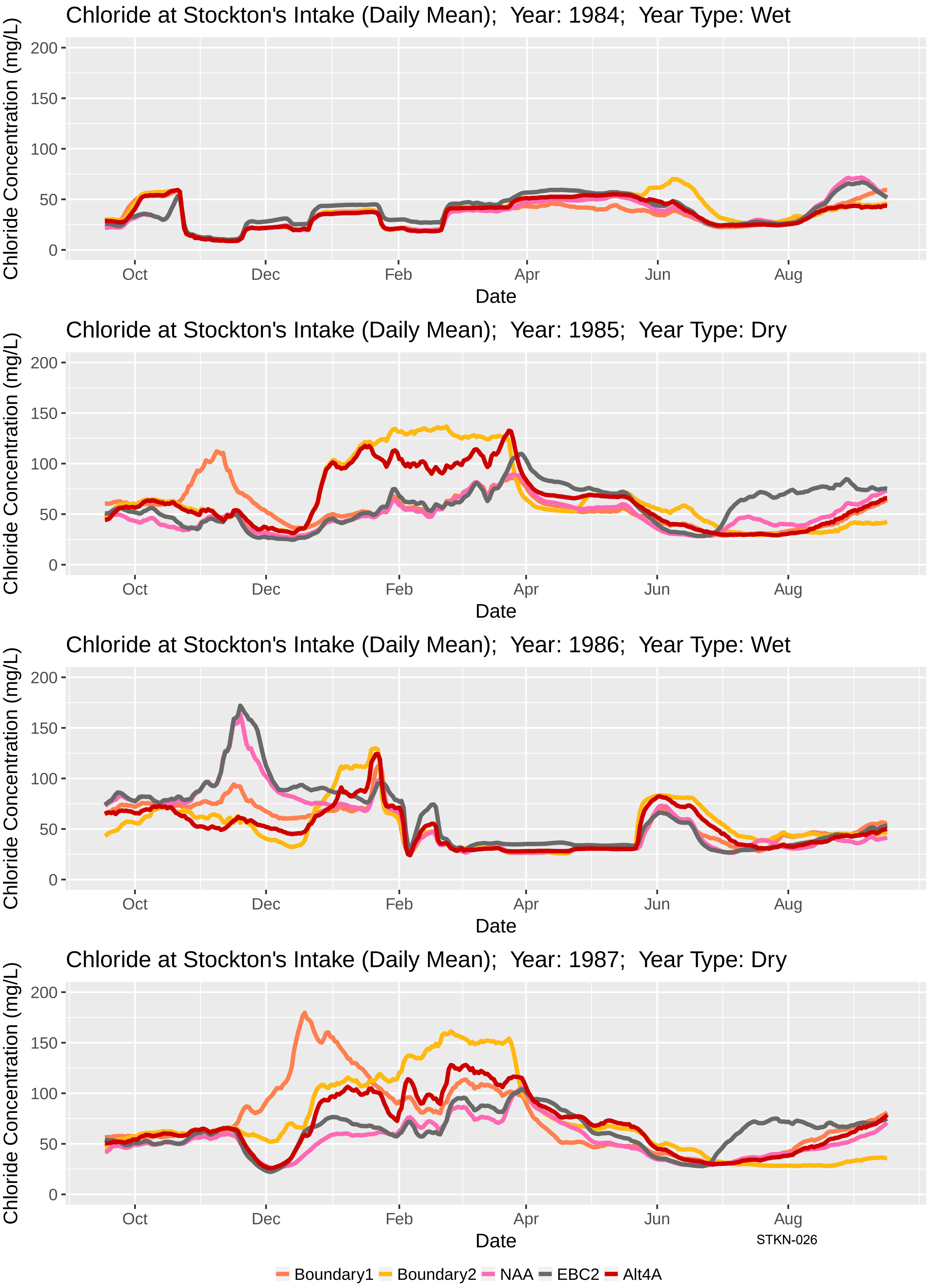
Chloride at Stockton's Intake (Daily Mean); Year: 1984; Year Type: Wet

Chloride at Stockton's Intake (Daily Mean); Year: 1985; Year Type: Dry

Chloride at Stockton's Intake (Daily Mean); Year: 1986; Year Type: Wet

Chloride at Stockton's Intake (Daily Mean); Year: 1987; Year Type: Dry

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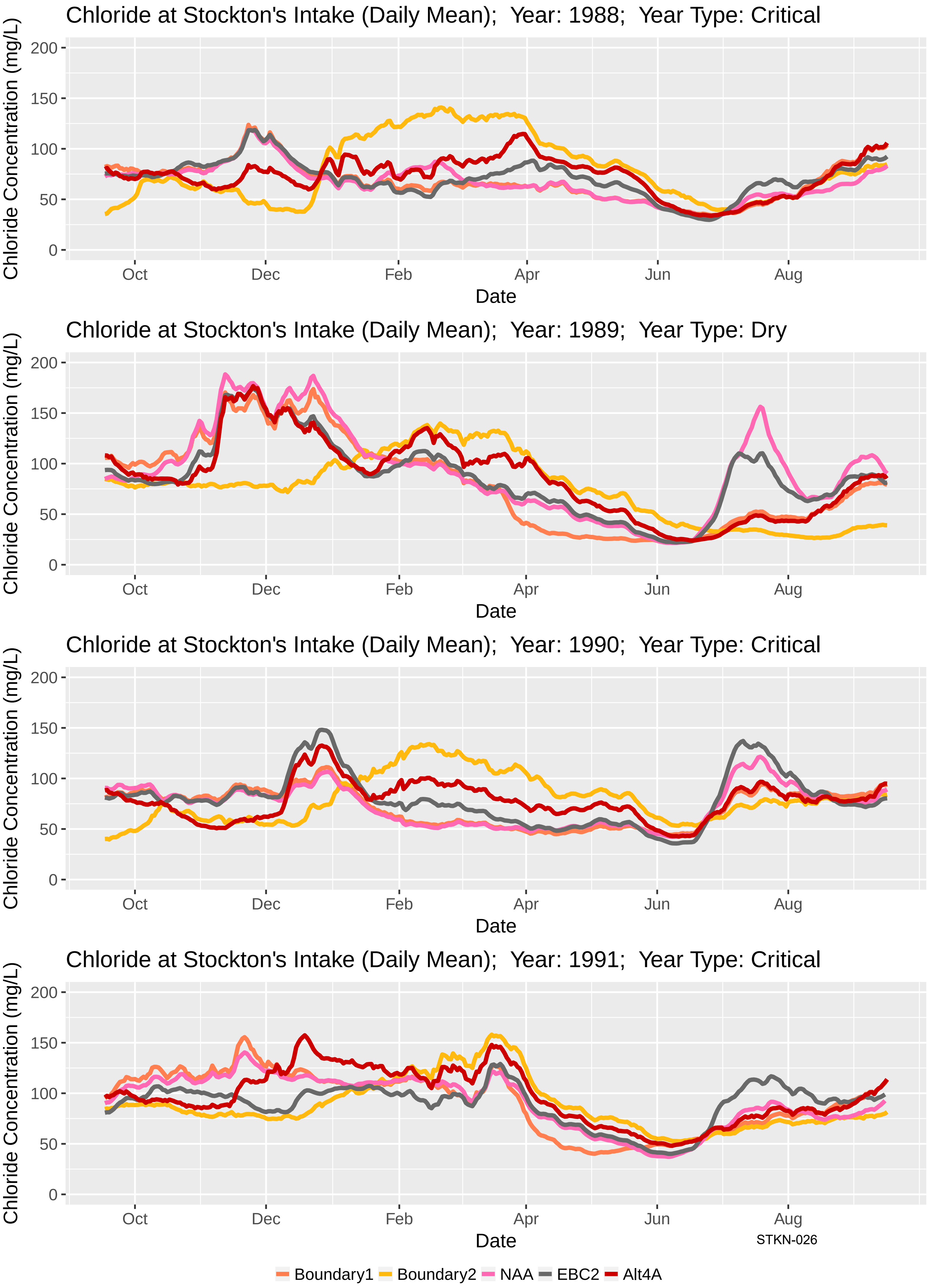
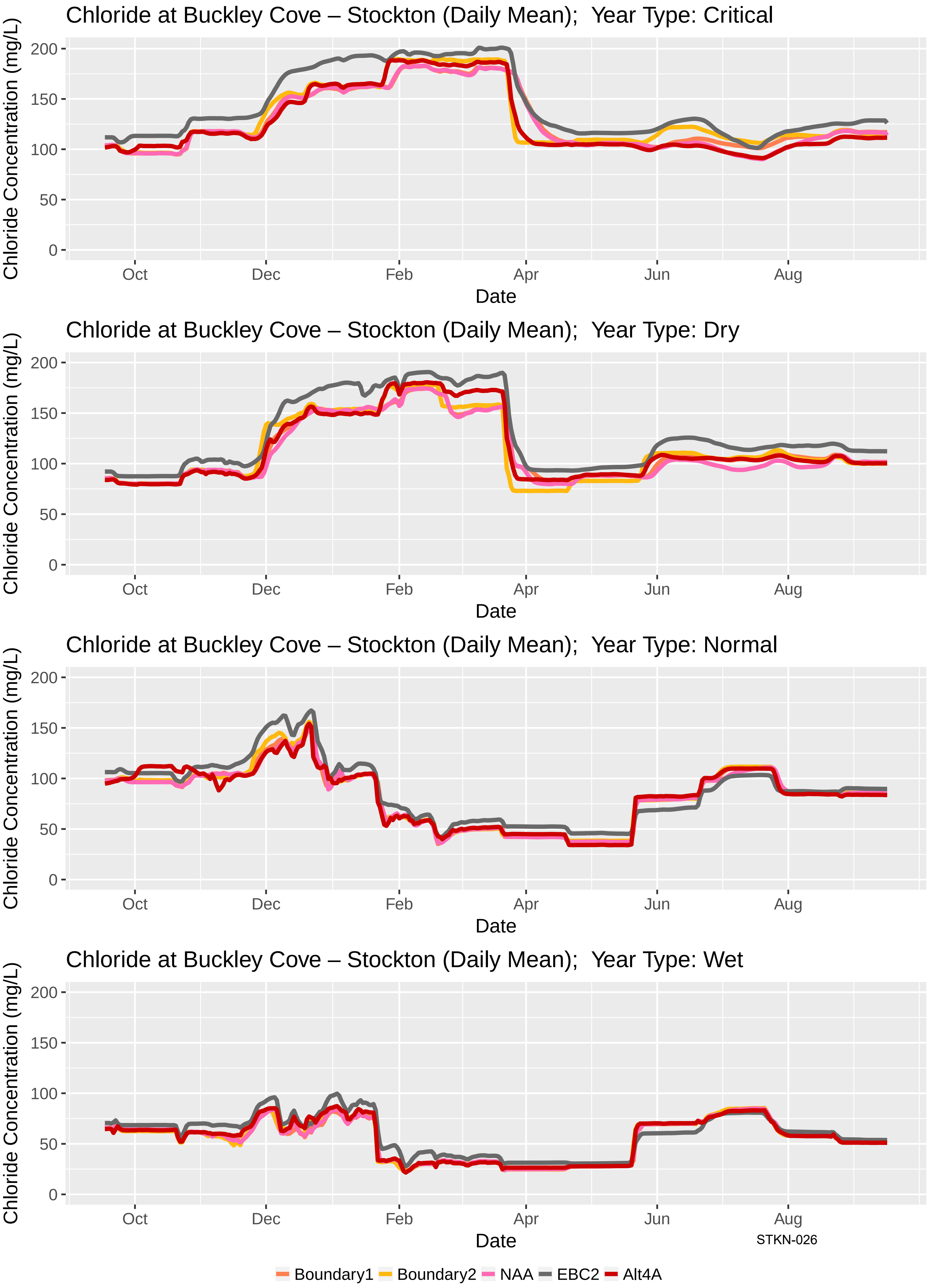
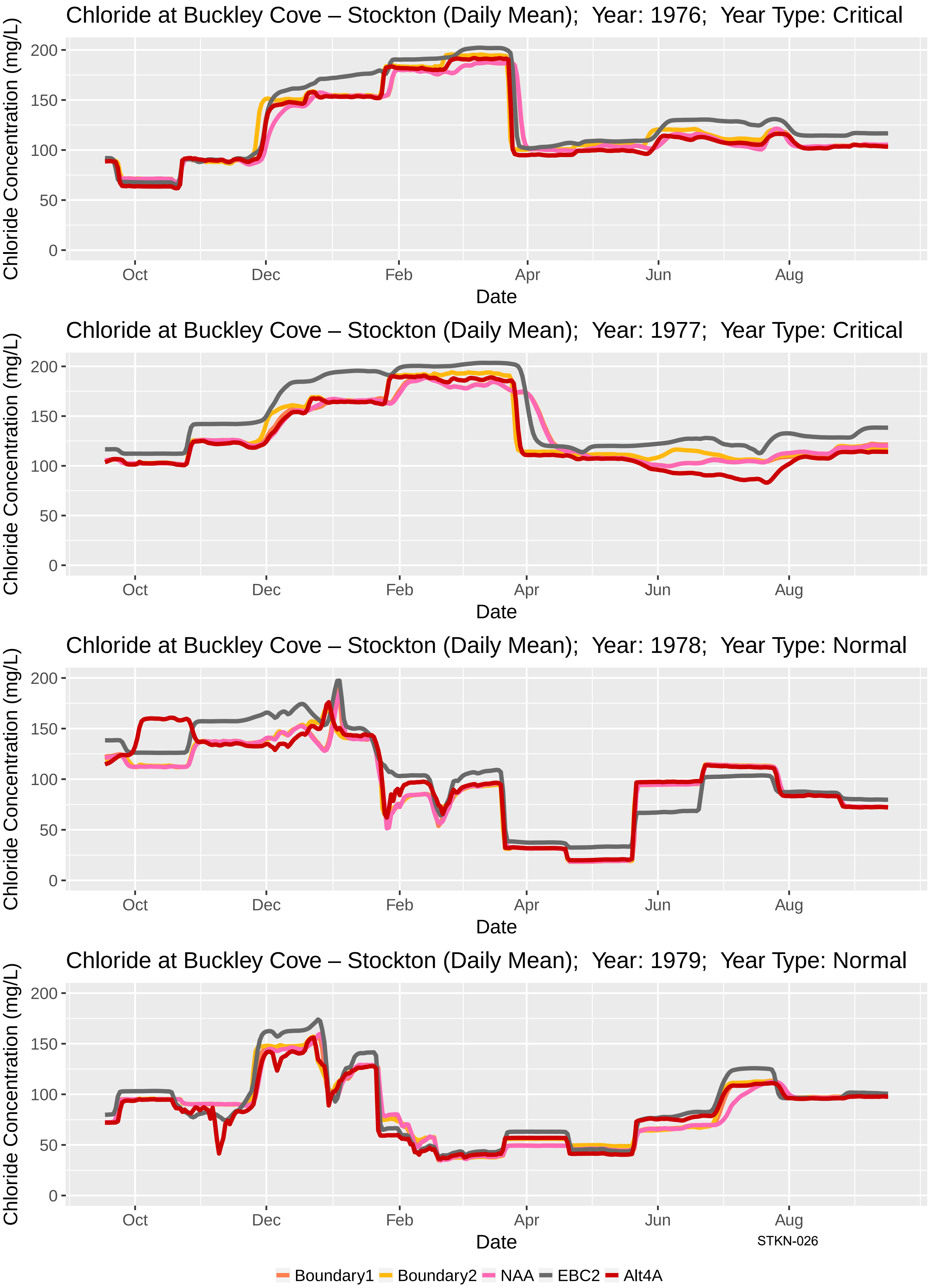

Chloride at Stockton's Intake (Daily Mean); Year: 1988; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1989; Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year: 1990; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1991; Year Type: Critical
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
Boundary1
Boundary2
NAA
EBC2
Alt4A

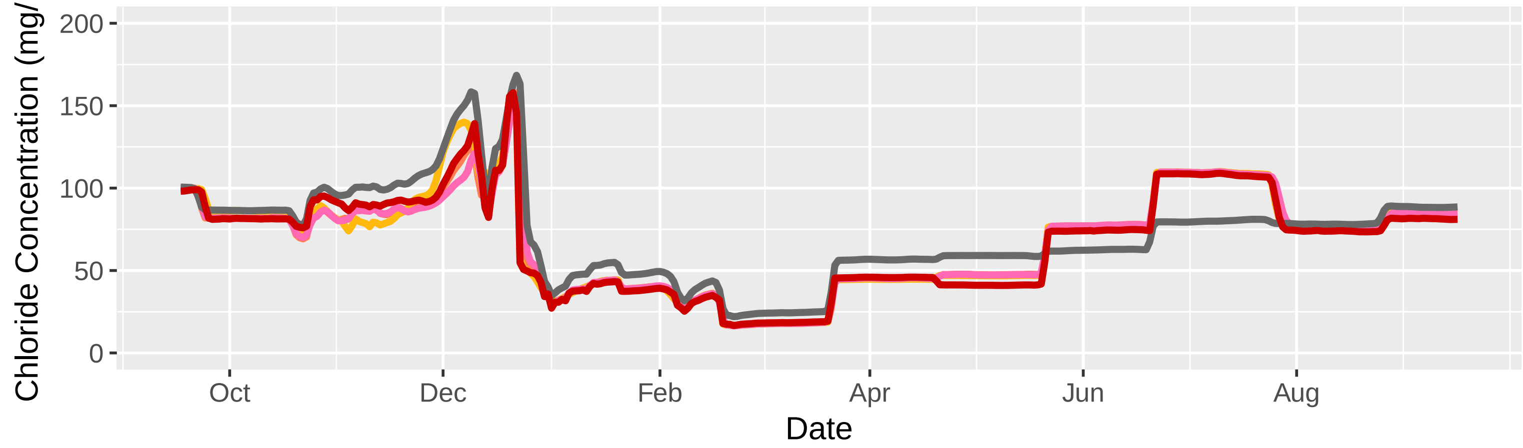

Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Critical
Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Dry
Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Normal
Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Wet
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
NAA
EBC2
Alt4A

STKN-026

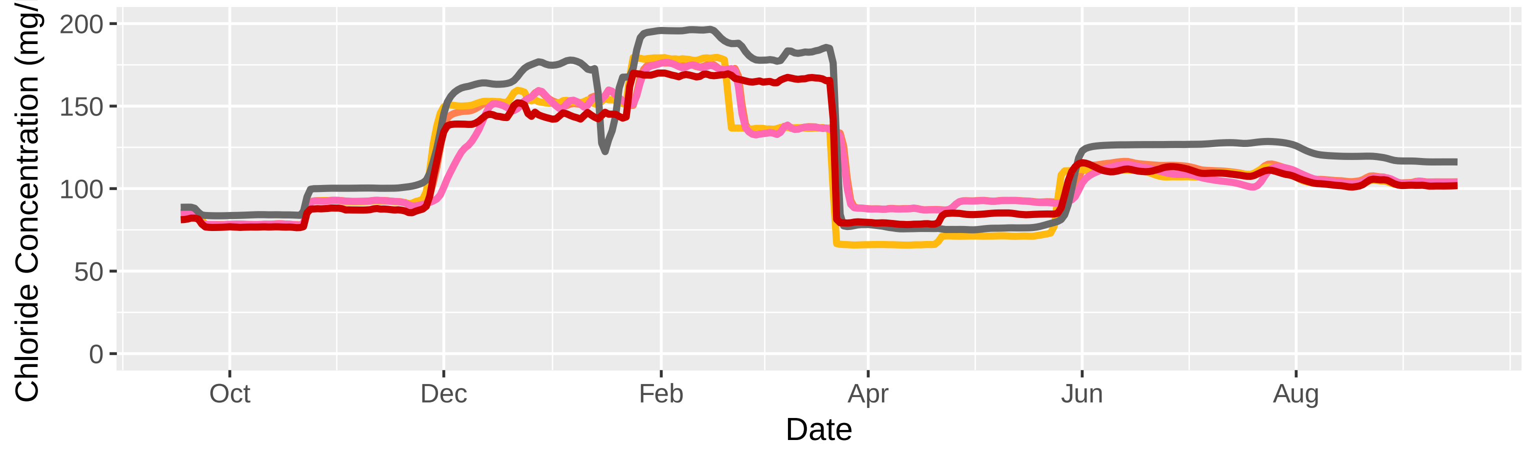

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1976; Year Type: Critical
Chloride Concentration (mg/L)
200
150
100
50
0
Oct
Dec
Feb
Apr
Jun
Aug
Date
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1977; Year Type: Critical
Chloride Concentration (mg/L)
200
150
100
50
0
Oct
Dec
Feb
Apr
Jun
Aug
Date
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1978; Year Type: Normal
Chloride Concentration (mg/L)
200
150
100
50
0
Oct
Dec
Feb
Apr
Jun
Aug
Date
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1979; Year Type: Normal
Chloride Concentration (mg/L)
200
150
100
50
0
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
NAA
EBC2
Alt4A

STKN-026

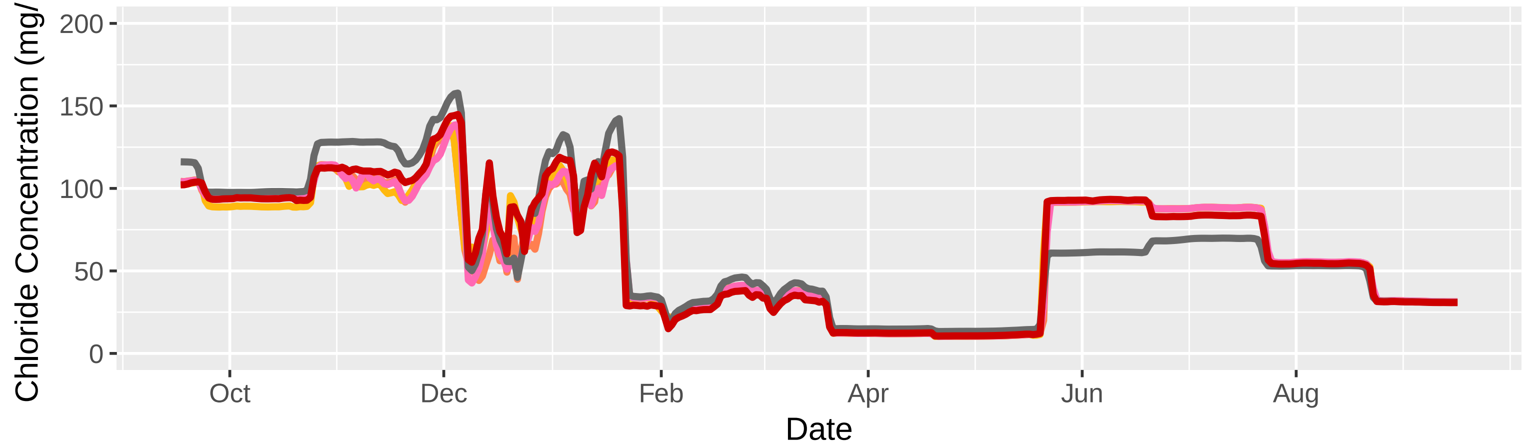
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1980; Year Type: Normal



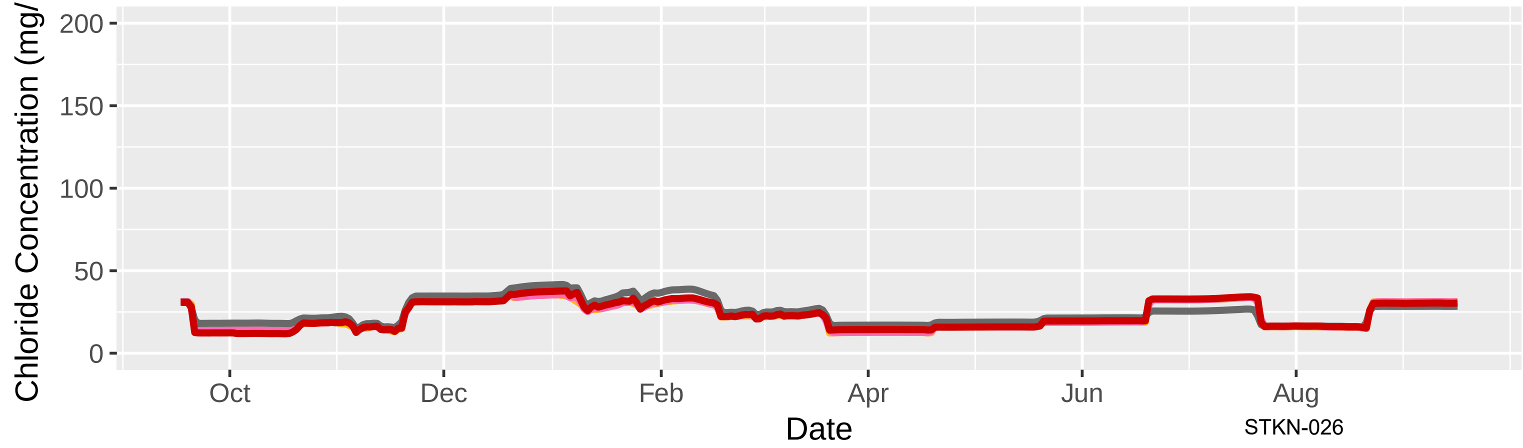
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1981; Year Type: Dry



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1982; Year Type: Wet



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1983; Year Type: Wet



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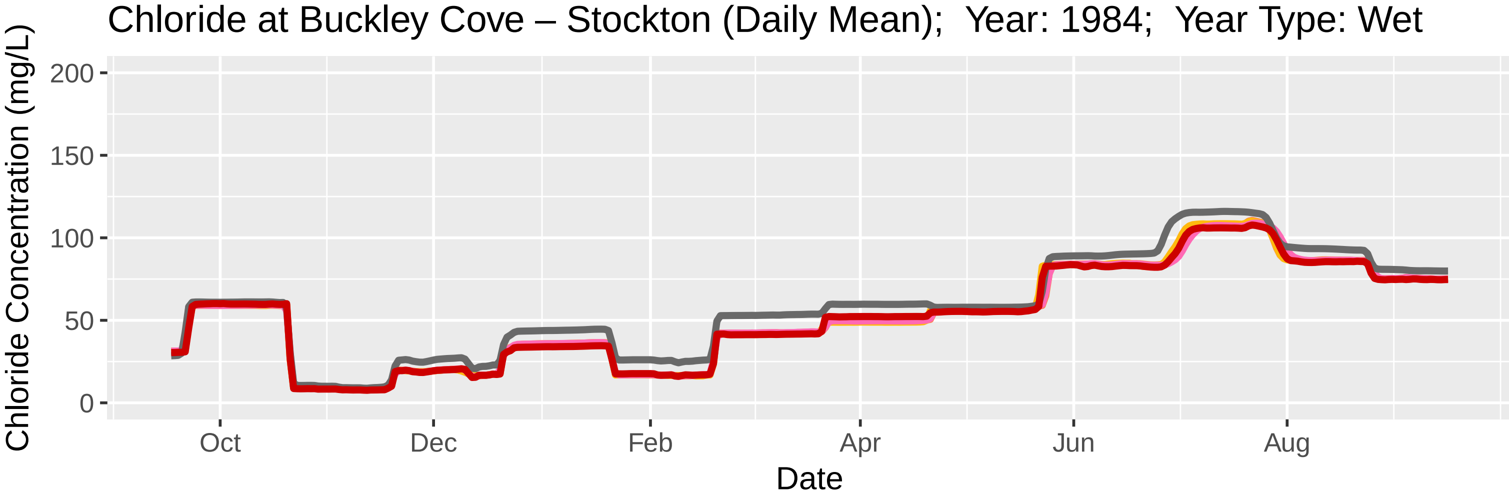
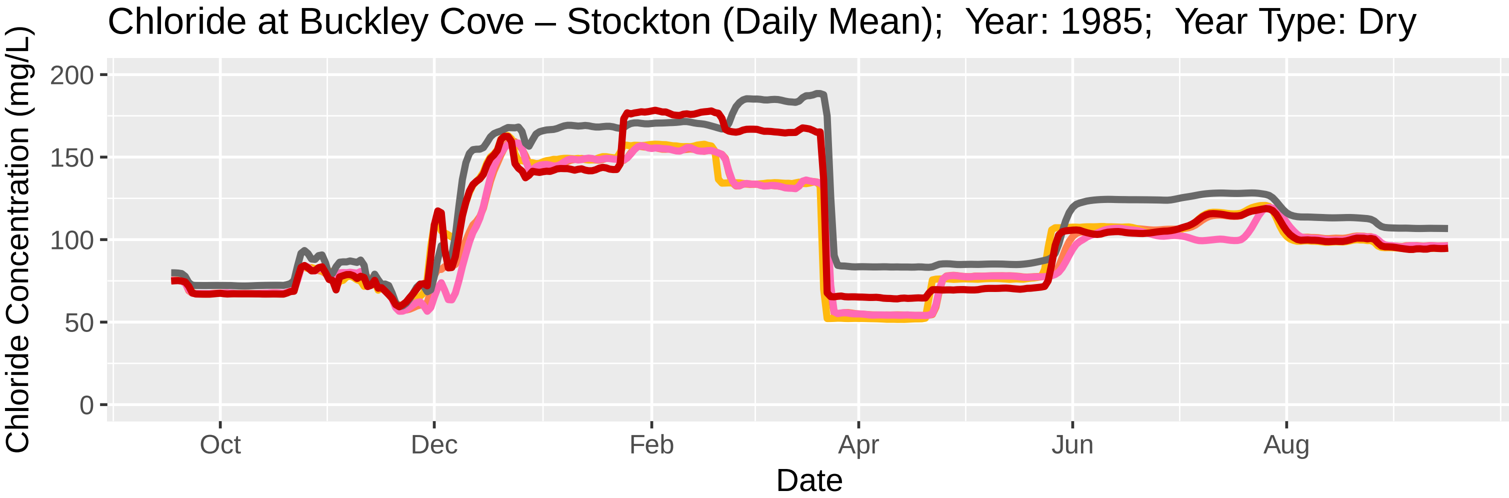
🟧 Boundary1 🟨 Boundary2 🟪 NAA ⬛ EBC2 🟥 Alt4A



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1984; Year Type: Wet



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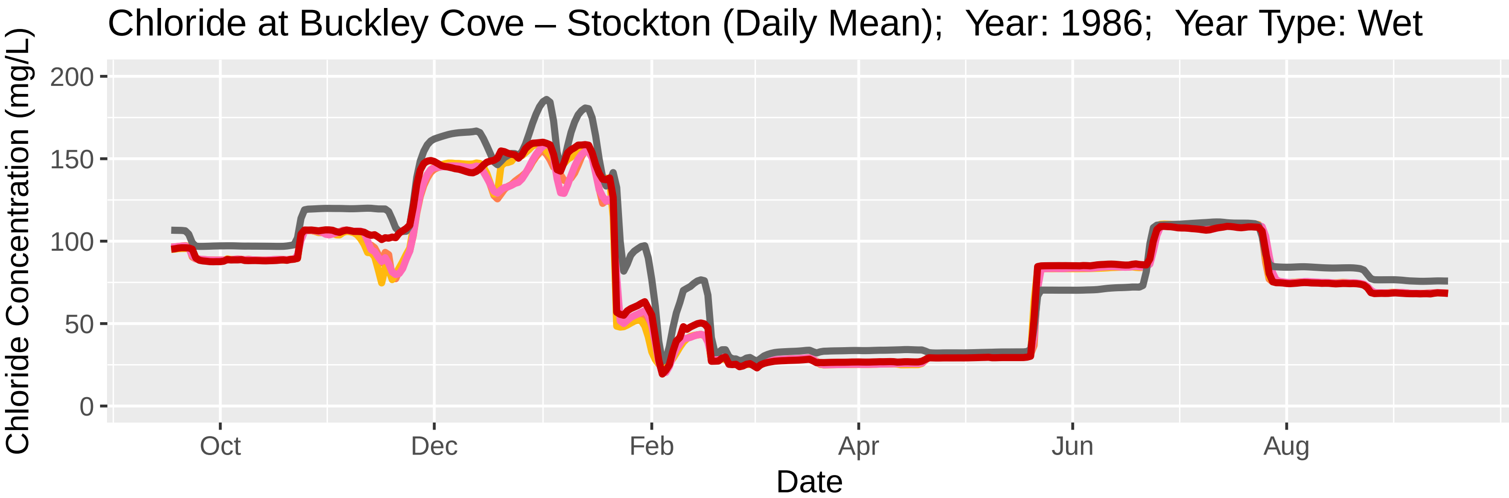

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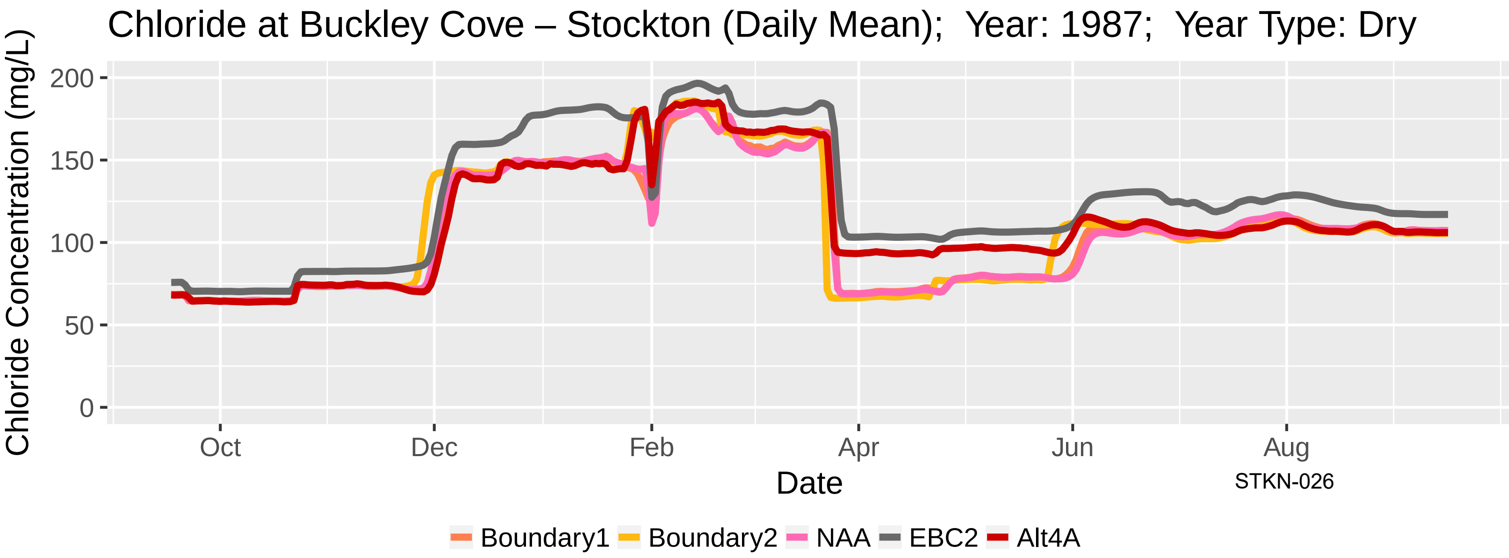

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1987; Year Type: Dry

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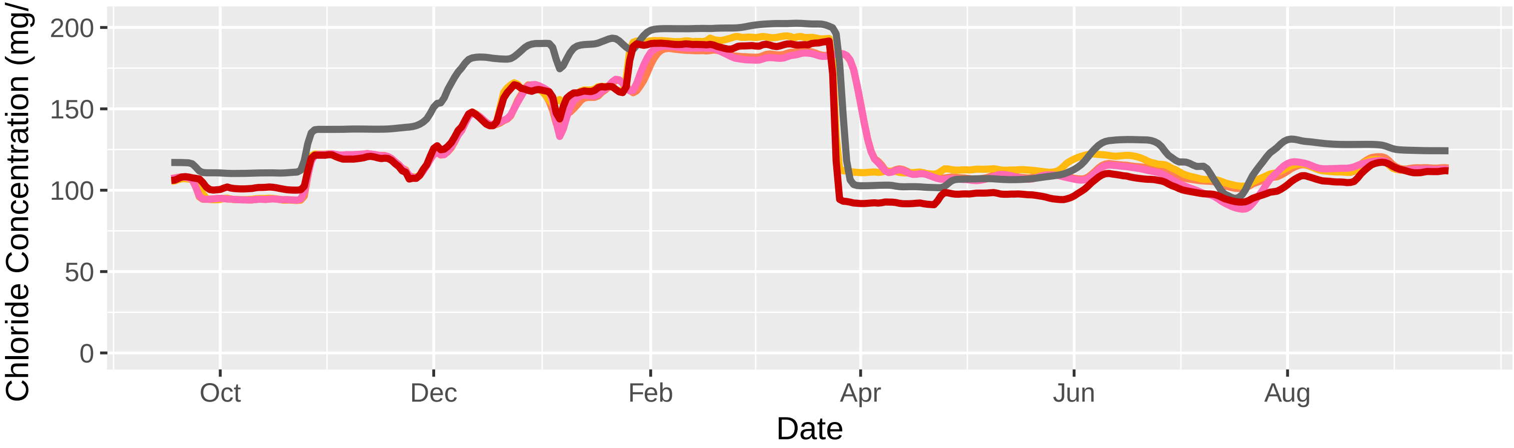
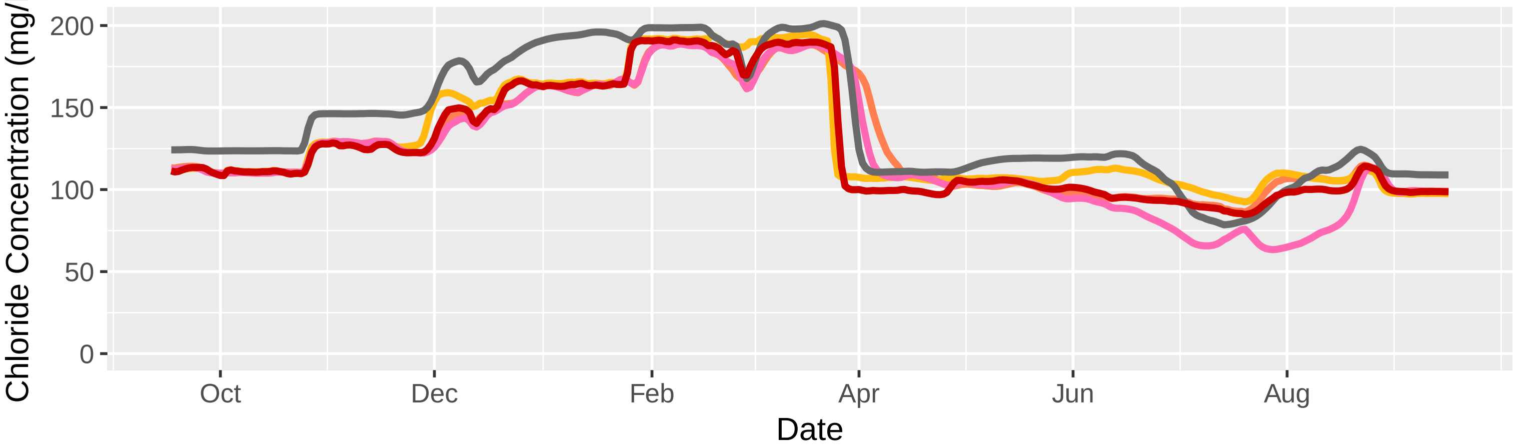
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1988; Year Type: Critical



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1989; Year Type: Dry



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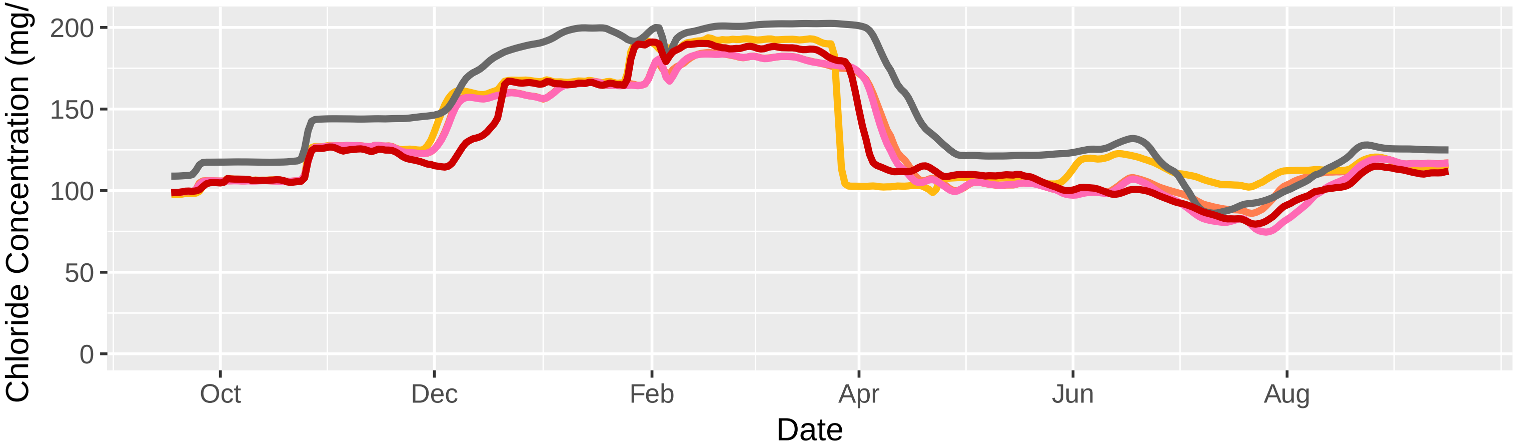
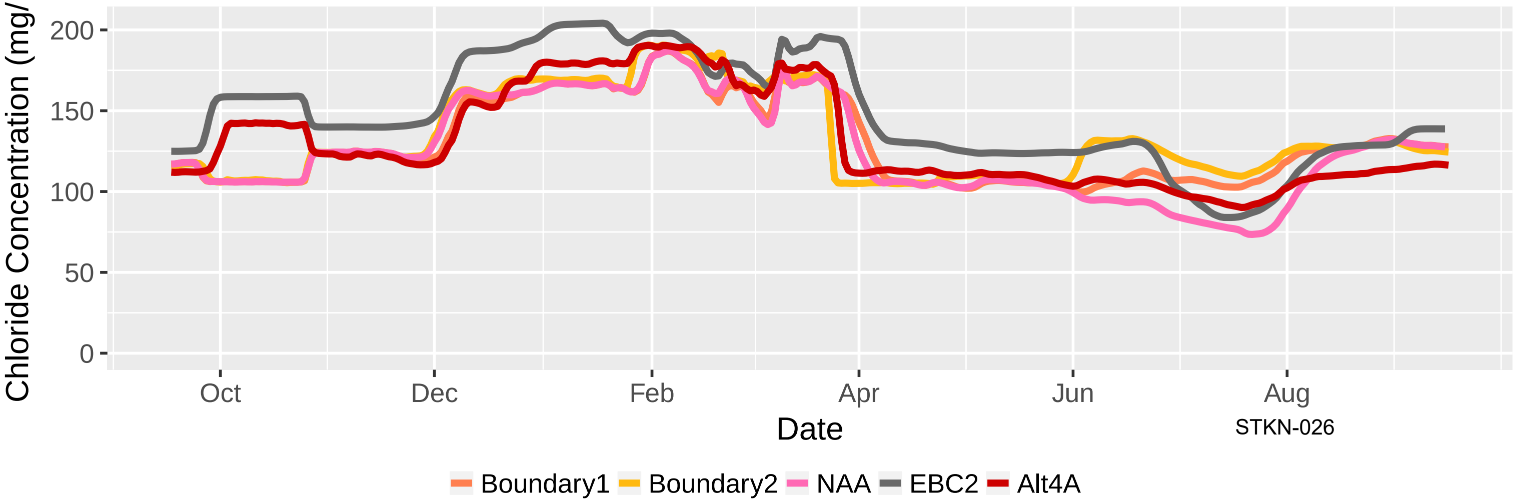


Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1991; Year Type: Critical



STKN-026

Appendix F

Calculated residence times for Delta inflows under various operational scenarios

APPENDIX F: Calculated residence times for Delta inflows

Month	Water Year Type	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	Dry	28	26.6	35.8	34.4	31.6	28%	23%	13%
November	Dry	32.3	32.3	36.5	40.2	38.6	13%	24%	20%
December	Dry	27.6	28.3	30.8	32.3	31.3	12%	17%	13%
January	Dry	31	31.7	32.9	35.9	34.2	6%	16%	10%
February	Dry	27.3	26.9	28.9	29.3	30.7	6%	7%	12%
March	Dry	24.2	24	26.4	26.1	27	9%	8%	12%
April	Dry	22.3	22.8	24.9	24.9	24.9	12%	12%	12%
May	Dry	38.2	39.3	37.1	40	39.2	-3%	5%	3%
June	Dry	36.4	36.9	37.9	40.1	37.8	4%	10%	4%
July	Dry	27.7	28.7	34.4	35.6	34.2	24%	29%	23%
August	Dry	23.2	26.7	31.1	31.8	30.9	34%	37%	33%
September	Dry	27.8	31.2	36.3	35.1	34.3	31%	26%	23%

Month	Water Year Type	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	Critical	32.7	32.3	39	39	37.1	19%	19%	13%
November	Critical	36.8	37.3	41.2	44.4	41.4	12%	21%	13%
December	Critical	35.5	37	39.7	42.2	38	12%	19%	7%
January	Critical	32.5	33.4	34.7	36.6	33.4	7%	13%	3%
February	Critical	35.6	33.9	36.2	37.1	36.5	2%	4%	3%
March	Critical	36	34.7	36.5	37.4	38.4	1%	4%	7%
April	Critical	36.3	36.4	38	39.2	38.6	5%	8%	6%
May	Critical	48.8	48	47.6	49.6	48.8	-2%	2%	0%
June	Critical	44.7	44.8	45.1	46.4	44	1%	4%	-2%
July	Critical	31.5	35.7	39	39.7	36.2	24%	26%	15%
August	Critical	29.4	34.9	36	37.5	34.5	22%	28%	17%
September	Critical	35.4	39.5	38.4	39.8	36.3	8%	12%	3%

Month	Water Year Type	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	Normal	31.6	31.6	39.6	40.2	38.1	25%	27%	21%
November	Normal	34.5	35.2	41	44.6	43.1	19%	29%	25%
December	Normal	31	30.9	36.7	38	35.9	18%	23%	16%
January	Normal	13.6	13.6	14.5	14.7	14.4	7%	8%	6%
February	Normal	8.2	8	8.5	8.5	8.6	4%	4%	5%
March	Normal	7.6	7.1	7.6	7.6	7.8	0%	0%	3%
April	Normal	13.9	13.3	14.7	14.7	14.8	6%	6%	6%
May	Normal	20.5	20.6	22.3	22.2	21.8	9%	8%	6%
June	Normal	23.8	25.7	27	28.5	27.5	13%	20%	16%
July	Normal	23.9	25.2	30.5	32.4	30.5	28%	36%	28%
August	Normal	23.8	24.2	32.8	32.4	30.2	38%	36%	27%
September	Normal	25.8	24.9	36.2	33.1	31.8	40%	28%	23%

Month	Water Year Type	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	Wet	24.1	25.6	34.1	33.4	31.5	41%	39%	31%
November	Wet	19.1	19.8	22.9	23.4	22.8	20%	23%	19%
December	Wet	8	7.5	8	7.8	8	0%	-3%	0%
January	Wet	7.1	6.3	6.7	6.6	6.8	-6%	-7%	-4%
February	Wet	6.2	5.6	5.9	5.9	6.1	-5%	-5%	-2%
March	Wet	4.1	3.8	3.9	3.9	4.1	-5%	-5%	0%
April	Wet	5.7	5.4	5.7	5.6	5.7	0%	-2%	0%
May	Wet	10.2	10.3	11	10.8	10.8	8%	6%	6%
June	Wet	14.1	15.9	17.4	17.7	17.5	23%	26%	24%
July	Wet	16.4	18.7	21.6	22.9	21.8	32%	40%	33%
August	Wet	21.1	22	29.1	29.3	27.1	38%	39%	28%
September	Wet	20.7	20.6	31.3	28.2	25.2	51%	36%	22%

Appendix G

Exponent comment letter for City of Stockton

Exponent®

EXTERNAL MEMORANDUM

TO: Robert Granberg, P.E., City of Stockton
Kelley Taber, Somach Simmons & Dunn

FROM: Susan Paulsen, Ph.D., P.E.

DATE: January 30, 2017

PROJECT: 1607644.000

SUBJECT: Technical Comments on the California WaterFix Project and Associated Final Environmental Impact Report and Environmental Impact Statement (FEIR/EIS)

At the request of the City of Stockton (the City), Exponent is pleased to submit comments on the California WaterFix Project (the Project) and Associated Final Environmental Impact Report/Environmental Impact Statement (FEIR/EIS).

The City retained Exponent to assist in evaluating the WaterFix Project and the associated FEIR/EIS. Exponent has also reviewed the prior comments on the Draft and Recirculated Draft Environmental Impact Report/Environmental Impact Statement (DEIR/EIS, RDEIR/EIS, respectively) submitted by the City. As detailed below, Exponent's analysis of the WaterFix Project and the FEIR/EIS relies on a review of the FEIR/EIS documentation as well as model input and output files for the various alternative operational scenarios that have been provided by the California Department of Water Resources (DWR).[1]

I. Introduction and Summary of Findings

A key concern expressed by the City in its comments on the DEIR/EIS and RDEIR/EIS was DWR's use of model results from a location known as "Buckley Cove" to evaluate water quality at the City's drinking water intake. DWR previously asserted, and the FEIR/FEIS continues to assert, that model results at the Buckley Cove location are representative of water quality at the City's intake location. However, as explained in detail below, Buckley Cove is over eight miles from the City's drinking water intake, and both the composition and quality of water at Buckley Cove differ significantly from the composition and quality of water at the City's intake. For these reasons, model results from Buckley Cove are not representative of and cannot be used to

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[1] Exponent has undertaken a diligent effort to identify the components of the FEIR/EIS that are relevant to the City's comments, and we have thoroughly reviewed the FEIR/EIS response to comments and sections/references cited in the response to the City's comments; however, given the size of the FEIR/EIS and the time available to comment, we have not reviewed the entire FEIR/EIS.

accurately assess water quality changes at the City's intake. Because the FEIR/EIS did not evaluate water quality impacts at the location of the City's drinking water intake, Exponent used DWR's model input files and the Delta Simulation Model II (DSM2) to obtain model results to describe water quality impacts at the City's intake location. Exponent has concluded that the Project will result in substantial changes in the source and quality of water present at the City's drinking water intake on the San Joaquin River. Water quality changes relative to existing conditions at the City's intake will result in part from the export from the northern Delta of greater volumes of water, and greater volumes of high quality Sacramento River water. Under most operational scenarios, a greater fraction of the water at the City's intake will come from the San Joaquin River rather than the Sacramento River, and higher salinity and other water quality changes will occur as a result.

Water quality impacts to the City's water supply will result from the implementation of the Project's preferred operational scenario (Alternative 4A), as well as from other scenarios within the operational range of the Project. DSM2 model results show that under the Project's Alternative 4A scenario, the chloride concentration at the City's intake will exceed the City's threshold of 110 mg/L more frequently than under existing conditions. For other operational scenarios, impacts are even greater.[2]

The FEIR/EIS does not disclose the impacts of the project to the City's drinking water supply in several additional ways. Namely, the FEIR/EIS uses an inappropriate existing condition baseline to model water quality impacts in the Delta; it does not disclose water quality changes modeled by DWR over the full operational range of the Project; and, as mentioned previously, it does not model water quality at the City's drinking water intake. In addition, the presentation of only monthly average water quality data in the FEIR/EIS masks salinity increases that occur over shorter time intervals and that must be assessed to evaluate water quality impacts at the City's intake, which operates on an hourly basis, not a monthly average basis. Lastly, the FEIR/EIS does not adequately address potential for increases in *Microcystis* blooms, which are a risk to humans and wildlife. The FEIR uses a whole-Delta analysis approach which does not consider area-specific changes as they relate to beneficial use.

II. Background

The City is located on the San Joaquin River in the southeast Sacramento-San Joaquin Delta (the Delta). The City of Stockton Municipal Utilities Department (COSMUD) serves approximately 55 percent of the total City of Stockton Municipal and Industrial (M&I) demand, with the remaining M&I demand met by the California Water Service Company and San

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[2] Due to time limitations associated with the very short review period for the FEIR/EIS, Exponent's technical analysis was limited to chloride and *Microcystis*, as well as changes in the hydrodynamics and residence times of the Delta indicated by the modeling. As noted in the City's comments on the DEIR/EIS and RDEIR/EIS, the City is also concerned about the potential for degradation of its water supply due to WaterFix-related increases in other water quality constituents, such bromide, nitrate and pesticides, and increased temperature, which could affect its compliance with wastewater discharge permit requirements. Based on Exponent's experience, the modeling and evaluation of chloride, and changes in the distribution and residence time of water within the Delta, Exponent would expect degradation for these water quality constituents of concern.

Joaquin County. In 2012, the COSMUD began obtaining a portion of its potable water supply from the San Joaquin River to establish a long-term reliable water supply.[3] Currently, the COSMUD obtains approximately 38 percent of its water supply from the San Joaquin River, with purchased water and groundwater providing the remaining supply. The volume of water extracted from the San Joaquin River is projected to increase over time, such that by 2035 water from the river intake will constitute about 50 percent of the COSMUD's supply. The current operational capacity of the intake is 30 million gallons per day (MGD), and the projected capacity in 2035 is 90 MGD. In 2015, the COSMUD's potable and raw water demand was approximately 26,300 acre-feet/year (ac-ft/yr), while the COSMUD's projected demand in 2035 is expected to be over 40,000 ac-ft/yr. COSMUD's intake pump station facility is located on the San Joaquin River as shown in Figure 1, which also shows the location of Buckley Cove.

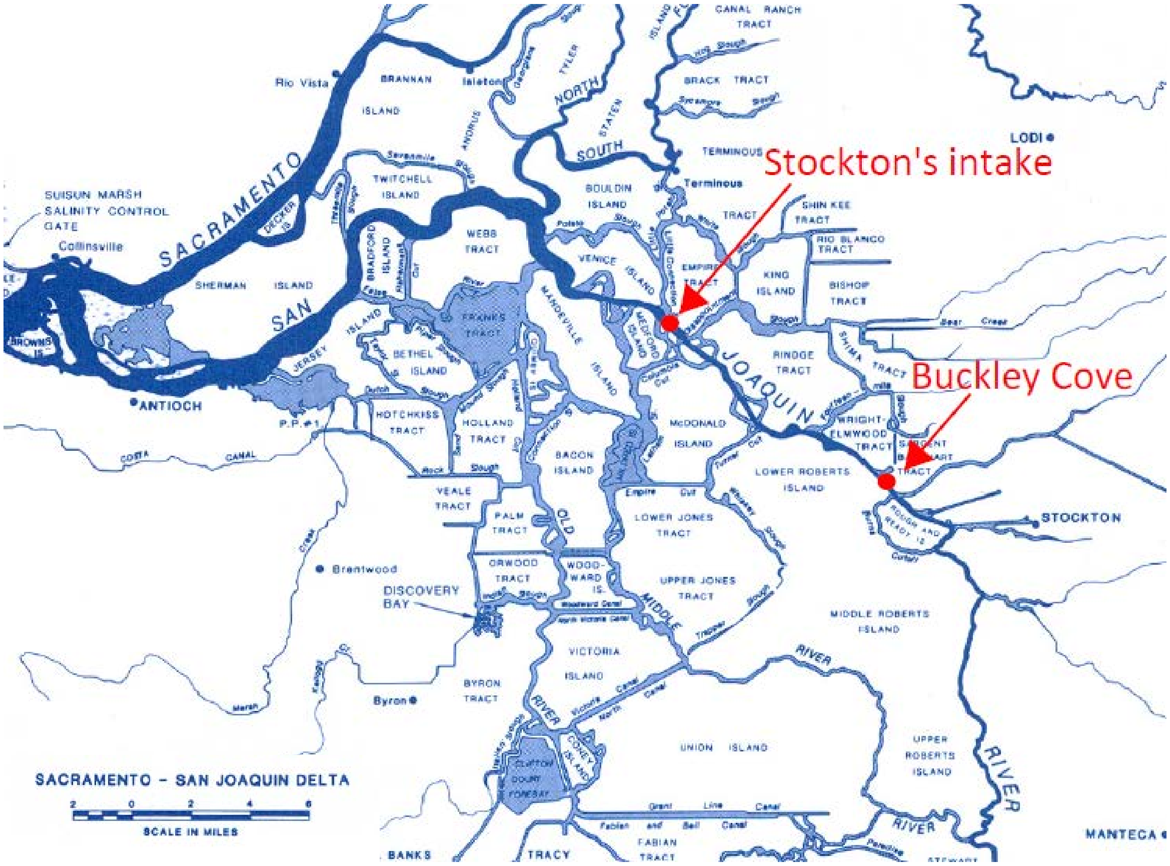

Figure 1. Location of Buckley Cove and Stockton's intake. Map adapted from DWR Sacramento-San Joaquin Delta Atlas (1995), available at http://baydeltaoffice.water.ca.gov/DeltaAtlas/.

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[3] Brown and Caldwell. 2016. City of Stockton 2015 Urban Watershed Management Plan. July.

III. Qualifications

I have 25 years of experience with projects involving hydrology, hydrogeology, hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents. I have knowledge of California water supply issues, including expertise in California's Bay-Delta estuary. My expertise includes designing and implementing field and modeling studies to evaluate groundwater and surface water flows, the source and distribution of water within the Delta, and contaminant fate and transport. I have also designed studies using one-dimensional hydrodynamic models, three-dimensional computational fluid dynamics models, longitudinal dispersion models, and Monte Carlo stochastic models to evaluate flows, water quality, and mixing within the Delta, and I have directed modeling studies and utilized the results of numerical modeling to evaluate surface and ground water flows. My curriculum vitae is provided as Attachment 1.

IV. Methods for Evaluating Impact on the City's Water Supply

The City asked Exponent to evaluate whether the proposed Project diversions will adversely impact the supply and quality of water available to the City from the Delta. In conducting this work, Exponent evaluated model runs performed by DWR, performed DSM2 modeling using DWR's model input files to obtain output not provided by DWR, and reviewed DWR's assessment of the proposed Project. Exponent obtained from DWR the modeling input and output files from DSM2, which was used to simulate hydrodynamics and water quality throughout the Delta for the proposed Project for a range of model conditions and operational scenarios. In addition to describing hydrodynamics and water quality, DSM2 can be used to perform "volumetric fingerprinting" to track inflows to the Delta throughout the model domain. Volumetric fingerprinting can be used to "tag" inflows to the Delta and to determine the source of water within the estuary. Because the model input and output files provided to the public by DWR did not include volumetric fingerprinting results, Exponent used the model input files provided by DWR and DSM2 to perform volumetric source fingerprinting to determine the location and time that flows from various sources entered the Delta. Exponent also used the model to evaluate hydrodynamics, water quality, and source fingerprints at the City's drinking water intake, since DWR did not analyze these quantities at that location. Exponent's analysis was performed for each of the Project scenarios and for the existing condition model run described below.

The salinity of water in the Delta has historically been expressed as electrical conductivity (EC), total dissolved solids (TDS), or chloride. Many salinity measurements in the Delta are made using EC, and EC is widely used as a surrogate for salinity. Guivetchi (1986)[4] derived linear relationships between EC, TDS, and chloride for various locations in the Delta and generated mathematical equations that can be used to convert one type of salinity measurement to another. DSM2 provides salinity as EC which is converted to chloride using these relationships.[5] For the

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[4] 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.

[5] See http://www.water.ca.gov/suisun/facts/salin/index.cfm for additional details.

City, the relationship used to convert EC to chloride for all water years was as follows: chloride [mg/L] = -28.9 + (0.23647*EC [µmhos/cm]). Thus, at the City's intake location, a chloride concentration of 110 mg/L (ppm) is assumed to correspond to an EC of approximately 587 µS/cm.

DSM2 produces data on 15-minute intervals. The time period modeled in DSM2 for most WaterFix analyses spans water year (WY) 1975–WY 1991; however, the model results from WY 1975 are considered model "spin-up" time and are excluded from analyses. Exponent's analyses are based on the 16-year record from WY 1976 to WY 1991.

Additionally, hydrology in the Delta varies from year to year. Water years in the Delta, defined as October through September of the following year, are classified as wet, above normal, below normal, dry, or critical. DWR determines the water year type by calculating a water year index number, which accounts for both the hydrology of the current year and the previous year's index.[6] By this classification system, the water years modeled in DSM2 by DWR fall into the following categories:

- Critical: 1976, 1977, 1988, 1990, 1991
- Dry: 1981, 1985, 1987, 1989
- Below Normal: 1979
- Above Normal: 1978, 1980
- Wet: 1982, 1983, 1984, 1986

Because there is only one Below Normal water year in the modeled record, Exponent combined results for the Below Normal year with model results for Above Normal water years for the purposes of analyzing the WaterFix model runs; the water year type for water years 1978–1980 is referred to from here forward as "Normal." In some analyses, data are averaged by water year type. This is done by aggregating data from those specific months or water year types and calculating an average.

In this analysis, source water fingerprints were used to determine both the location and time at which freshwater flows entered the Delta. Five inflows are typically considered in DSM2 for fingerprinting purposes: the Sacramento River, the San Joaquin River, east-side streams, agricultural return flows, and flows from the Bay at Martinez. For a given date and location, DSM2 was used to calculate the percentage contribution from each of the respective inflow sources.

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[6] Water years in the Delta, defined as October through September of the following year, are classified as wet, above normal, below normal, dry, or critical. DWR determines the water year type by calculating a water year index number, which accounts for both the hydrology of the current year and the previous year's index. Water year classifications were obtained from the California Data Exchange Center, accessed at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

Because the water quality of the various water sources to the Delta differs, source water fingerprints provide information to explain and interpret water quality data within the Delta. The EC of freshwater inflows to the Delta is lower than that of water that enters the estuary from San Francisco Bay, which 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 flows. For example, in 2015, average measured EC in the Sacramento River at Freeport was 168 µS/cm (equivalent to a TDS of 103 mg/L[7]), while the average EC in the San Joaquin River at Vernalis was 595 µS/cm (343 mg/L TDS). The average EC at Martinez (downstream boundary of Delta) was 26,384 µS/cm (17,882 mg/L TDS). By contrast, the salinity of seawater is approximately 50,000 µS/cm (35,000 mg/L TDS).[8,9]

DSM2 has been widely used by DWR and others to analyze the source of water within the Delta for various time periods and conditions, and for both observed and hypothetical conditions (e.g., to evaluate the impacts of potential operational changes). Source water fingerprints are presented in FEIR/EIS Appendix 8D for various locations in the Delta under different modeled scenarios; however, there are no source fingerprints in Appendix 8D for Stockton's intake.

Exponent produced volumetric fingerprints for both Buckley Cove and the City's intake under the range of Project operational scenarios presented in the FEIR/EIS. Those scenarios included existing biological conditions 1 (EBC1, which includes current sea levels and excludes the Fall X2 requirement[10]), a no action alternative (NAA), Boundary 1, Boundary 2, and the preferred Project Alternative 4A. Exponent also evaluated the existing biological conditions 2 model run (EBC2, which includes current sea levels and the Fall X2 requirement).

Exponent evaluated modeled salinity data at Buckley Cove and the City's intake under the EBC2, NAA, Boundary 1, Boundary 2, and Alternative 4A scenarios. The modeled salinity data were used to evaluate the effects of the Project on the water quality conditions at the City's intake in the San Joaquin River. The City typically employs a chloride threshold of 110 mg/L at the intake for diverting water that is useable for M&I supply; if the chloride concentration exceeds 110 mg/L, the City must generally use an alternative water supply, such as purchased water or groundwater. Because the City is able to turn its intake on and off over relatively short timescales, Exponent evaluated the number of one-hour intervals (added together and reported

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

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

[9] See Attachment 2: 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.

[10] Fall X2 is defined as the distance in kilometers from the Golden Gate Bridge to the point where salinity on the bottom is 2 parts per thousand (ppt). DWR and U.S. Bureau of Reclamation (Reclamation) are required to provide sufficient outflow during fall months to establish the X2 position at specified locations to improve habitat for Delta smelt.

in terms of "equivalent" days) that the water in the San Joaquin River exceeded 110 mg/L chloride under various water year types and operational scenarios. Specifically, Exponent averaged the 15-minute DSM2 output to calculate hourly average chloride concentrations and compared hourly concentrations to the threshold value. The number of hourly averaged data points below the 110 mg/L chloride threshold were summed, converted to days (i.e., 24 one-hour intervals below the threshold became one "equivalent" day), and averaged by water year type.

V. Findings

These water quality and water supply evaluations are organized into eight distinct findings, presented below.

1. The FEIR/EIS Does Not Evaluate Water Quality at Stockton's Intake

The FEIR does not assess the expected water quality impacts at the City's drinking water supply intake from operation of the Project. Rather, the FEIR/EIS discusses model results describing water quality at Buckley Cove in the San Joaquin River and purports to use model results from Buckley Cove to assess the range of water quality impacts expected at the City's water supply intake;[11] however, the City's intake is located more than eight miles downstream of Buckley Cove, and a number of sloughs and waterways join the San Joaquin River downstream of Buckley Cove. These sloughs and waterways (see Figure 1) carry water from the Mokelumne River and other sources to the San Joaquin River. For this reason, water supply and water quality conditions are significantly different at the City's drinking water intake than at Buckley Cove.

As described in the Methods section of these comments, Exponent conducted DSM2 trials to evaluate the "source fingerprints" of water at Buckley Cove and at the City's drinking water intake. These results indicate that water at Buckley Cove has a markedly different composition than water at the City's intake. For example, source water fingerprints describing existing conditions (NAA and EBC2 scenarios) in Figure 2, show that Sacramento River water is present at the City's intake throughout the year in concentrations ranging from 30 percent (in April) to more than 90 percent (in July, August, and December). The San Joaquin River constitutes between 0 and 50 percent of the water at the City's intake, and agricultural drainage constitutes between 5 and 15 percent (Figure 2). In contrast, water at Buckley Cove comprises primarily 45 to nearly 100 percent San Joaquin River water during all months of dry water years (Figure 3) with small contributions from agricultural return flows (up to 30 percent on average) and Sacramento River water (up to 20 percent on average) in the summer months. During October to

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[11] The FEIR/EIS states, "For municipal intakes located in the Delta interior, assessment locations at Contra Costa Pumping Plant No. 1 and Rock Slough are taken as representative of Contra Costa's intakes at Rock Slough, Old River and Victoria Canal, and the assessment location at Buckley Cove is taken as representative of the City of Stockton's intake on the San Joaquin River" (FEIR/EIS, p. 8-165).

May, 80 to 95 percent of the water at Buckley Cove originates from the San Joaquin River. During May to September, the San Joaquin River fraction falls to approximately 50 percent, with up to 30 percent agricultural drainage and 20 percent Sacramento River water.

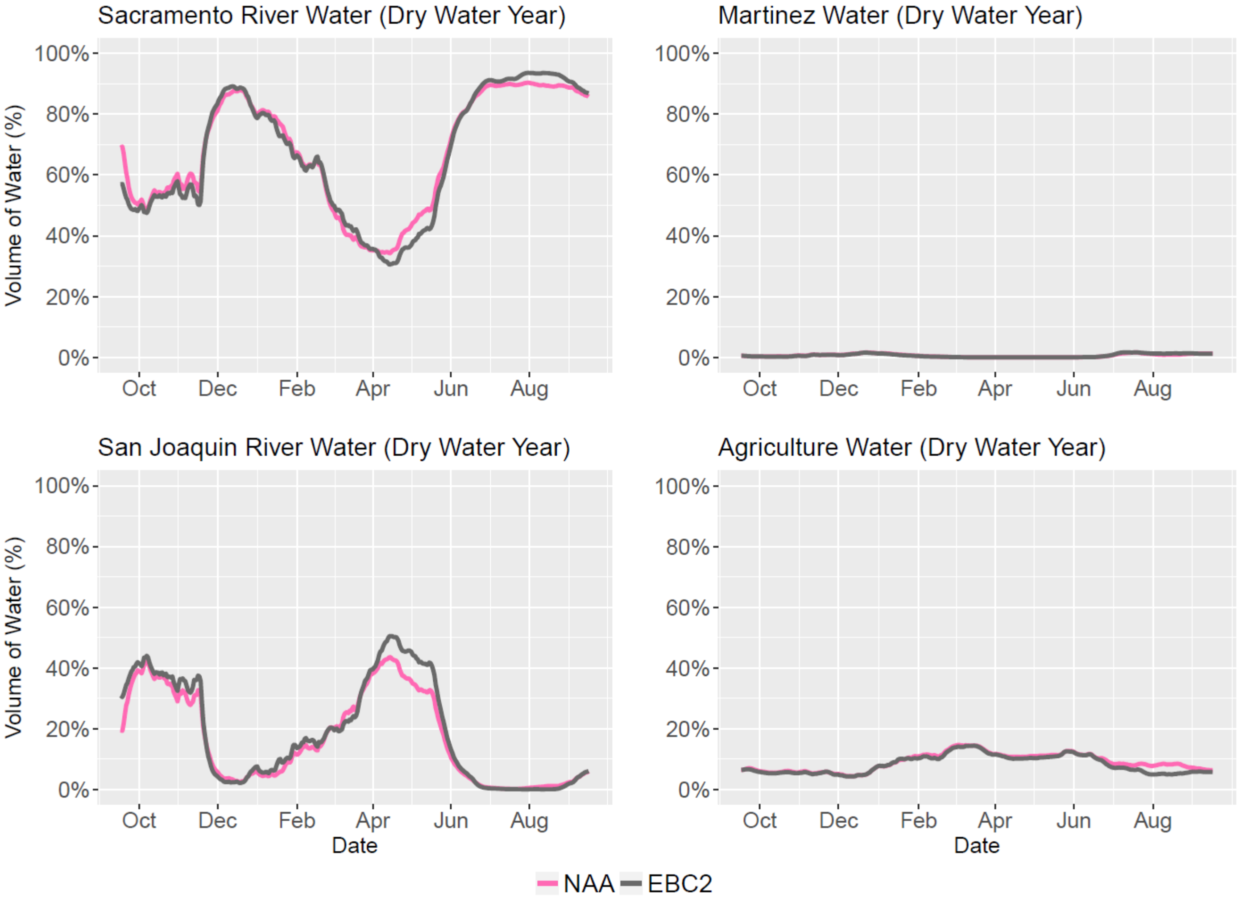

Figure 2. Source water fingerprint at Stockton's intake under the NAA and EBC2 baseline conditions during dry water years (1981, 1985, 1987, and 1989)

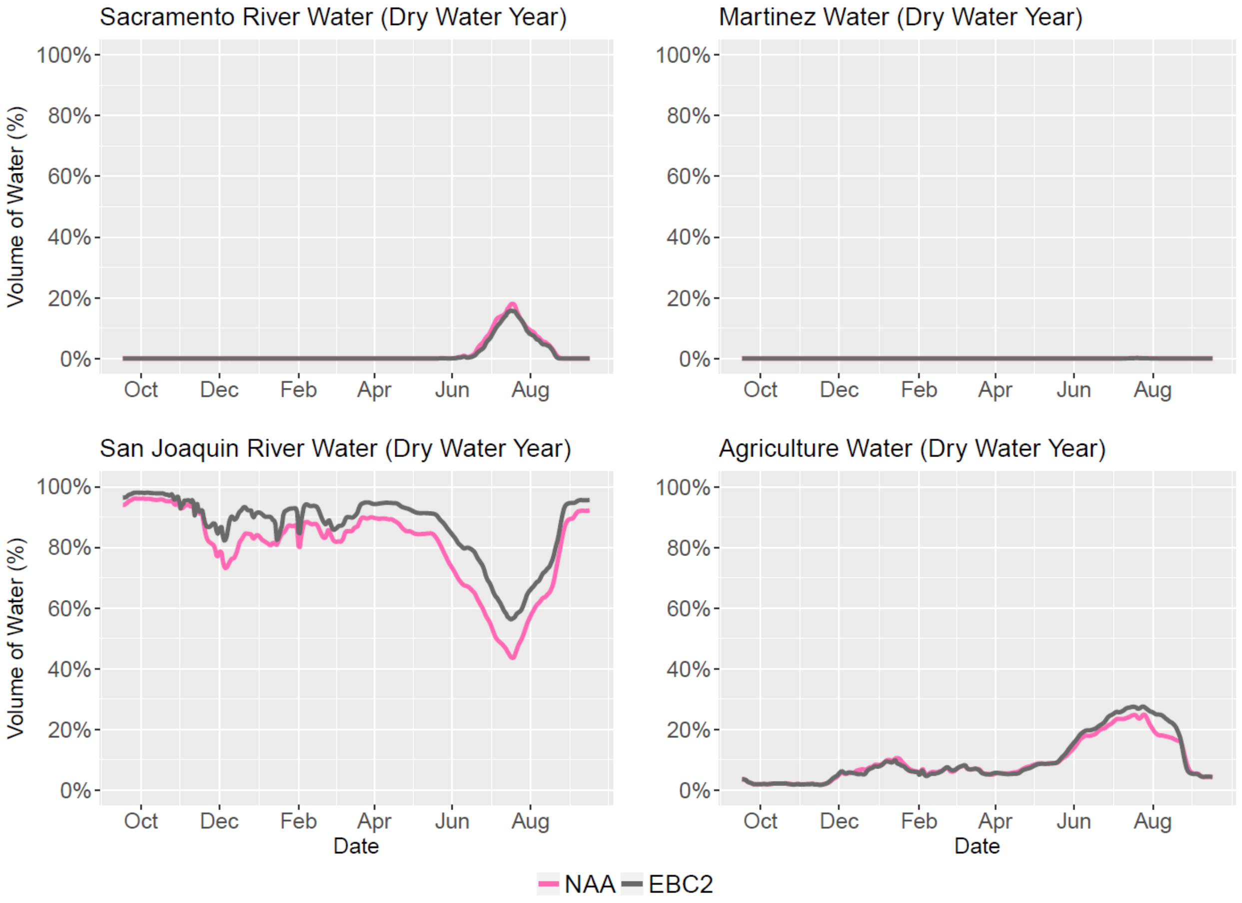

Figure 3. Source water fingerprint at Buckley Cove under the NAA and EBC2 baseline conditions during dry water years (1981, 1985, 1987, and 1989)

The differences in source water make-up between Buckley Cove and the City's intake are observed under all water year types. In nearly every water year during the modeled period (1976 to 1991), the modeled percentage of Sacramento River water at the City's intake (up to 95 percent) was significantly greater than at Buckley Cove (up to 40 percent) (Figure 4). Source fingerprints at the City's intake and Buckley Cove for all other water year types are presented in Attachment 3.

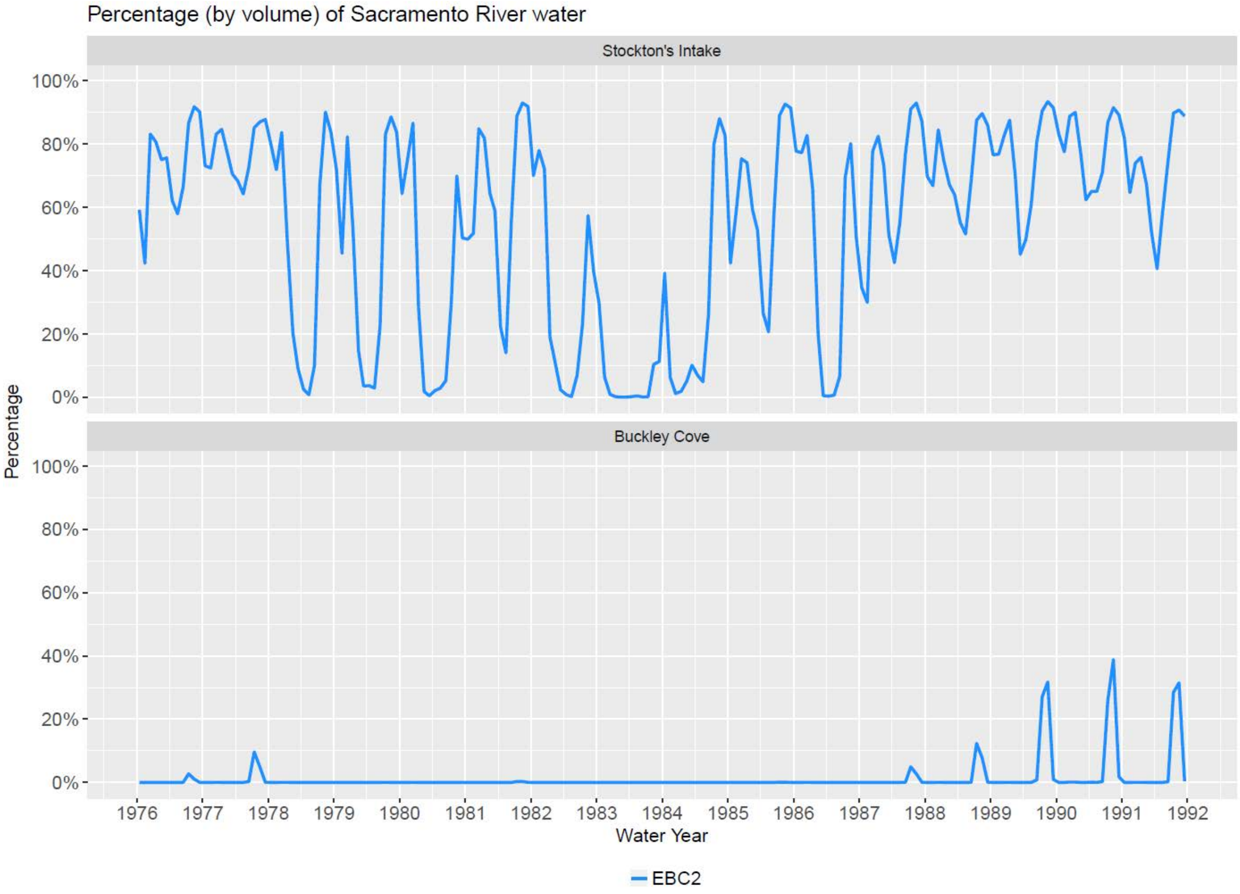

Figure 4. Percentage (by volume) of Sacramento River water at Stockton's intake (top panel) and Buckley Cove (bottom panel) from 1976 to 1991 under existing condition (EBC2)

Water quality is also notably different at the City's intake than at Buckley Cove. As discussed in the methods section above, the yearly average salinity of the San Joaquin River is higher (343 mg/L TDS in 2015) than the Sacramento River (103 mg/L TDS in 2015); because the Sacramento River represents a larger fraction of the water at the City's intake (up to 90 percent in July, August, and December), the salinity at the City's drinking water intake is generally lower than at Buckley Cove. Figure 5 and Figure 6 show the average simulated chloride concentration at the City's intake and at Buckley Cove, respectively, during dry water years under the EBC2 baseline. During dry water years, the average chloride concentration at the City's intake varies from 25 mg/L during June to 100 mg/L during March (Figure 5). In contrast, the average chloride concentration at Buckley Cove varies from approximately 80 mg/L during October to 180 mg/L during February and March (Figure 6). Chloride concentration model results for other water year types are presented in Attachment 4.

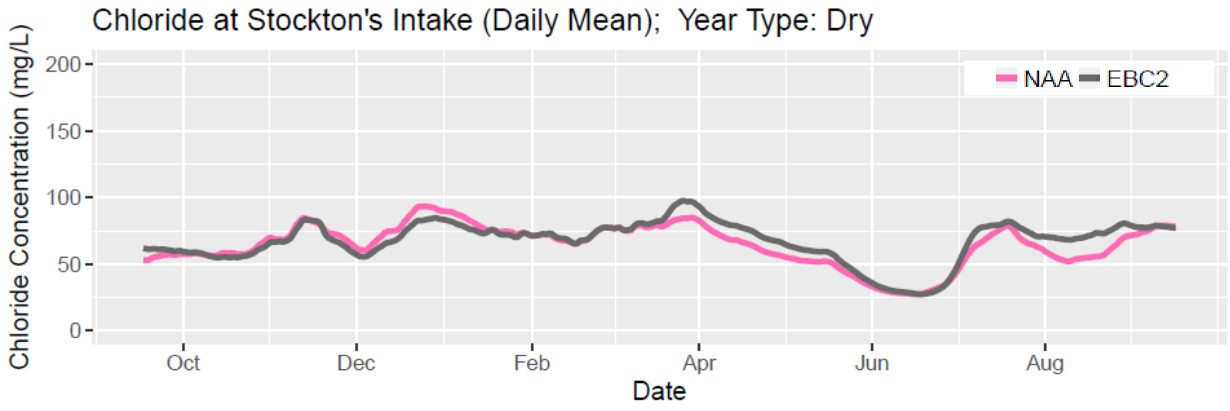

Figure 5. Simulated concentration of chloride at the City's intake during dry water year under baseline conditions NAA and EBC2

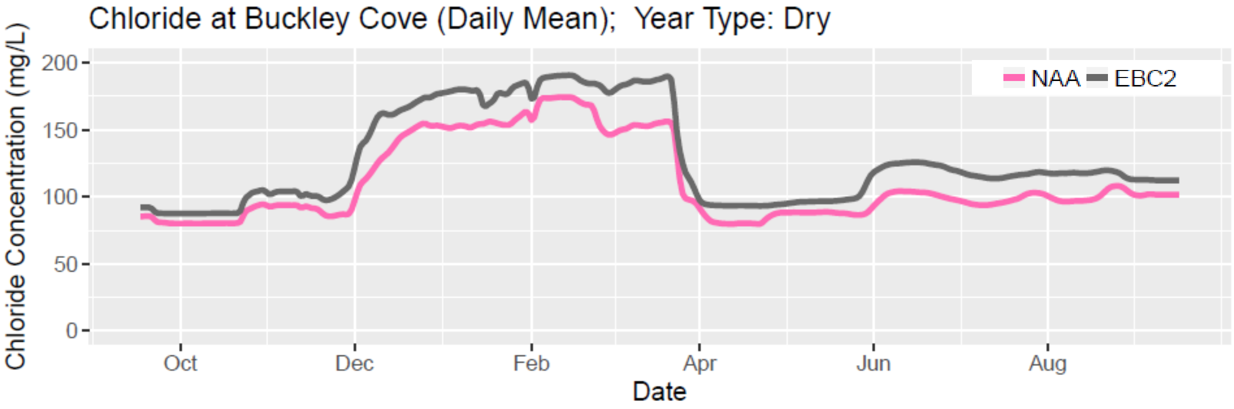

Figure 6. Concentration of chloride at the Buckley Cove during a dry water year under baseline conditions NAA and EBC2

Although the FEIR/EIS asserts that water quality conditions at Buckley Cove are representative of Stockton's water supply, perhaps due to the close proximity of Buckley Cove to the City proper, this conclusion is erroneous. DWR's response to the City's comment pointing out the discrepancy states that "the effects of alternatives at the locations assessed are considered representative of the effects of the alternatives in various portions of the Delta as a whole," and DWR asserts that water quality conditions at Buckley Cove are representative of the "eastern Delta, where the City's intake is located."[12] As discussed above, this assumption in the FEIR/EIS is incorrect, as the conditions at Buckley Cove and within other portions of the eastern Delta interior can vary significantly from the City's intake location. As a result, water quality data modeled at Buckley Cove do not represent the range of impacts that are expected at the City's water supply intake under the proposed Project.

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[12] FEIR/EIS, RECIRC Comment Responses Letters 2400-2499, pp. 156–157.

2. The FEIR/EIS Model Scenarios do not Describe Existing Conditions or Use the Appropriate Baseline for the Impact Analysis

The FEIR/EIS model utilizes the EBC1 existing condition to evaluate Project impacts under the preferred Alternative 4A scenario; however, this baseline is flawed and inappropriate as it does not include the Fall X2 provision of the 2008 U.S. Fish and Wildlife Service Biological Opinion (2008 BiOp) that governs CVP/SWP operations.[13] Failing to include the Fall X2 provision in EBC1 increases the modeled salinity of the existing condition, which in turn makes the water quality impacts of Alternative 4A appear less significant than they would with the appropriate baseline. Because the 2008 BiOp presents the requirement to manage Delta outflows and operate water storage and releases to achieve the Fall X2 provision, the existing condition evaluated to assess Project impacts should reflect operations conducted to meet this requirement. DWR previously released modeling that utilized a baseline condition designed to meet Fall X2: the EBC2 scenario, presented in the 2013 Revised Administrative Draft; however, the 2013 DEIR/EIS, the 2015 RDEIR/EIS, and the 2016 FEIR/EIS use only the EBC1 scenario.

Table 1 shows that the number of days existing source water at Stockton's intake exceeds a chloride concentration of 110 mg/L is greater under the EBC1 scenario than under the EBC2 scenario for most water year types. For example, the average number of days in a dry water year that the chloride concentration at the City's intake exceeds 110 mg/L is 58 under the EBC1 baseline and 31 under the EBC2 scenario (Table 1). Thus, the baseline water quality condition used by DWR in the FEIR/EIS (EBC1) is more saline as a result of the failure to operate to Fall X2 conditions. Because the EBC2 scenario more appropriately represents an accurate baseline condition by adhering to the Fall X2 requirement, Exponent has evaluated Project impacts using the EBC2 baseline condition.

By failing to use the EBC2 scenario as the existing conditions scenario, the FEIR/EIS does not accurately disclose the magnitude of water quality impacts that would occur from the Project relative to existing conditions.

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[13] On p. 4-6, the FEIR/EIS states that the Fall X2 salinity requirement was not included in the existing condition baseline since "[a]s 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."

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, 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 requirements should have been included (together with the other BiOp requirements that were included) in the baseline existing condition.

Table 1. Number of days that water at Stockton's intake exceeds 110 mg/L chloride under three modeled baseline scenarios according to water year type

Water Year Type	No. of days per year that water at Stockton's intake exceeds a chloride threshold of 110 mg/L		
	EBC1 Existing Condition **Does not** include Fall X2 **No** sea-level rise	EBC2 Existing Condition **Includes** Fall X2 **No** sea-level rise	NAA baseline condition **Includes** Fall X2 **15-cm** sea-level rise
Critical	50	35	50
Dry	58	31	36
Normal	44	36	44
Wet	11	11	11

3. The FEIR/EIS Does Not Fully Characterize the Entire Range of Expected Project Operations or Associated Water Quality Impacts.

The FEIR/EIS does not characterize the water quality and water supply impacts that would be expected over the full range of the Project's proposed operational scenarios. The FEIR/EIS does not fully evaluate the water quality impacts of Boundary 1 or Boundary 2, which are representative of proposed operations of the Project, as DWR has indicated in testimony to the State Water Resources Control Board (SWRCB) in the WaterFix water rights change petition proceedings.[14] In the water rights proceedings, DWR disclosed that under its intended Adaptive Management and Monitoring Program (AMMP) Project diversion and conveyance facility operations could fall anywhere from the Boundary 1 scenario (characterized by low Delta outflow and high exports) to the Boundary 2 scenario (characterized by high Delta outflow). The FEIR/EIS assessed more than 18 different Project alternatives (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A); Alternative 4 was also evaluated as Alternatives H1 through H4. DWR has stated that Boundary 1 and Boundary 2 are operational scenarios that fall outside the range of H1 to H4; according to DWR, Boundary 1 impacts can be assessed by examining impacts from Alternatives 1A and 3, while Boundary 2 impacts can be assessed by examining impacts from Alternatives 4H3+ and 8.[15] Table 2 shows operational scenarios that were released by the DWR in various model files in support of the Project and reviewed by Exponent. Although this list is not an exhaustive list of all files released by DWR,

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[14] The FEIR/EIS states that "operation of the future conveyance facility under a possible adaptive management range represented by Boundary 1 and Boundary 2 will be consistent with the impacts discussed for the range of alternatives considered in this document" (FEIR/EIS, p. 3-288) and "Boundaries 1 and 2 were presented to the State Water Board during the water rights petition process as a means to represent a potential range of operations that could occur as a result of the proposed Adaptive Management Program" (FEIR/EIS, p. 5E-1).

[15] The FEIR/EIS states that "[c]onsistent with the goals of this analysis, the nature and severity of the impacts generally fall within the range of impacts disclosed under Alternatives 1A and 3 for Boundary 1, Alternative 4H3, Alternative 4H3+, and Alternative 8 for Boundary 2" (FEIR/EIS, p. 5E-170).

it points to the number and types of operational scenarios that were assessed and released by DWR over time.

Table 2. Exponent's record of model files released by the California Department of Water Resources in support of the California WaterFix Project

Accompanying Document	Model Files Acquired by Exponent
March 2013 Revised Administrative Draft BDCP	EBC1, EBC2, NAA (ELT, LLT), all Project alternatives, including Alternative 4 (H1, H2, H3, H4) at LLT and ELT
2013 Draft EIR/EIS	EBC1, NAA (ELT, LLT), all Project alternatives, including Alternative 4 (H1, H2, H3, H4) at LLT and ELT
2015 RDEIR/SDEIS	Updated 2013 Draft EIR/EIS model files and sensitivity analyses released. Alternative 4A (or H3+) introduced as the preferred alternative but not modeled
Draft BA model files (released January 2016, before document release)	NAA (ELT), Preferred Alternative (Alternative 4A)
Final FEIR/EIS model files (released March 2016, before document release)	NAA (ELT), Alternative 2D, Alternative 4A, Alternative 5A
WaterFix Petition (May 2016)	B1, B2, NAA, H1, H2, H3, H4

B1 = Boundary 1
B2 = Boundary 2
EBC1 = existing baseline condition without the Fall X2 standard
EBC2 = existing baseline condition including the Fall X2 standard
ELT = early long term (i.e., 2025 with 15 cm of sea level rise)
LLT = later long term (i.e., 2060 with 45 cm of sea level rise)
NAA = no action alternative

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 were found to have significant adverse impacts with respect to chloride concentrations at the Contra Costa Pumping Plant #1 (FEIR/EIS Figure 8-0a). Only Alternatives 4A, 2D, and 5A were found to have no significant impact/no adverse effects (FEIR/EIS Figure 8-0a). Thus, operation of the Project to Boundaries 1 and 2, which DWR states are represented by scenarios 1A, 3, and 8, would also have significant/adverse impacts.

Although Appendix 5E of the FEIR/EIS contains a highly generalized summary of modeling DWR performed to evaluate the water quality impacts of Boundary 1 and Boundary 2 (including salinity), these impacts are not assessed in the same comprehensive manner that the preferred Alternative 4A and other alternatives (including Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A) were assessed (see FEIR/EIS Chapter 8). (In addition, the Boundary 1 and Boundary 2 scenarios are not presented in the Executive Summary for the FEIR/EIS, including FEIR/EIS Table ES.4.2, which summarizes the findings for eighteen (18) individual scenarios, and finds that chloride impacts for scenarios 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9 are both "significant and unavoidable (any mitigation not sufficient to render impact less than significant)" and "adverse." In contrast with the information presented in Chapter 8 of the FEIR/EIS, Appendix 5E presents water quality results for a more limited number of Delta locations, for fewer water quality constituents, and in much less detail.

The model results of Appendix 5E were also not used to make the final impact assessment of the Project.[16]

4. The Water Quality Impacts of Alternative 4A at the City's Intake are Significant.

As noted in Finding 1, the FEIR/EIS does not evaluate the impacts of any of the Project alternatives, including Alternative 4A, the preferred alternative, at the location of the City's intake. DSM2 results show the impact of Alternative 4A on the City's water source make-up and water quality is markedly different from either existing conditions (EBC2) or the future no action alternative (NAA).

Modeling demonstrates that under Alternative 4A, the volume of higher quality Sacramento River water at the City's intake is expected to decrease substantially relative to the existing baseline condition (EBC2), while the volume of more saline and lower quality San Joaquin River water and agricultural flows is expected to increase. For example, during February of dry water years, DSM2 indicates the volume of Sacramento River water at the City's intake decreases from an average of 65 percent under EBC2 to 45 percent under Alternative 4A (Figure 7). During October of dry water years, on average the composition of water at the intake decreases from 55 percent Sacramento River water under EBC2 to 30 percent under Alternative 4A (Figure 7). The percentage of San Joaquin River water increases concomitantly at the City's intake. During February of dry water years, for example, the volume of San Joaquin River water increases from 15 to 40 percent (EBC2 to Alternative 4A); during October of dry years, the volume increases from 40 to 65 percent (EBC2 to Alternative 4A) (Figure 7). The volume of Sacramento River water at the City's intake also decreases under Alternative 4A for all other water year types. The water source fingerprints under the various operational scenarios for all water year types are presented in Attachment 5.

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[16] Appendix 5E comprises additional modeling requested by the State Water Board for the Boundary scenarios and an additional scenario, "Scenario 2." The impact determinations made in Chapter 8 are specific to each Alternative presented in the main body of the text (i.e., 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 4A, 2D, and 5A) and do not include the Boundary scenarios.

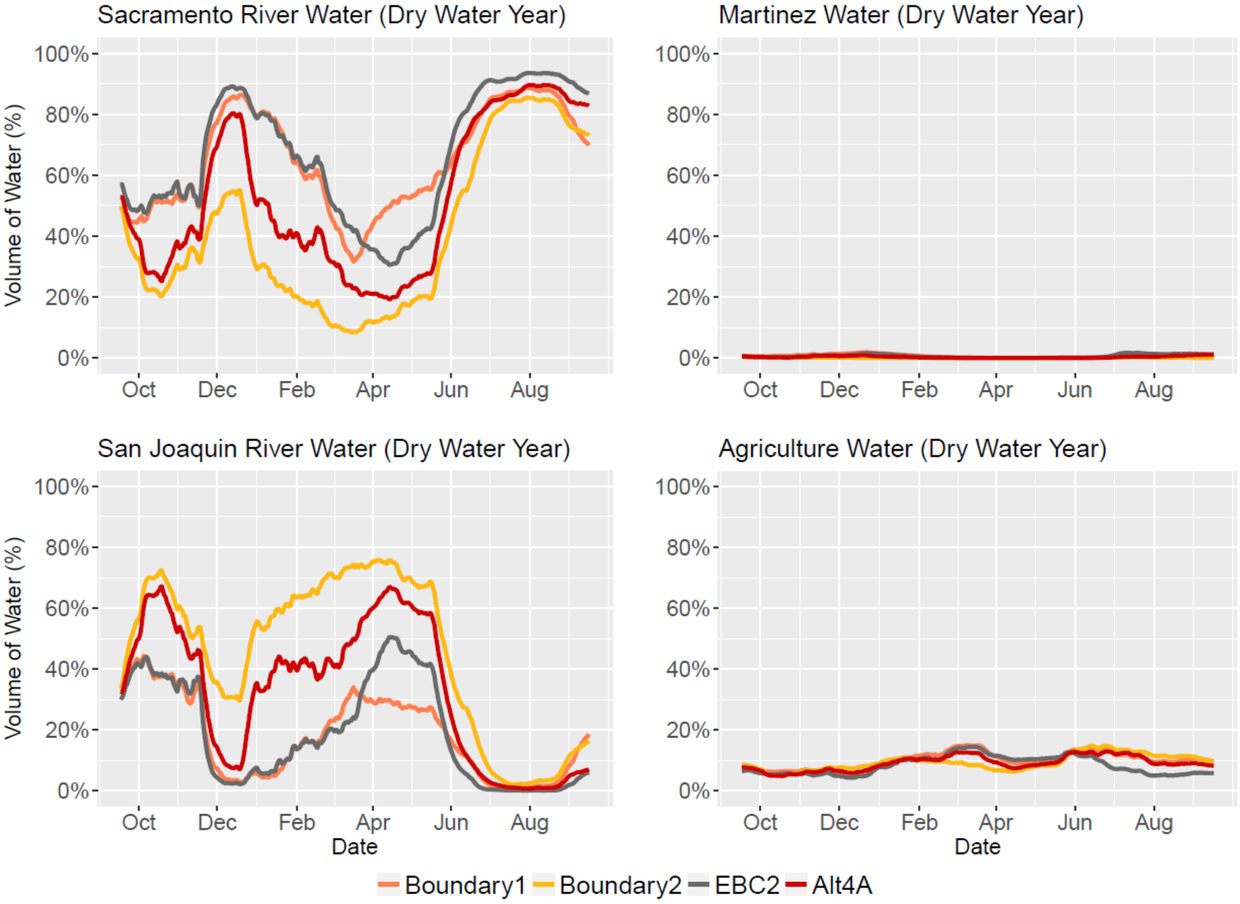

Figure 7. Source water fingerprint at Stockton's intake under the proposed California WaterFix Project scenarios during dry water year years (1981, 1985, 1987, and 1989)

Water quality impacts at the City's intake will also be significant under the Project's preferred operational scenario Alternative 4A. DSM2 results show that the number of days that chloride will exceed the City's 110 mg/L threshold during critical water years will increase from 35 days under EBC2 to 53 days under Alternative 4A (Table 3). Similarly, the number of days that chloride will exceed the 110 mg/L during dry years is simulated to increase from 31 days per year under EBC2 to 58 days per year under Alternative 4A (Table 3). This difference represents up to a 87 percent increase in the number of days that water in the San Joaquin River at the City's intake will not be useable to the City (see dry water year, Table 3). Table 4 shows the number of days per year that water at the City's intake exceeds 110 mg/L chloride for every year during the 16-year model period (1976 to 1991).

Table 3. Number of equivalent days that water at Stockton's intake *exceeds* 110 mg/L chloride under various modeled baseline scenarios according to water year type

Water Year Type	No. of days water at Stockton's intake exceeds chloride threshold of 110 mg/L					Percentage increase from EBC2 to B1	Percentage increase from EBC2 to B2	Percentage increase from EBC2 to Alt4A
	EBC2	NAA	B1	B2	Alt 4A			
Critical	35	50	47	75	53	35%	112%	52%
Dry	31	36	46	77	58	49%	151%	87%
Normal	36	44	57	18	32	60%	-49%	-11%
Wet	11	11	8	4	2	-28%	-61%	-79%

Table 4. Number of equivalent days that water at Stockton's intake *exceeds* 110 mg/L chloride under various modeled baseline scenarios for each water year between 1976 and 1991

Water ear	Water Year Type	Total Days	No. of days water at Stockton's intake exceeds chloride threshold of 110 mg/L					Percentage increase from EBC2 to B1	Percentage increase from EBC2 to B2	Percentage increase from EBC2 to Alt4A
			EBC2	NAA	B1	B2	Alt 4A			
1976	Critical	366	25	0	11	87	25	-55%	248%	-1%
1977	Critical	365	9	76	56	71	57	513%	685%	526%
1978	Normal	365	45	82	105	24	72	131%	-46%	60%
1979	Normal	365	12	29	33	31	18	171%	150%	45%
1980	Normal	366	50	23	34	1	6	-32%	-98%	-88%
1981	Dry	365	12	14	5	82	38	-58%	602%	223%
1982	Wet	365	20	23	30	4	4	49%	-82%	-81%
1983	Wet	365	0	0	0	0	0	NA	NA	NA
1984	Wet	366	0	0	0	0	0	NA	NA	NA
1985	Dry	365	7	1	7	76	42	-8%	921%	469%
1986	Wet	365	26	20	4	15	7	-86%	-42%	-74%
1987	Dry	365	11	6	63	81	44	465%	627%	291%
1988	Critical	366	15	10	18	88	22	19%	487%	44%
1989	Dry	365	93	125	109	71	107	17%	-24%	15%
1990	Critical	365	54	24	11	57	37	-79%	5%	-32%
1991	Critical	365	75	139	143	72	129	92%	-3%	72%
Summary	(all)		455	572	627	759	606	38%	67%	33%

Chloride concentrations at the City’s intake for dry water years (average of 1981, 1985, 1987, and 1989) are displayed graphically in Figure 8 for various operational and baseline scenarios. From January through April the Alternative 4A scenario results in higher chloride than EBC2, NAA, and Boundary 1 scenarios. In fact, chloride concentrations appear to exceed the 110 mg/L threshold towards the end of February, and through most of March, during which times the EBC2 and NAA scenarios simulate chloride concentrations around 90 mg/L. The DSM2-simulated chloride concentrations at the City’s intake under the various operational scenarios are provided in Attachment 6 for all water year types and during every year in the modeled period (1976 to 1991).

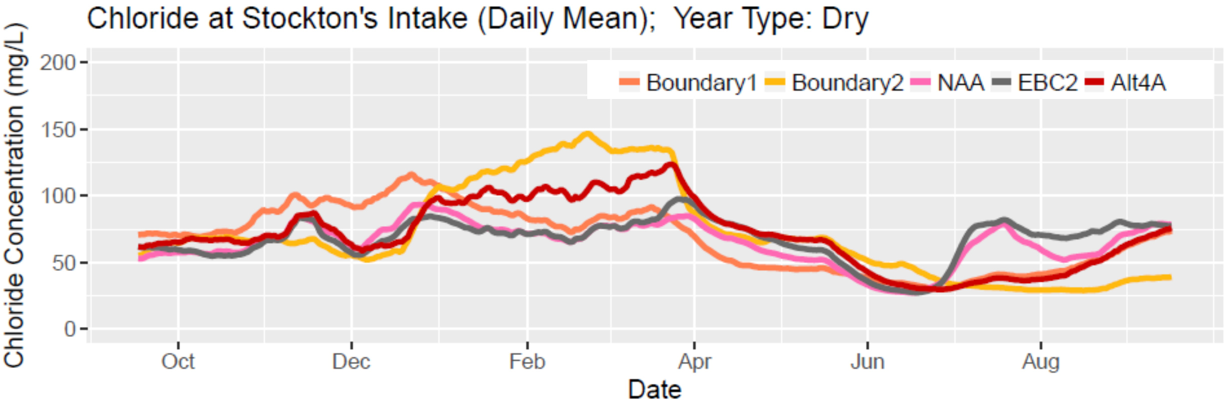

Figure 8. Concentration of chloride at Stockton’s intake under various operational scenarios during dry water years (1981, 1985, 1987, and 1989)

5. The Water Quality Impacts of the Full Range of Operational Scenarios (Boundary 1 and Boundary 2) at Stockton’s Intake are Significant.

The FEIR/EIS does not evaluate the full range of potential Project operational scenarios on the water source make-up and water quality at the City’s intake. As discussed in Finding 3 above, DWR testified in the 2016 SWRCB water rights change petition hearings that Boundary 1 and Boundary 2 represent the range of potential Project operational outcomes that may result from implementation of the AMMP. Boundary 1 (characterized by a high volume of exported water) and Boundary 2 (characterized by high Delta outflow) represent a broad range of potential Project operations that is substantially different from any alternative evaluated in any of the Project environmental documents (DEIR/EIS, RDEIR/EIS, FEIR/EIS)[17] and a broad range of potential impacts to the City’s water supply that should have been evaluated fully within one of the draft environmental documents and circulated for public review and comment.

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[17] Model results show more water will be exported from the Delta under the B1 scenario than scenario Alternative 4A in all but critical water years. During wet and normal years, Boundary 1 results in 622 thousand acre-feet (TAF) and 638 TAF of additional exports, respectively. Note that Boundary 1 and Boundary 2 are presented in a highly generalized fashion in Appendix 5E of the FEIR/EIS, but water quality impacts were not evaluated for the City’s intake, and the impacts of these two scenarios were not presented in detail or included in the summary impact tables in either the Executive Summary of the FEIR/EIS or in Chapter 8.

To evaluate the potential impacts due to the broad operational ranges that DWR has indicated are possible, Exponent compared the source of water and water quality at the City's intake for the boundary scenarios to the preferred Alternative 4A and to the existing condition (EBC2). This analysis demonstrates that the source of the water at the City's intake, and the fraction of Sacramento River water, will change significantly relative to Alternative 4A, in all year types, if Scenario Boundary 2 is implemented (see Figure 7 and Attachment 5). Changes for Scenario Boundary 2 relative to Alternative 4A are most pronounced during dry and critical water years. For example, in December of a dry water year, operation to Boundary 2 parameters would decrease the amount of Sacramento River water at the intake from 80 percent (Alternative 4A) to 55 percent (Boundary 2) (Figure 7). Operation to Boundary 2 would also increase the volume of lower quality San Joaquin River water relative to Alternative 4A and existing conditions (EBC2) during all water year types (Figure 7 and Attachment 5).

The number of days per year the chloride concentration at the City's intake exceeds the 110 mg/L usability threshold would also be greater under the Boundary 1 scenario than existing baseline EBC2 during normal (57 and 36 for Boundary 1 and EBC2), dry (46 and 31), and critical years (47 and 35) (Table 3). The number of days per year the chloride threshold is exceeded would be greater under the Boundary 2 scenario than EBC2 during dry (77 and 31 for Boundary 2 and EBC2) and critical years (75 and 31) (Table 3). Not only do the Boundary 1 and Boundary 2 operational scenarios generate water quality and source water changes that are significantly different from each other, they also generate impacts that are significantly different from the preferred Alternative 4A.

Figure 8 shows that during a dry water year under Boundary 2 operation, the 110 mg/L threshold would most frequently be exceeded from January to April and chloride concentrations up to 150 mg/L are simulated to occur. Compared to Alternative 4A, operating to the Boundary 1 scenario during a dry water year would cause higher chloride concentrations at the City's intake during the months of September through December; and operating to the Boundary 2 scenario would cause chloride concentrations to increase during the months of January through March (Figure 8). Compared to existing conditions (EBC2), operating to Alternative 4A during a dry water year causes chloride concentrations at the City's intake to increase during the months of January through March, May, October, and November (Figure 8). Thus, there are sizable impacts to the City's water quality during the operations of Project scenarios Boundary 1, Boundary 2, and Alternative 4A. These impacts have not been properly evaluated or disclosed in the FEIR/EIS.

6. By Presenting Water Quality Results as Monthly or Long-term Averages, the FEIR/EIS Does Not Adequately Describe Water Quality Changes that will be caused by the Project.

As shown in Finding 4, above, operating the Project to the preferred Alternative 4A will cause salinity to increase substantially at the City's intake. Although Chapter 8 of the FEIR/EIS shows the projected impact of Alternative 4A at various locations in the Delta (but not at the City's intake), the water quality data are presented as monthly average concentrations of EC and chloride.[18] Monthly average chloride concentrations cannot be used to evaluate the impacts of the proposed Project on drinking water intakes within the Delta. Long-term average concentrations by definition cannot show shorter-term changes in salinity and water quality levels, and have the effect of masking substantial increases that will adversely affect Delta water users, including the City. Thus, even if the locations evaluated in the FEIR/EIS were representative of conditions at the City's intake, the decision to present water quality data in terms of long-term monthly average concentrations masks the substantial adverse changes in water quality that will occur.

The FEIR/EIS's justification for its use of long-term average concentrations is inadequate and inaccurate.[19] Because water intake operations are typically managed on an hourly or sub-hourly basis, hourly or sub-hourly chloride concentrations are needed for drinking water operators to understand the impacts on their operations. DSM2 offers the best available tool for assessing impacts to drinking water operations on a time scale relevant to operations (i.e., daily concentrations), and it is well-established that the DSM2 is suited to simulate the tidally driven hydrodynamics of the Delta, which are, in part, the cause of water quality changes over daily or sub-daily timescales. Although the model is not intended to be used in a predictive fashion, the use of the model's daily (or hourly, or sub-hourly) average concentration output can be employed for comparing and contrasting various operational scenarios. This comparison provides appropriate and valuable information for gauging water quality impacts to the City's intake.

Although the FEIR/EIS did not assess chloride impacts at the City's intake, impacts at Buckley Cove were assessed. Figure 9 is an excerpt of Table Cl-70 from Appendix 8G of the FEIR/EIS (p. 8G-84) which shows the change in average chloride concentration under Alternative 4A relative to the NAA and EBC1 baselines. The change in chloride concentrations in the table is reported as a monthly average concentration. As shown in Figure 9 (FEIR/EIS Table Cl-70), the maximum reported change in chloride at Buckley Cove relative to the NAA during the month of March is 9 mg/L; however, DSM2 model output evaluated by Exponent under this scenario

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[18] The DSM2 model produces output data at 15-minute intervals. For example, the DSM2 model provides a modeled electrical conductivity (used to calculate chloride levels) values for each 15-minute interval in the 16-year modeled record (water years 1976-1991). DWR has aggregated the 15-minute model output data to calculate long-term monthly averages, which was done by first averaging data from each individual month at a specific location, and second, by averaging all data for that month over the full 16-year simulation period. For example, the 16 values of the monthly average chloride concentration for all the months of March at Buckley Cove were averaged to generate the average chloride concentration at Buckley Cove for the month of March (and the same process was followed for other months).

[19] FEIR/EIS Master Response 14 (pp. 1-123 to 1-124) states, "Given the models used and the associated limitations in interpreting the output, utilizing a shorter time step than monthly average for assessing water quality changes at the City of Antioch and CCWD's intakes would not result in a more accurate assessment of effects of the Project on salinity-related parameters (i.e., EC, chloride, bromide) or organic carbon. While there would be days within a month in which parameter concentrations/levels at a given location would be higher than the monthly average at that location (just as there would be days when it is lower), given the modeling limitations, comparing alternatives and baselines based on the monthly average at those locations is considered appropriate for the purposes of NEPA and CEQA."

shows that the change in chloride concentration in March at Buckley Cove can be much greater than 9 mg/L. For example, the difference in chloride concentration at Buckley Cove (between Alternative 4A and NAA) during March of 1981 (a dry water year) is over 25 mg/L (Figure 10).

DWR’s use of long-term average monthly concentrations in the FEIR/FEIS serves to mask increases in chloride concentrations that may occur under various operational scenarios and is inappropriate for assessing water quality impacts in the Delta. The use of daily average salinity is more appropriate for evaluating water quality impacts.

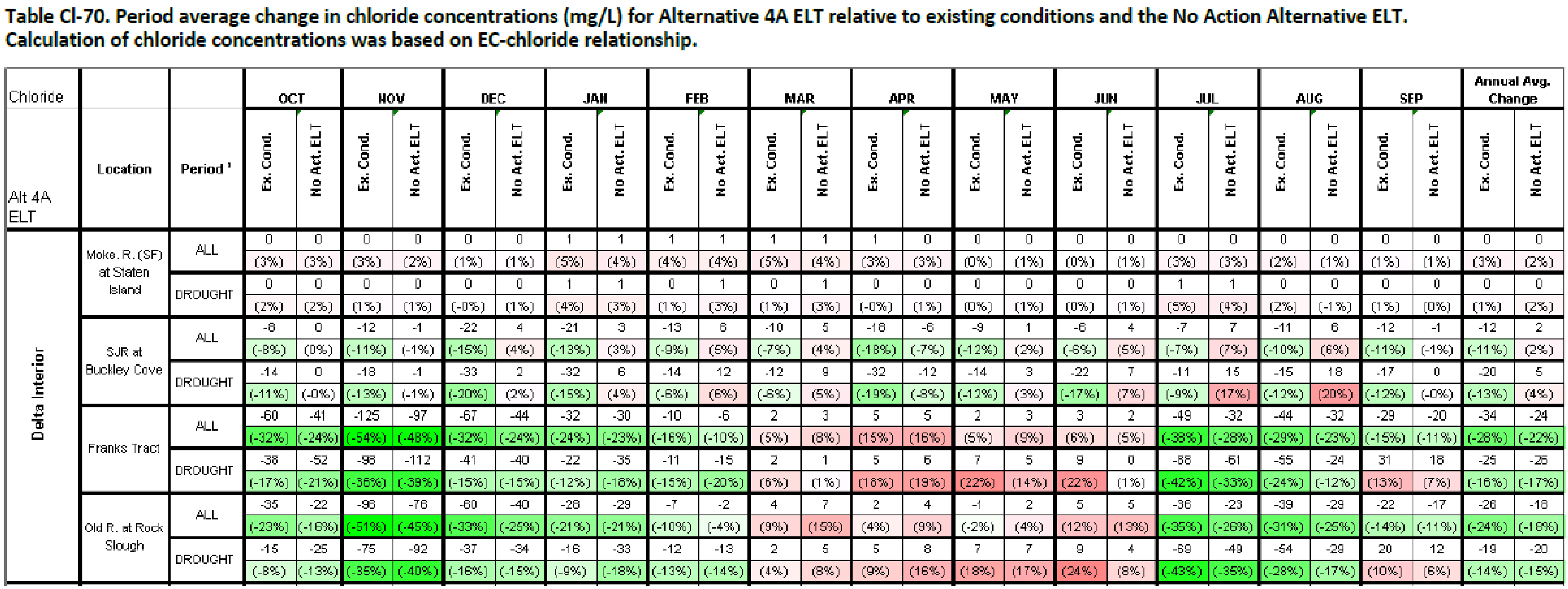

Table Cl-70. Period average change in chloride concentrations (mg/L) for Alternative 4A ELT relative to existing conditions and the No Action Alternative ELT. Calculation of chloride concentrations was based on EC-chloride relationship.

Chloride			OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		Annual Avg. Change	
Alt 4A ELT	**Location**	**Period ¹**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**	**Ex. Cond.**	**No Act. ELT**
Delta Interior	Moke. R. (SF) at Staten Island	ALL	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
			(3%)	(3%)	(3%)	(2%)	(1%)	(1%)	(5%)	(4%)	(4%)	(4%)	(5%)	(4%)	(3%)	(3%)	(0%)	(1%)	(0%)	(1%)	(3%)	(3%)	(2%)	(1%)	(1%)	(1%)	(3%)	(2%)
		DROUGHT	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
			(2%)	(2%)	(1%)	(1%)	(-0%)	(1%)	(4%)	(3%)	(1%)	(3%)	(1%)	(3%)	(-0%)	(1%)	(0%)	(1%)	(0%)	(1%)	(5%)	(4%)	(2%)	(-1%)	(1%)	(0%)	(1%)	(2%)
	SJR at Buckley Cove	ALL	-8	0	-12	-1	-22	4	-21	3	-13	6	-10	5	-18	-6	-9	1	-6	4	-7	7	-11	6	-12	-1	-12	2
			(-8%)	(0%)	(-11%)	(-1%)	(-15%)	(4%)	(-13%)	(3%)	(-9%)	(5%)	(-7%)	(4%)	(-18%)	(-7%)	(-12%)	(2%)	(-6%)	(5%)	(-7%)	(7%)	(-10%)	(6%)	(-11%)	(-1%)	(-11%)	(2%)
		DROUGHT	-14	0	-18	-1	-33	2	-32	6	-14	12	-12	9	-32	-12	-14	3	-22	7	-11	15	-15	18	-17	0	-20	5
			(-11%)	(-0%)	(-13%)	(-1%)	(-20%)	(2%)	(-15%)	(4%)	(-6%)	(6%)	(-6%)	(5%)	(-19%)	(-8%)	(-12%)	(3%)	(-17%)	(7%)	(-9%)	(17%)	(-12%)	(20%)	(-12%)	(-0%)	(-13%)	(4%)
	Franks Tract	ALL	-60	-41	-125	-97	-67	-44	-32	-30	-10	-6	2	3	5	5	2	3	3	2	-49	-32	-44	-32	-29	-20	-34	-24
			(-32%)	(-24%)	(-54%)	(-48%)	(-32%)	(-24%)	(-24%)	(-23%)	(-16%)	(-10%)	(5%)	(8%)	(15%)	(16%)	(5%)	(9%)	(6%)	(5%)	(-38%)	(-28%)	(-29%)	(-23%)	(-15%)	(-11%)	(-28%)	(-22%)
		DROUGHT	-38	-52	-98	-112	-41	-40	-22	-35	-11	-15	2	1	5	6	7	5	9	0	-68	-61	-55	-24	31	18	-25	-26
			(-17%)	(-21%)	(-36%)	(-39%)	(-15%)	(-15%)	(-12%)	(-16%)	(-15%)	(-20%)	(6%)	(1%)	(16%)	(19%)	(22%)	(14%)	(22%)	(1%)	(-42%)	(-33%)	(-24%)	(-12%)	(13%)	(7%)	(-16%)	(-17%)
	Old R. at Rock Slough	ALL	-35	-22	-96	-76	-60	-40	-26	-29	-7	-2	4	7	2	4	-1	2	5	5	-36	-23	-39	-29	-22	-17	-26	-16
			(-23%)	(-16%)	(-51%)	(-45%)	(-33%)	(-25%)	(-21%)	(-21%)	(-10%)	(-4%)	(9%)	(15%)	(4%)	(9%)	(-2%)	(4%)	(12%)	(13%)	(-35%)	(-26%)	(-31%)	(-25%)	(-14%)	(-11%)	(-24%)	(-16%)
		DROUGHT	-15	-25	-75	-92	-37	-34	-16	-33	-12	-13	2	5	5	8	7	7	9	4	-69	-49	-54	-29	20	12	-19	-20
			(-8%)	(-13%)	(-35%)	(-40%)	(-16%)	(-15%)	(-9%)	(-18%)	(-13%)	(-14%)	(4%)	(8%)	(9%)	(16%)	(18%)	(17%)	(24%)	(8%)	(-43%)	(-35%)	(-28%)	(-17%)	(10%)	(6%)	(-14%)	(-15%)

Figure 9. Excerpt of Table Cl-70 from Appendix 8G of the FEIR/EIS (p. 8G-84) showing the change in average chloride concentration under Alternative 4A relative to the NAA and EBC1 baselines

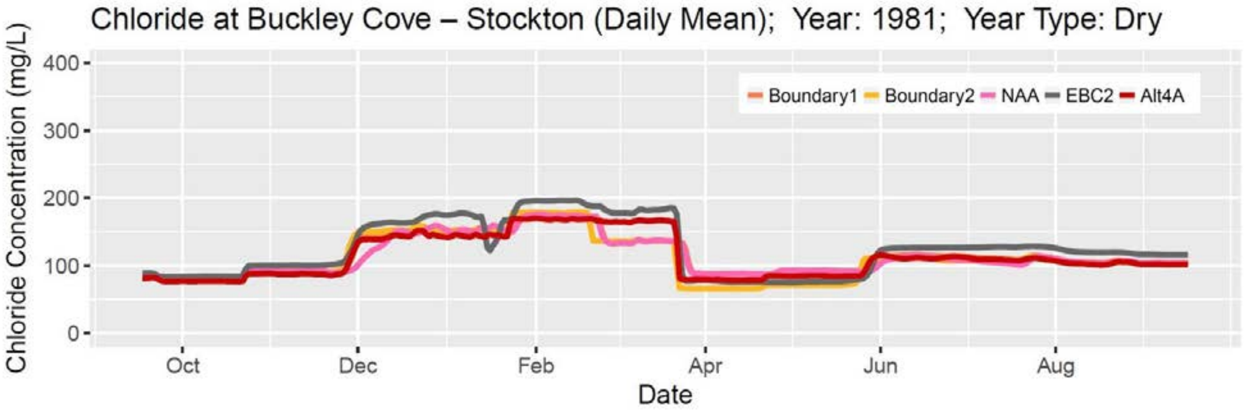

Figure 10. Concentration of chloride at Buckley Cove under various operational scenarios during water year 1981

7. The AMMP Remains Undefined in the FEIR/EIS and Does not Present a Clear Method or Rationale for Managing WaterFix Operations

The AMMP remains almost wholly undefined in the FEIR/EIS and offers only a broad description of program objectives and the program's conceptual framework. The AMMP is intended to be a project management strategy that allows for wide flexibility in determining the rates, volumes, and timing of water diversion operations from the Sacramento River, and which is expected to be a central component of the Project. As described in Finding 3, above, DWR has indicated that Project operations may vary within a very wide range of operations, from Scenario B1 to Scenario B2; however, DWR has provided almost no documentation in the FEIR/EIS or within other documents to describe how Project operations will be managed under the AMMP.

Instead, DWR states that "detailed monitoring and research plans *will be developed* that identify specific metrics and protocols" (FEIR/EIS p. 3-26, emphasis added) which should govern the AMMP. The FEIR/EIS also states that the AMMP may serve as a means to change Project operations beyond permitted limits.[20] The specific metrics and protocols by which the Project operations will be managed will determine the impacts of the proposed Project but thus far have not been developed or described. The FEIR/EIS also does not describe which agencies or personnel will be responsible for the research plans, operational protocols, and metric evaluation, or what the respective authorities and limits of the agencies will be.

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[20] The FEIR/EIS (p. 3-287) states that "[t]he collaborative science effort is expected to inform operational decisions within the ranges established by the biological opinion and 2081b permit for the proposed Project. However, if new science suggests that operational changes may be appropriate that fall outside of the operational ranges evaluated in the biological opinion and authorized by the 2081b permit, the appropriate agencies will determine, within their respective authorities, whether those changes should be implemented."

The little information that is provided on the AMMP in the FEIR/EIS focuses on water supply and water quality outcomes that impact fish survival, rather than those that impact M&I water supply. On page 3-283 of the FEIR/EIS, DWR states that “Under the current BiOps and future operations under California WaterFix, a ‘real-time operations’ (RTO) mechanism will allow for adjustments of water operations, within established conditions … to benefit covered fish species.” The AMMP does not describe efforts or protocols to protect water quality for M&I beneficial uses, does not include metrics, standards, or boundaries that will be used to evaluate water quality impacts, and does not describe any measures that may be implemented to address or mitigate water quality degradation. The fact that water quality apparently will not be considered to protect drinking water beneficial uses within the AMMP leads to still more uncertainty regarding the potential impacts of the proposed Project on the City.

8. Increased *Microcystis* Growth May Result from the Project.

Increases in *Microcystis* blooms are a concern in the Delta, as these cyanobacteria are 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.[21] To evaluate the possibility of increased risk from this organism, the FEIR/EIS attempted to categorize all proposed project alternatives on a relative scale.

Overall, the factors known to control *Microcystis* growth in the Delta that are identified in the FEIR/EIS seem consistent with the state of the science. An increase in temperature and a decrease in flow rates were identified as the two most important influences on *Microcystis* growth in the Delta, with smaller potential impacts from changes in turbidity and nutrient concentrations.[22] However, the FEIR/EIS provides only a qualitative analysis of the potential impact of each proposed alternative on the likelihood that an increase in *Microcystis* blooms may occur. No detail is given on the criteria used to generate these results, which include a numerical rating proportional to the extent of the predicted impact, and which are presented on a whole-delta basis.[23] The use of a whole-Delta approach is inappropriate, as it does not consider area-specific changes as they relate to beneficial uses. On a whole-Delta basis, it would be possible to maintain a constant frequency of *Microcystis* blooms, while increasing ecological and human health risk, simply by altering the likely locations or timing of the blooms such that blooms are likely to be present at or near a drinking water intake for a longer period of time or more frequently.

In particular, the changes in temperature, flow rate (which is related to residence time), and turbidity in areas of drinking water intakes, including the City’s intake, need to be specifically considered. It is established that lower streamflows that result in higher residence times

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

[22] FEIR/EIS p. 8-196 through 8-197.

[23] FEIR/EIS Figure 8.0-b.

correlate with an increased likelihood of blooms in the Delta.[24] All of the proposed Alternatives evaluated result in an increase in predicted summer mean residence times for all subregions of the Delta, with the exception of Suisun Marsh.[25] Although the FEIR/EIS specifically notes that under proposed Alternative 4A, "residence times may increase in parts of the southern and central Delta,"[26] Alternative 4A is not ranked as more likely to contribute to *Microcystis* blooms than the No Action Alternative (NAA).[27] The reasoning behind this conclusion is not presented.

Likewise, because studies have shown a sharp increase in the likelihood of *Microcystis* blooms in the Delta based on only moderate increases in temperature (from a likelihood of 10% at 20ºC to 50% at 25ºC[28]), the effect of temperature at locations throughout the Delta should be addressed explicitly in the FEIR/EIS. It is important to examine both the relative increases and decreases in temperature at specific locations, and also the absolute temperature predictions in relation to known thresholds (e.g., *Microcystis* blooms can occur when temperatures are greater than 19ºC[29]).

In summary, the FEIR/EIS conclusions regarding *Microcystis* are not fully explained and appear to be unfounded, and some factors, such as temperature, are not addressed fully. Given the increase in the residence time of water within the Delta that is predicted to occur as a result of the WaterFix Project, the likelihood of *Microcystis* blooms can be expected to increase.

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[24] 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.

[25] FEIR/EIS Table 8-60a.

[26] See FEIR/EIS at p. 8-980. Additionally, Exponent has previously demonstrated that residence times in the interior Delta will increase under certain WaterFix alternatives, including the Boundary 1 scenario, as a result of the diversion both of more water and of more Sacramento River water, which otherwise would have entered the Delta and increased the rate at which flushing of the Delta occurs. See Section 6C of Attachment 2.

[27] FEIR/EIS Figure 8.0-b.

[28] Mioni, C. 2012. What Controls Harmful Algal Blooms and Toxicity in the Sacramento-San Joaquin Delta? Research Summaries, California Sea Grant College Program, U.C. San Diego. Available: http://escholarship.org/uc/item/3qf633v9.

[29] 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.

Attachment 1

Curriculum vitae of
Susan C. Paulsen, Ph.D., P.E.

Exponent®

Susan C. Paulsen, Ph.D., P.E.

Principal Scientist & Practice Director

Professional Profile

Dr. Susan Paulsen is a Principal Scientist and the Director of Exponent's Environmental and Earth Sciences practice. Dr. Paulsen has 24 years of experience with projects involving hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents. She has provided expert testimony on matters involving the Clean Water Act and state water quality regulations, and she also provides scientific and strategic consultation on matters involving Superfund (CERCLA) and Natural Resources Damages (NRD). She has expertise designing and implementing field and modeling studies of dilution and analyzing the fate and transport of organic and inorganic pollutants, including DDT, PCBs, PAHs, copper, lead, and selenium, in surface and groundwater and in sediments.

Dr. Paulsen has designed and implemented field studies in reservoir, river, estuarine, and ocean environments using dye and elemental tracers to evaluate the impact of pollutant releases and treated wastewater, thermal, and agricultural discharges on receiving waters and drinking-water intakes. Dr. Paulsen has designed and managed modeling studies to evaluate transport and mixing, including the siting and design of diffusers, and has evaluated water quality impacts of stormwater runoff, irrigation, wastewater and industrial process water treatment facilities, and desalination brines. Dr. Paulsen has extensive knowledge of California water supply issues, including expertise in California's Bay-Delta estuary, the development of alternative water supplies, and integration of groundwater basins into supply and storage projects.

Dr. Paulsen has designed studies using one-dimensional hydrodynamic models (including DSM2 and DYRESM), three-dimensional CFD modeling, longitudinal dispersion modeling, and Monte Carlo analysis. Dr. Paulsen has participated in multi-disciplinary studies of the fate and transport of organic and inorganic pollutants, including DDT, PCBs, PAHs, copper, lead, selenium, and indicator bacteria in surface waters, groundwaters, and/or sediments. She has worked on matters involving both CERCLA and NRDA, including several involving the fate and transport of legacy pollutants, and she has evaluated the impacts of oil-field operations on drinking-water aquifers.

Dr. Paulsen has broad expertise with water quality regulation through the Clean Water Act and state regulations in California, Washington, Hawaii, and other states, and has worked on temperature compliance models, NPDES permitting, permit compliance and appeals, third-party citizens' suits, and TMDL development. She has evaluated the importance of background and natural sources on stormwater and receiving-water quality and the development of numeric limits for storm flows and process-water discharges. Dr. Paulsen is the author of multiple reports describing the history and development of water quality regulations and has provided testimony on regulatory issues, water quality, and water rights.

Academic Credentials and Professional Honors

Ph.D., Environmental Engineering Science, California Institute of Technology, 1997
M.S., Civil Engineering, California Institute of Technology, 1993
B.S., Civil Engineering, Stanford University (with honors), 1991

Licenses and Certifications

Registered Professional Civil Engineer, California, #66554

Languages

Italian (Conversational)
German (Conversational)

Selected Publications and Presentations

Byard JL, Paulsen SC, Tjeerdema RS, Chiavelli D. DDT, Chlordane, Toxaphene and PCB Residues in Newport Bay and Watershed: Assessment of Hazard to Wildlife and Human Health. Reviews of Environmental Contamination and Toxicology 2015; 235.

California Council for Environmental and Economic Balance (CCEEB); authored by Paulsen SC. A Clear Path to Cleaner Water: Implementing the vision of the State Water Board for improving performance and outcomes at the State Water Boards. CCEEB: San Francisco, CA. 2013. Available at www.cceeb.org.

South Orange Coastal Ocean Desalination (SOCOD) Project; authored by Expert Panel Member Paulsen SC. Expert Panel Report: Offshore Hydrogeology/Water Quality Investigation Scoping, Utilization of Slant Beach Intake Wells for Feedwater Supply. Municipal Water District of Orange County (MWDOC): Fountain Valley, CA. 2012. Available at http://www.mwdoc.com/filesgallery/FINAL_Expert_Panel_Rept_10_9_2012.pdf.

Paulsen SC, Goteti G, Kelly BK, Yoon VK. Automated flow-weighted composite sampling of stormwater runoff in Ventura County, CA. Proceedings, Water Environment Federation 2011.12 (2011): 4186-4203. Also published as automated flow-weighted composite sampling of stormwater runoff. Water Environment Laboratory Solutions 2012; 19(2):1–6.

Paulsen SC, List EJ, Kavanagh KB, Mead AM, Seyfried R, Nebozuk S. Dynamic modeling and field verification studies to determine water quality and effluent limits downstream of a POTW discharge to the Sacramento River, California. Proceedings, Water Environment Federation 2007; 12:5695–5721.

Paulsen SC, List EJ. Potential background constituent levels in storm water at Boeing's Santa Susana Field Laboratory. Report to Expert Panel convened by The Boeing Company and Regional Water Quality Control Board, Los Angeles Region, 2007. Available at http://www.boeing.com/assets/pdf/aboutus/environment/santa_susana/water_quality/tech_reports/2007_background/2007_background_report.pdf.

Paulsen SC, List EJ, Santschi PH. Modeling variability in 210Pb and sediment fluxes near the Whites Point Outfalls, Palos Verdes Shelf, California. Environmental Science & Technology 1999; 33:3077–3085.

Paulsen SC, List EJ, Santschi PH. Comment on “In situ measurements of chlorinated hydrocarbons off the Palos Verd es Peninsula, California.” Environmental Science & Technology 1999; 33:3927–3928.

Paulsen SC, List EJ. A study of transport and mixing in natural waters using ICP-MS: Water-particle interactions. Water, Air, and Soil Pollution 1997; 99:149–156.

Paulsen SC, List EJ. Tracing discharges in ocean environments using a rare earth tracer. Presented at the 27th IAHR Congress, San Francisco, CA, August 1997.

Prior Experience

- Various positions including President, Flow Science Incorporated, Pasadena, California, 1997–2014
- Consultant to Flow Science Incorporated, Pasadena, California, 1994–1997
- Staff Engineer, Dames & Moore, Civil Design Group, San Francisco, California, 1990-1992
- Graduate Research and Teaching Assistant, Hydrologic Transport Processes and Fluid Mechanics, California Institute of Technology, Pasadena, California, 1993–1997
- Research Engineer, Fraunhofer Institute for Atmospheric Environmental Research, Garmisch-Partenkirchen, Germany (West), 1989
- Instructor, Technical Communications Program (joint Business School/School of Engineering program), Stanford University, Stanford, CA, 1989–1990

Professional Affiliations

- American Society of Civil Engineers—ASCE
- Member, National Ground Water Association

Depositions (last 4 years)

Robert Bruncati and Maureen Bruncati v. Billy Wayne Andrews, Jr., et al., Case No. CIVDS1309044, in the Superior Court of the State of California, County of San Bernardino, San Bernardino District. August 24, 2015, and September 8, 2015.

City of Cerritos, et al., v. Water Replenishment District of Southern California, Case No. BS128136, in the Superior Court of the State of California, County of Los Angeles. November 24, 2014.

The Boeing Company et al. v. State of Washington, Department of Ecology, Appeal of the 2010 Industrial Stormwater General Permit, Pollution Control Hearings Board, State of Washington. Case No. 09-140. 2011.

Puget Soundkeeper Alliance v. BNSF Railway Co., Case No. C09-1087-JCC, in the United States District Court, Western District of Washington at Seattle. 2011.

Trials and Hearings (last 4 years)

Robert Bruncati and Maureen Bruncati v. Billy Wayne Andrews, Jr., et al., Case No. CIVDS1309044, in the Superior Court of the State of California, County of San Bernardino, San Bernardino District. 2015.

The Boeing Company et al. v. State of Washington, Department of Ecology, Appeal of the 2010 Industrial Stormwater General Permit, Pollution Control Hearings Board, State of Washington. Case No. 09-140. 2011.

Attachment 2

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.

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

Exhibit Brentwood-102

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

Exhibit Brentwood-102

Prepared for

City of Brentwood
2201 Elkins Way
Brentwood, California 94513

Prepared by

Exponent
1055 E. Colorado Blvd., Suite 500
Pasadena, CA 91106

August 30, 2016

Contents

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Acronyms and Abbreviations

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

1. Introduction

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

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

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

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

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

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

2. Background

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

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

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

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

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

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

3. Methods

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

a. DSM2 Modeling and Volumetric Fingerprinting

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

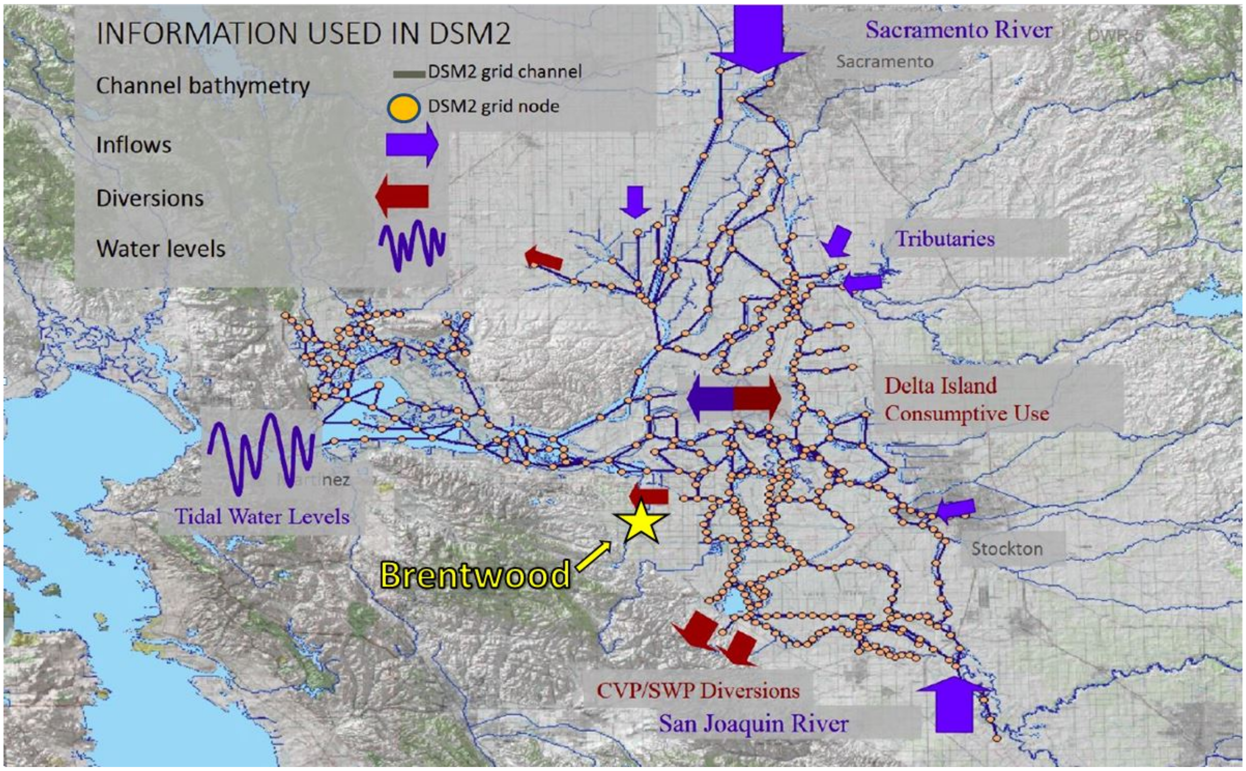

Figure 1. DSM2 model domain showing the grid nodes and channels. The City of Brentwood is shown in addition to primary inflows and diversions. (Source: Exhibit DWR-4 page 10, modified to show the general location of the City of Brentwood).

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

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

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

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

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

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

b. Residence Time in the Delta

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

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

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

c. Water Year Type Classification

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

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

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

- Wet: 1982, 1983, 1984, 1986

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

f. Salinity Conversions

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

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

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

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

4. Delta Hydrodynamics

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

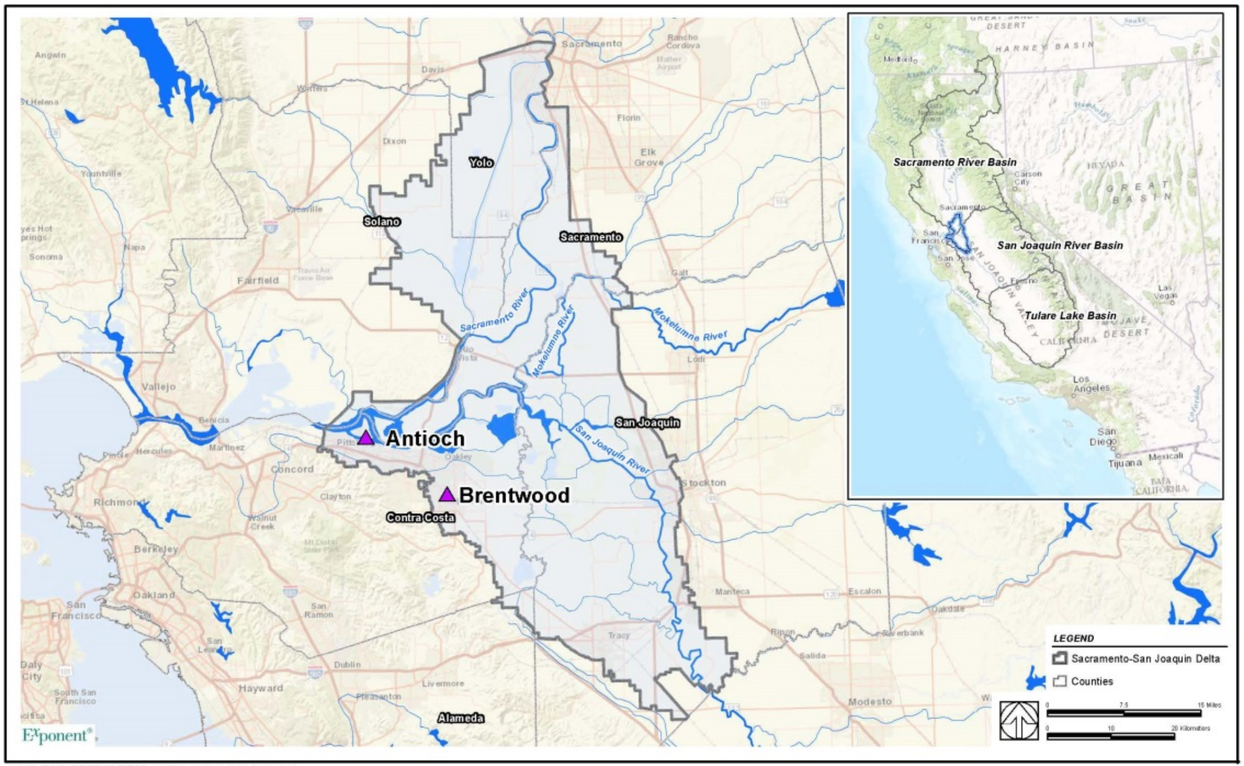

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Figure 2. Overview of the Sacramento-San Joaquin Delta showing the approximate location of the City of Brentwood. The City of Antioch is also shown.

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

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

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

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

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

a. Residence Time

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

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[6] Exhibit Brentwood-110

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

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

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

a. The evaluation uses a flawed and inappropriate baseline.

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

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

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

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

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

b. Project operations are poorly defined.

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

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

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

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

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

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

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

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[9] See Exhibit DWR-51, pp. 10:4–14.

[10] See Exhibit DWR-71, pp. 15:11–14.

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

In contrast,

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

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

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

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

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

[14] See Exhibit DWR-51, pp. 14:7–9.

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

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

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

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

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

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

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

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

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

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

c. The Adaptive Management and Monitoring Program is undefined.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[22] See Exhibit DWR-66, pp. 6:21–26

[23] See Exhibit DWR-71, pp. 5:16–18.

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

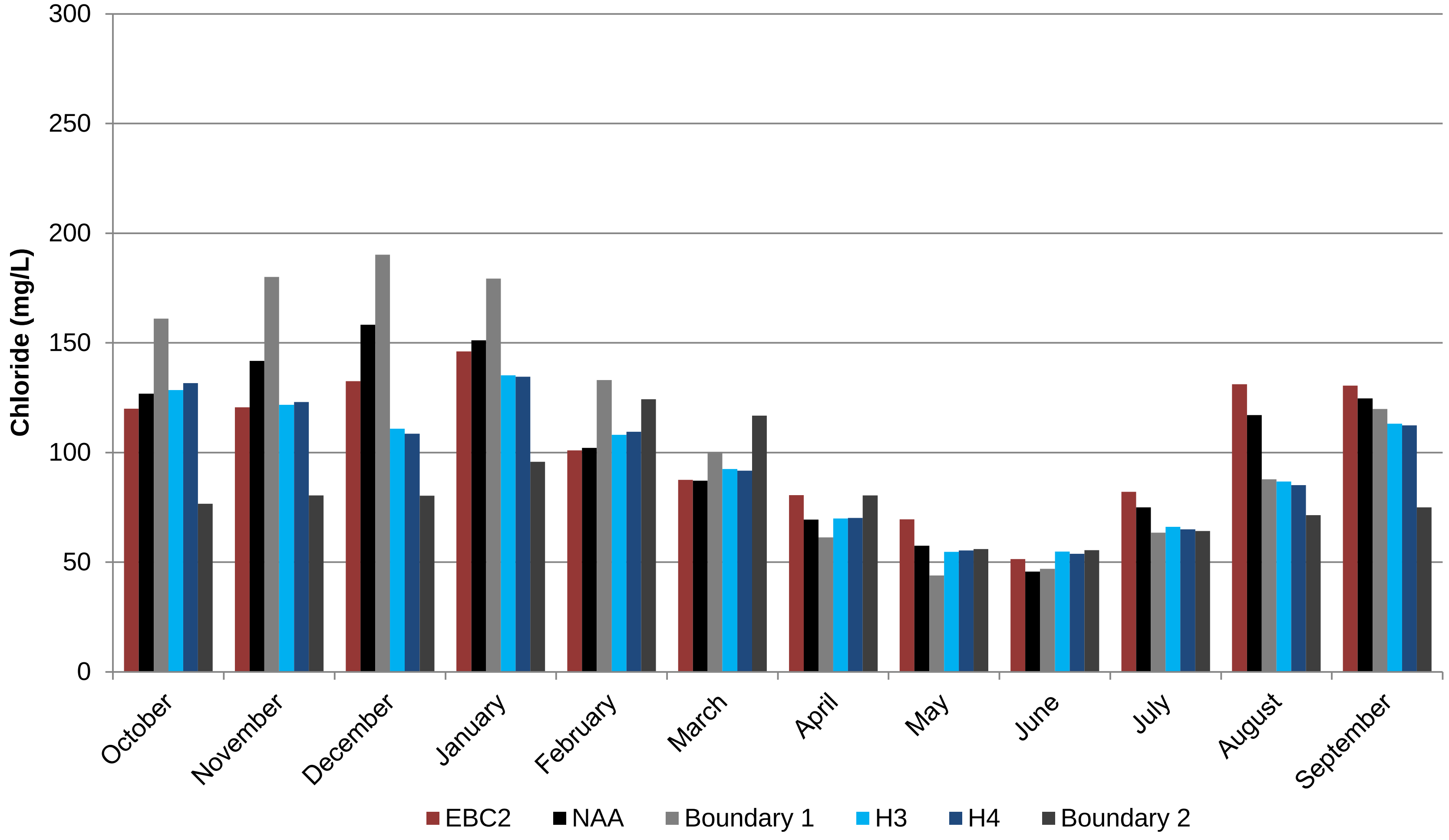

Figure 3. Monthly average chloride concentration at PP#1 from the 16-year modeled record. Note that the bars for the NAA, Boundary 1, H3, H4, and Boundary 2 scenarios were provided by DWR in DWR-513 (values may differ slightly due to different salinity conversions); Exponent has added the bar representing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

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

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

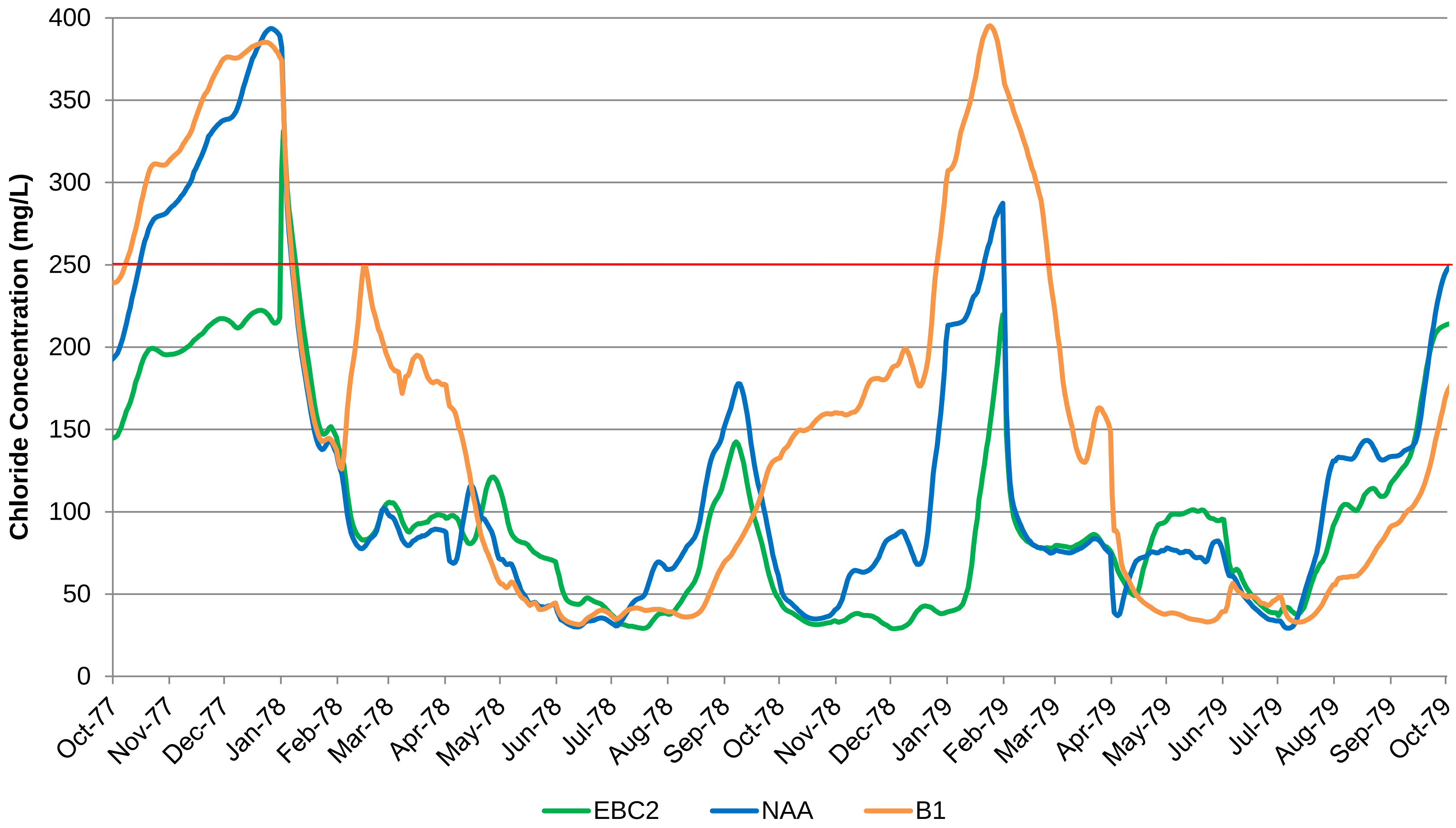

Figure 4. Daily average chloride concentrations at PP#1 for WY 1978–WY 1979, from DWR's model results. The red line indicates the 250 mg/L chloride threshold of D-1641.

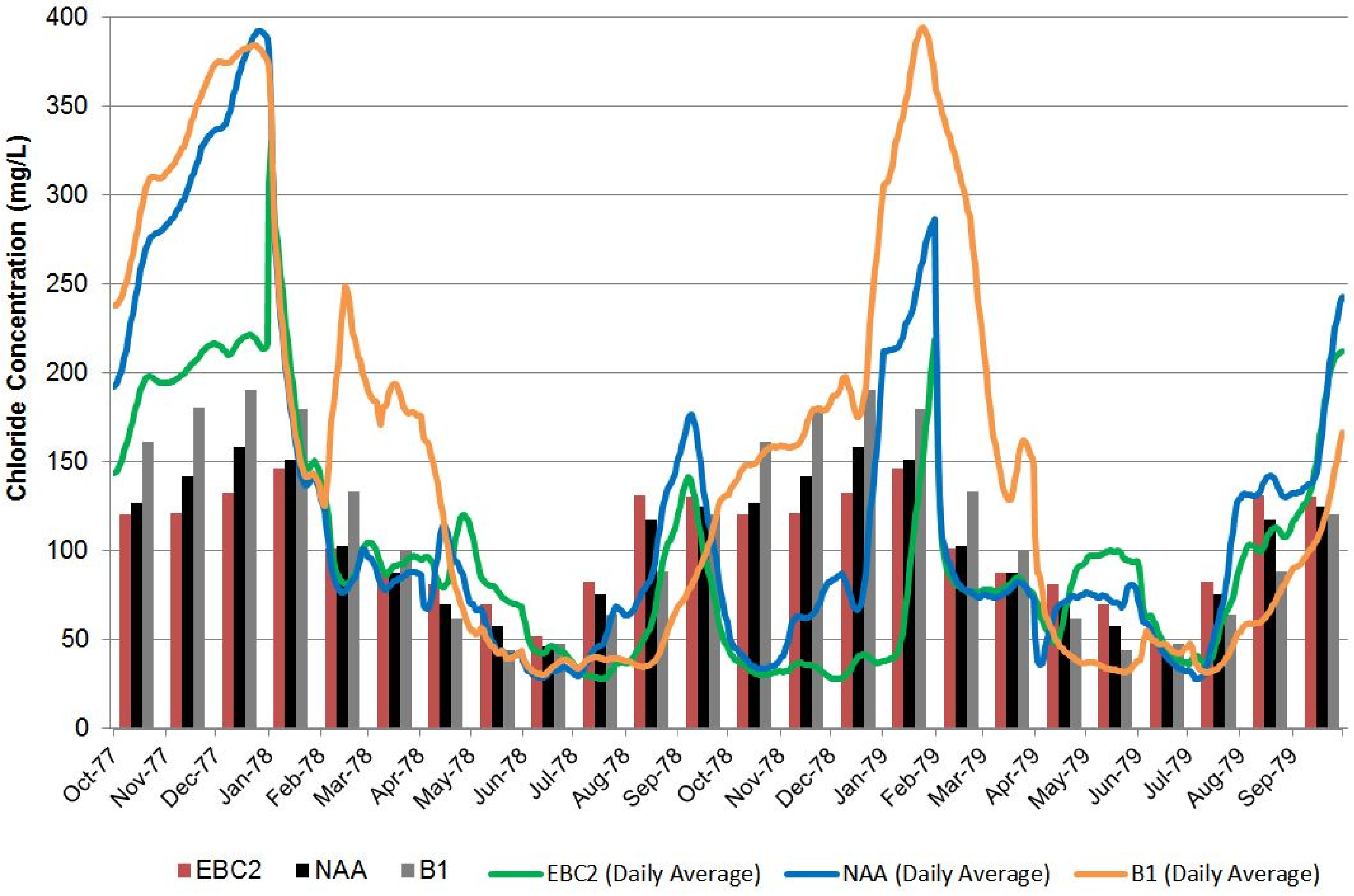

Figure 5. Daily average chloride concentrations at PP#1 for WY 1978-WY 1979 superimposed on the monthly averaged data presented in DWR-513 and recreated in Figure 3. The bars describing average salinity were repeated for each month in WY 1978 and 1979.

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

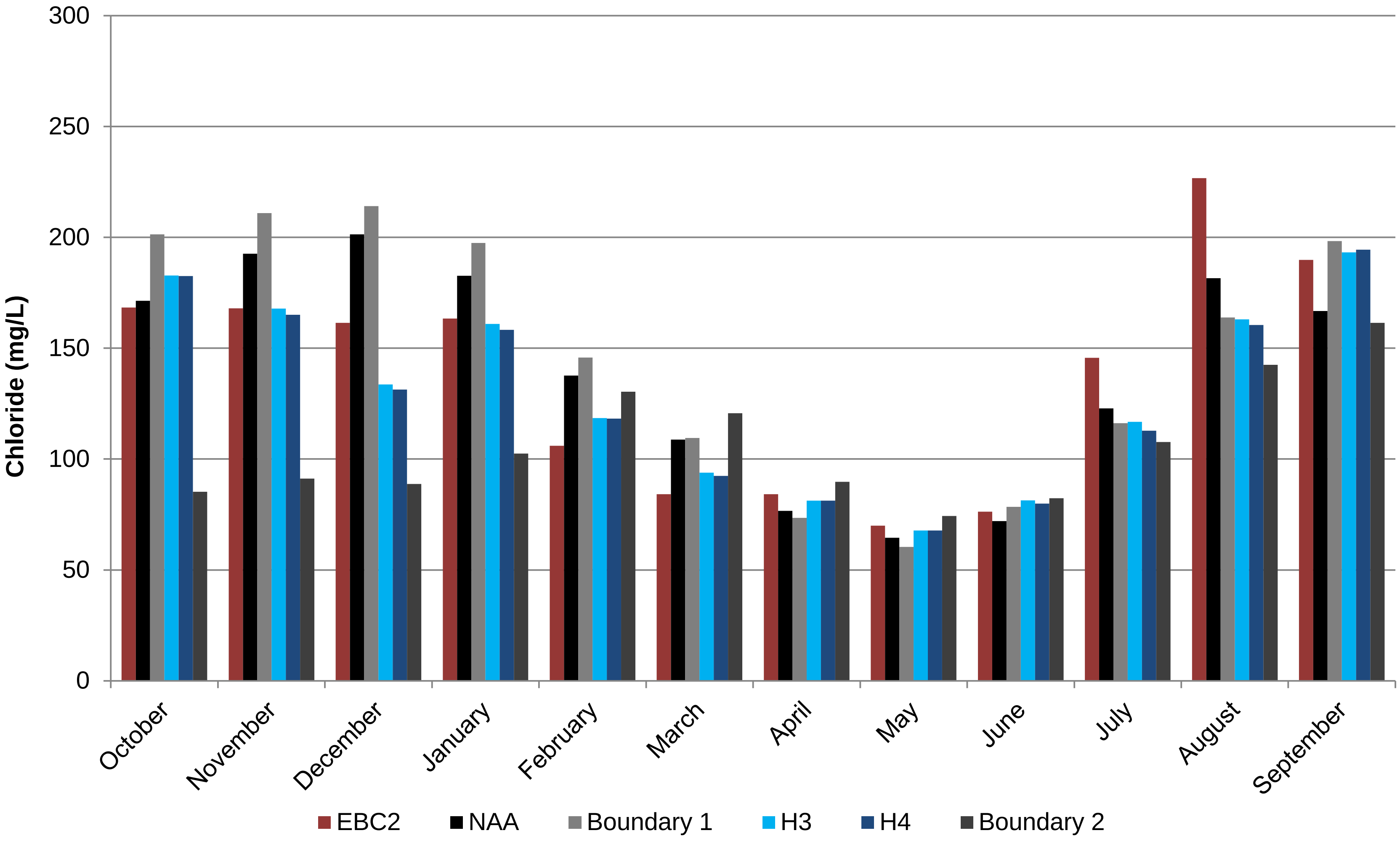

Figure 6. Modeled monthly average chloride concentrations at PP#1 in critical water years (1976, 1977, 1988, 1990, 1991).
Calculated from DWR model results.

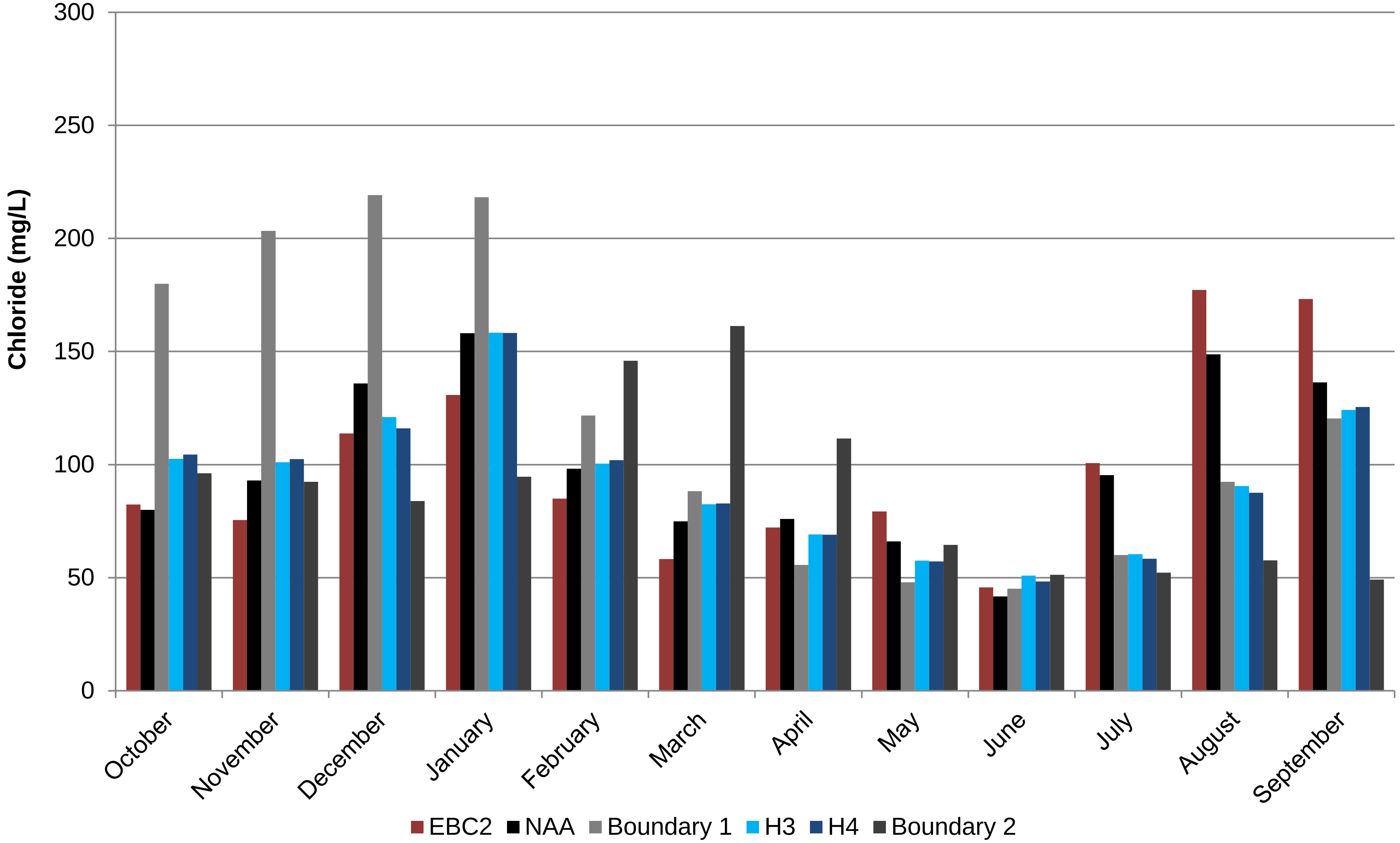

Figure 7. Modeled monthly average chloride concentrations at PP#1 in dry water years (1981, 1985, 1987, 1989). Calculated from DWR model results.

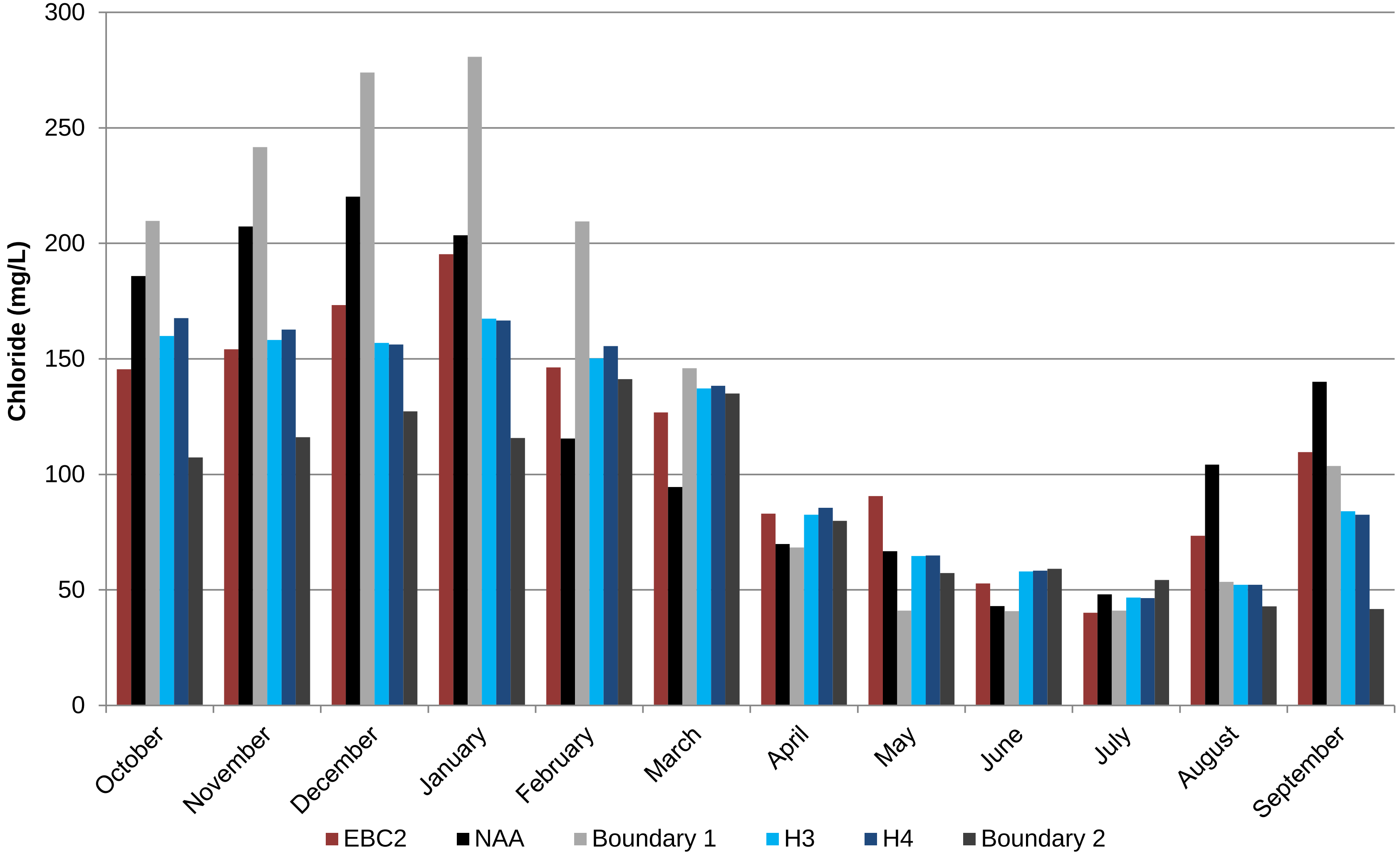

Figure 8. Modeled monthly average chloride concentrations at PP#1 in normal water years (1978, 1979, 1980). Calculated from DWR model results.

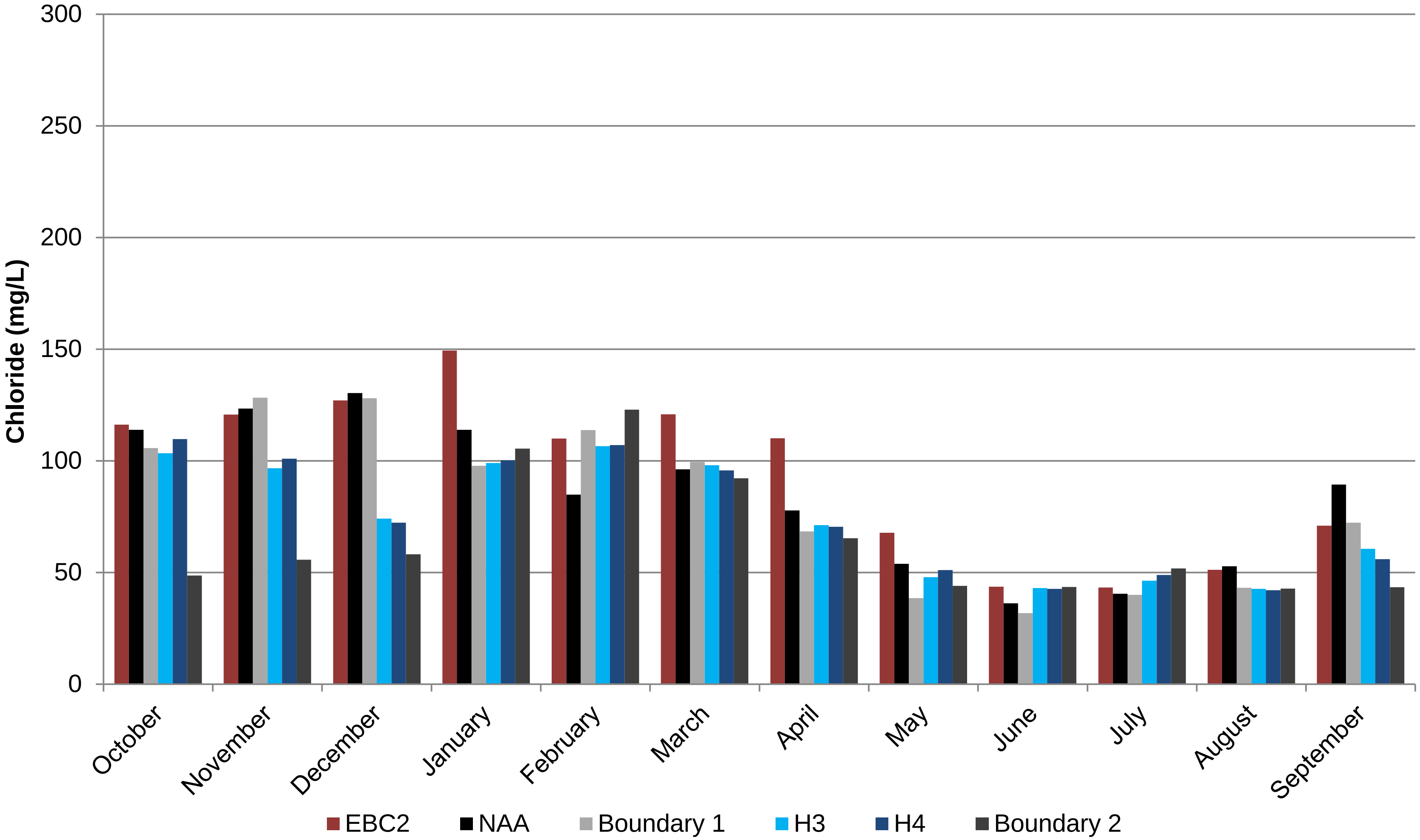

Figure 9. Modeled monthly average chloride concentrations at PP#1 in wet water years (1982, 1983, 1984, 1986). Calculated from DWR model results.

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

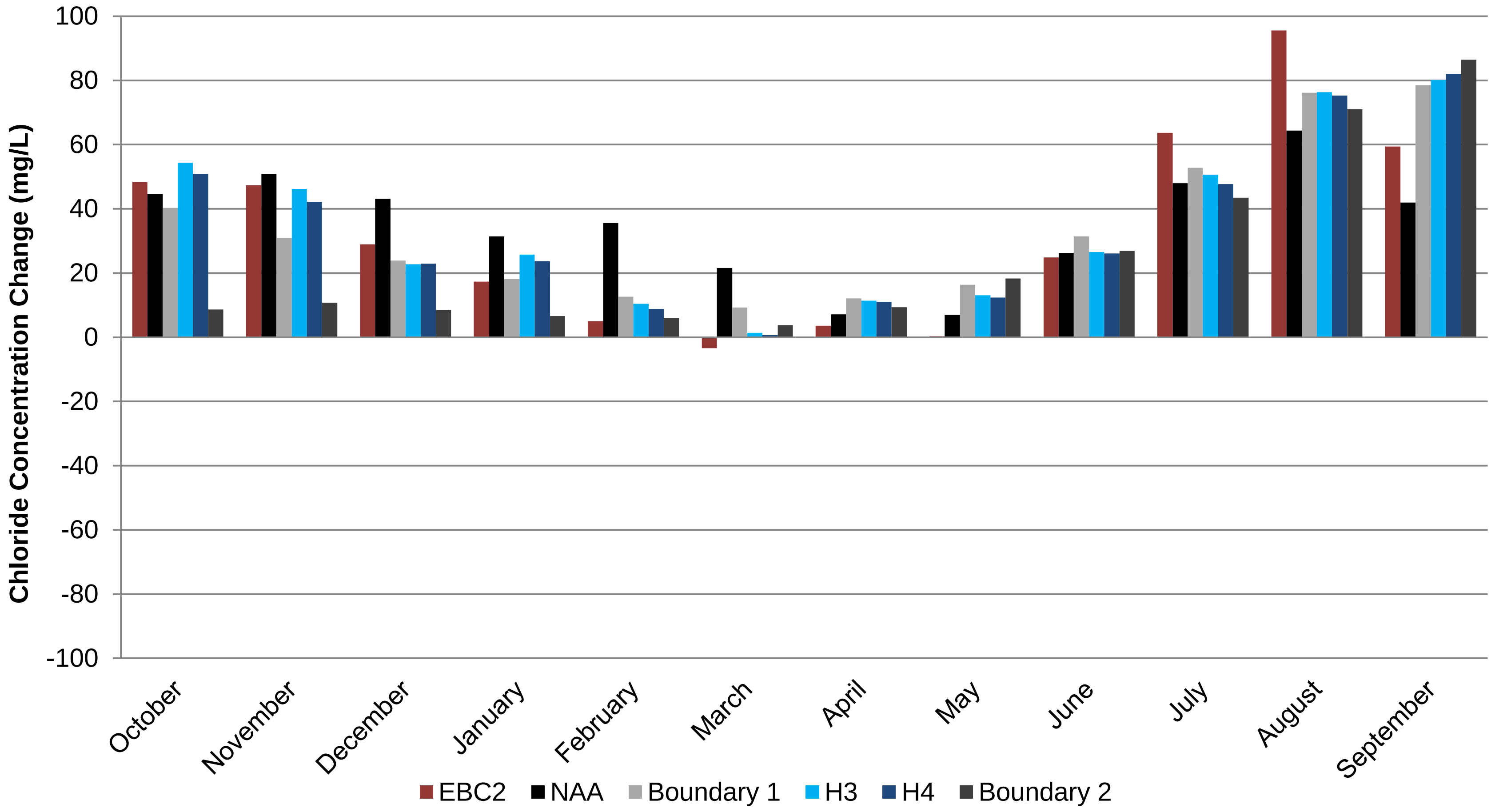

Figure 10. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for critical water year types.

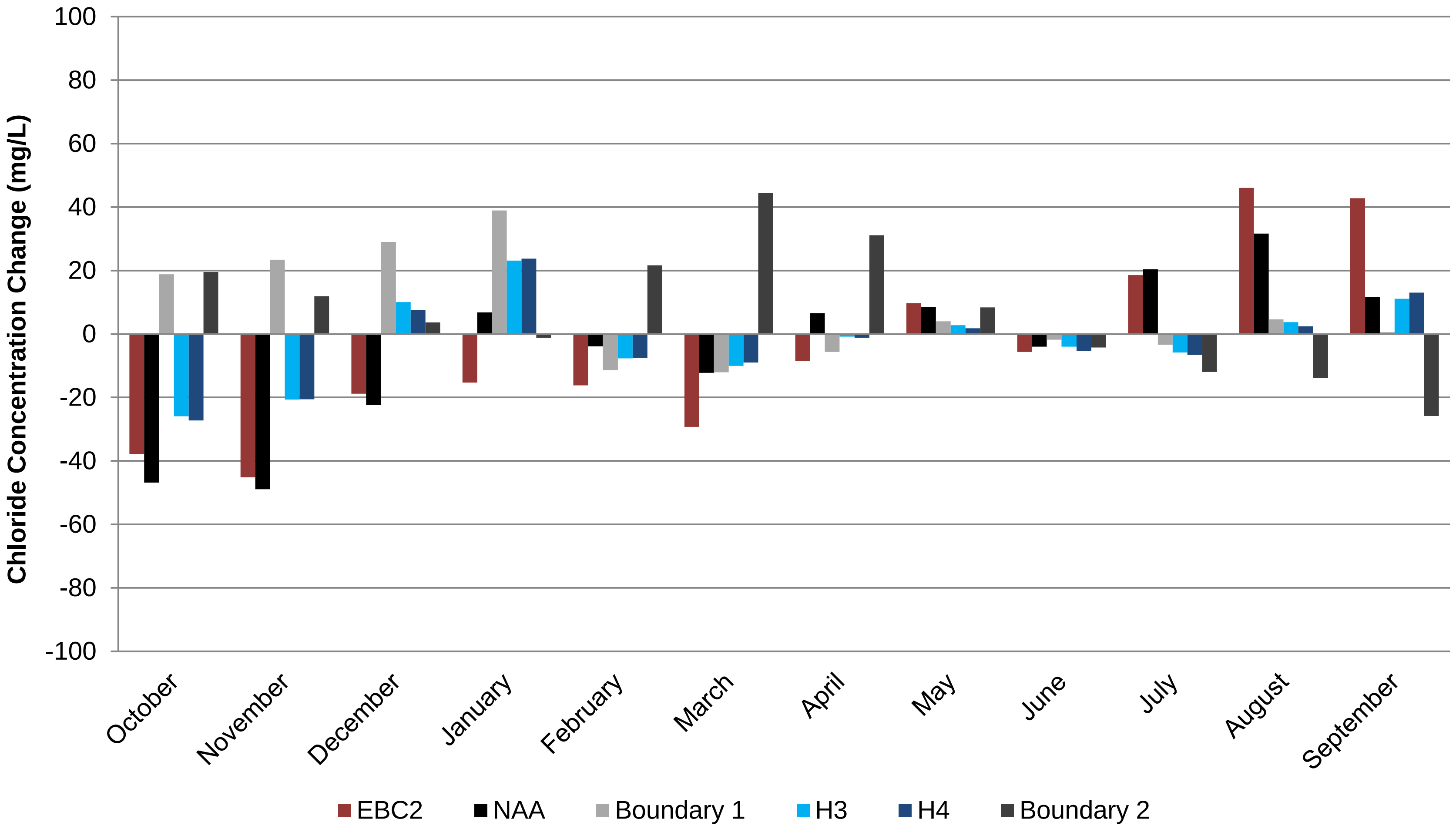

Figure 11. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for dry water year types.

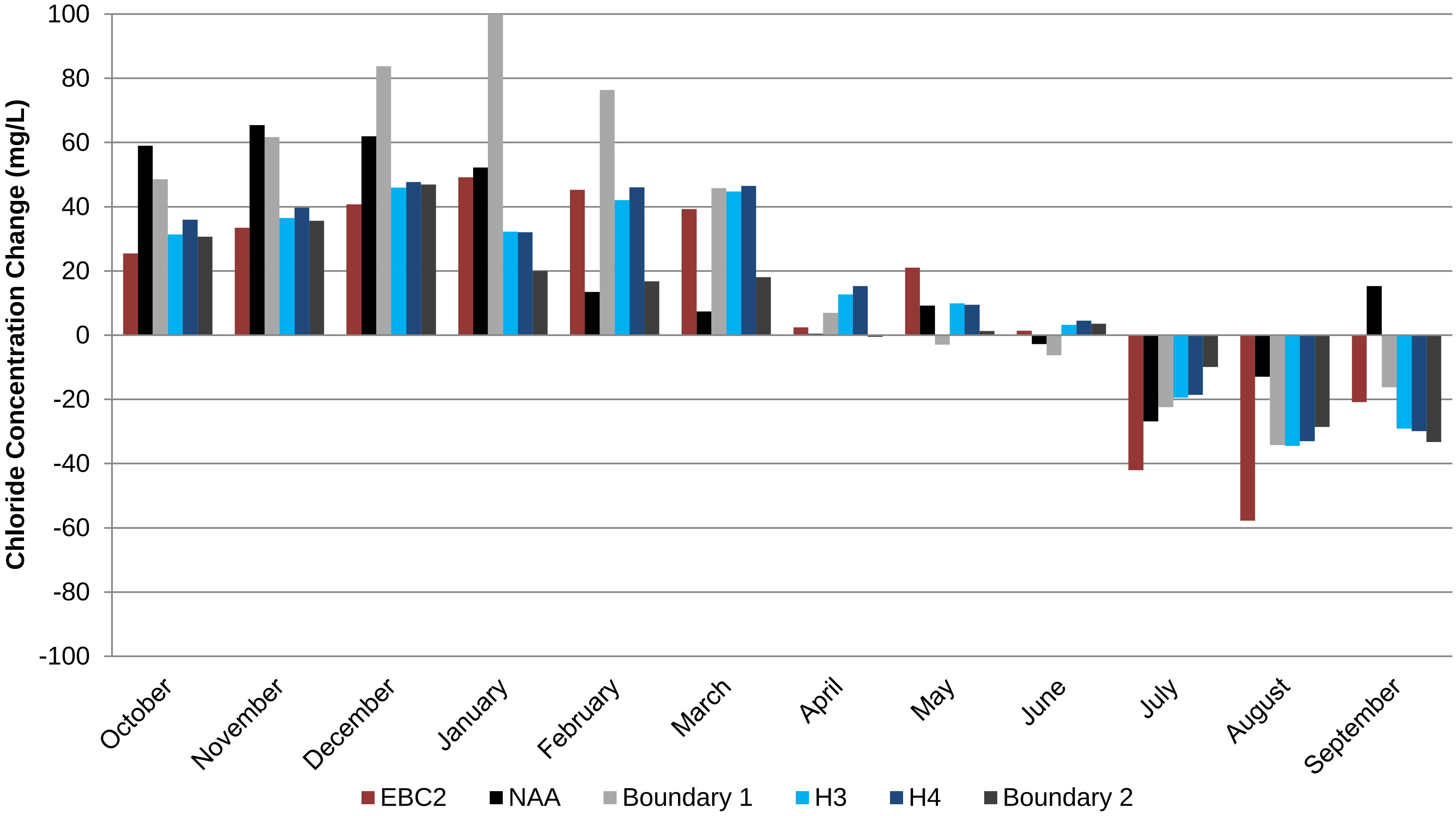

Figure 12. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for normal water year types.

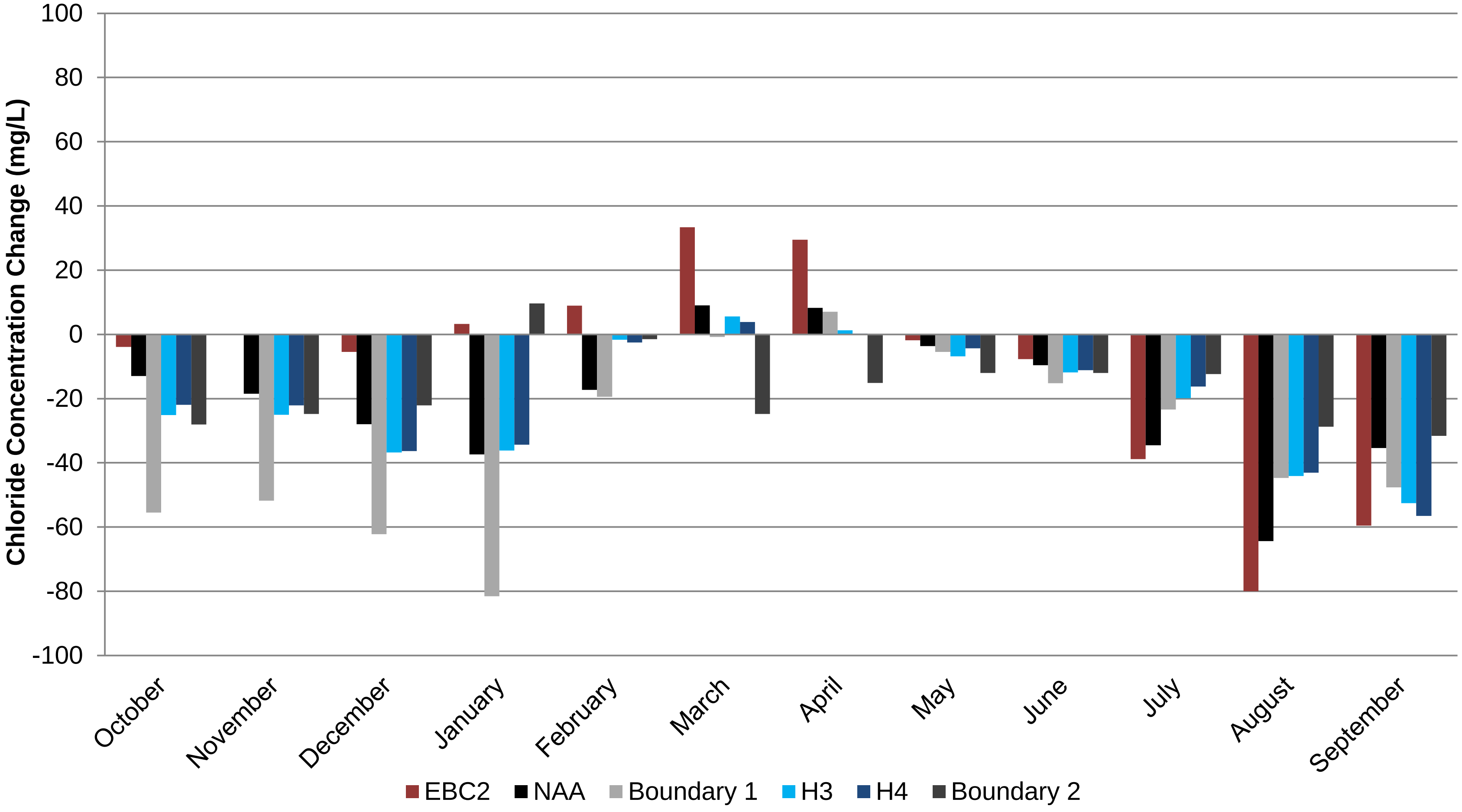

Figure 13. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for wet water year types.

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

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

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

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

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

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

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

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

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

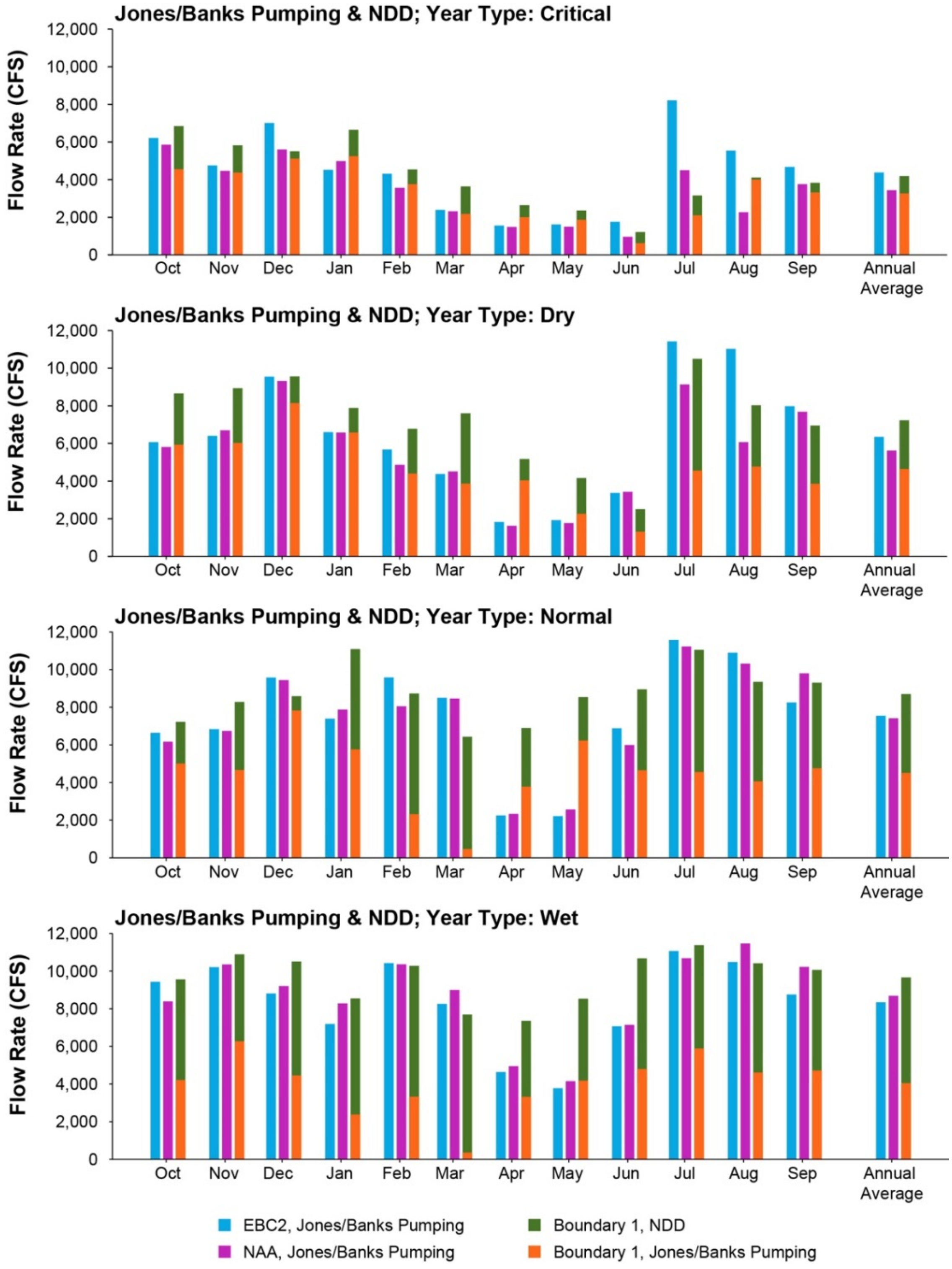

Figure 14. Quantity of water that would be exported from the Delta under the model Scenarios EBC2, NAA, and B1 as modeled by DSM2. Exports in the B1 scenario are divided to show the location from which water was exported from the Delta in the model simulations: either from the South Delta or from the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

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

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

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

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

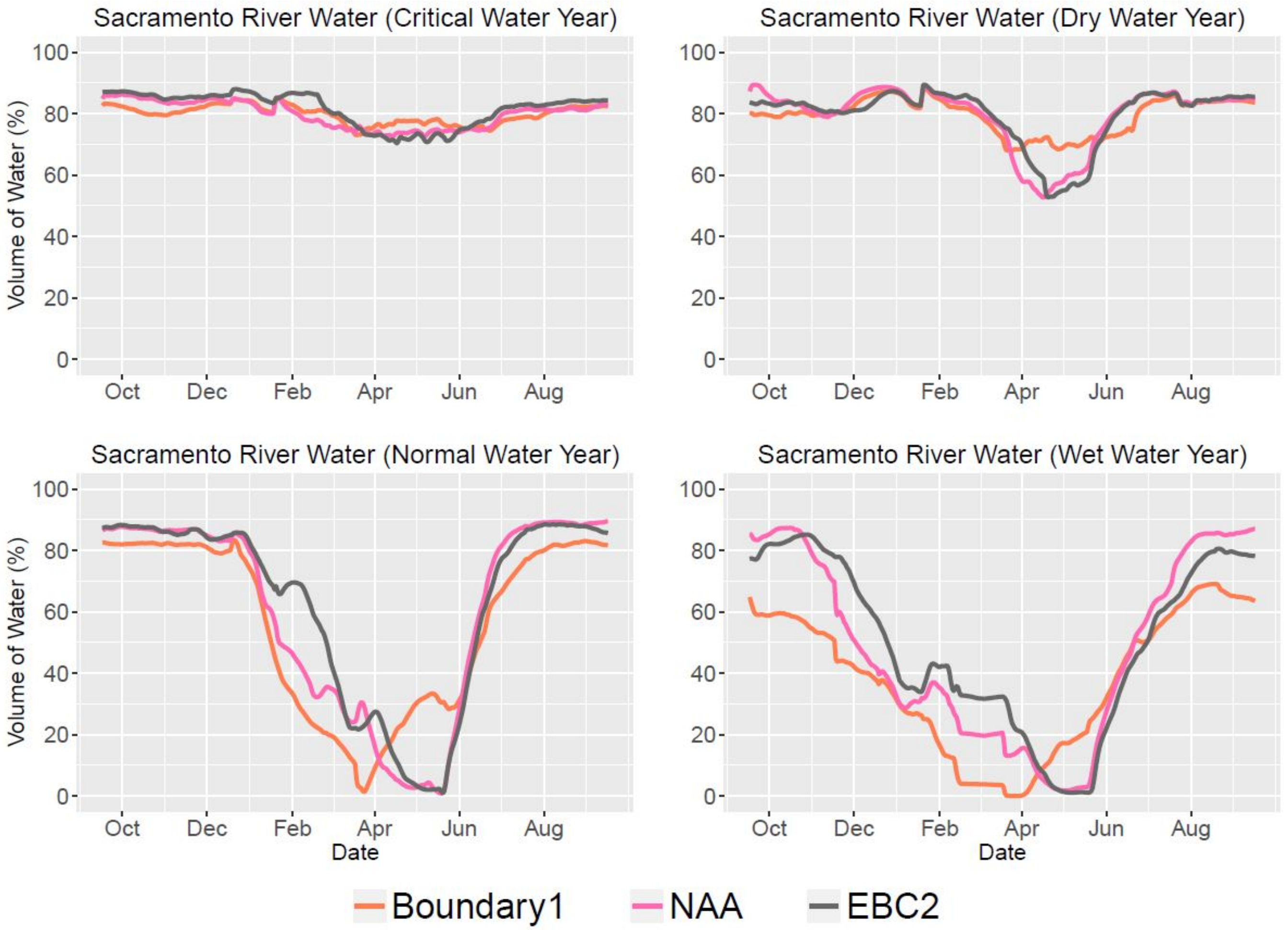

Figure 15. Source fractions of Sacramento River water at PP#1 as modeled by DSM2. Each figure represents the average daily source fraction of Sacramento River water averaged for a given water year type.

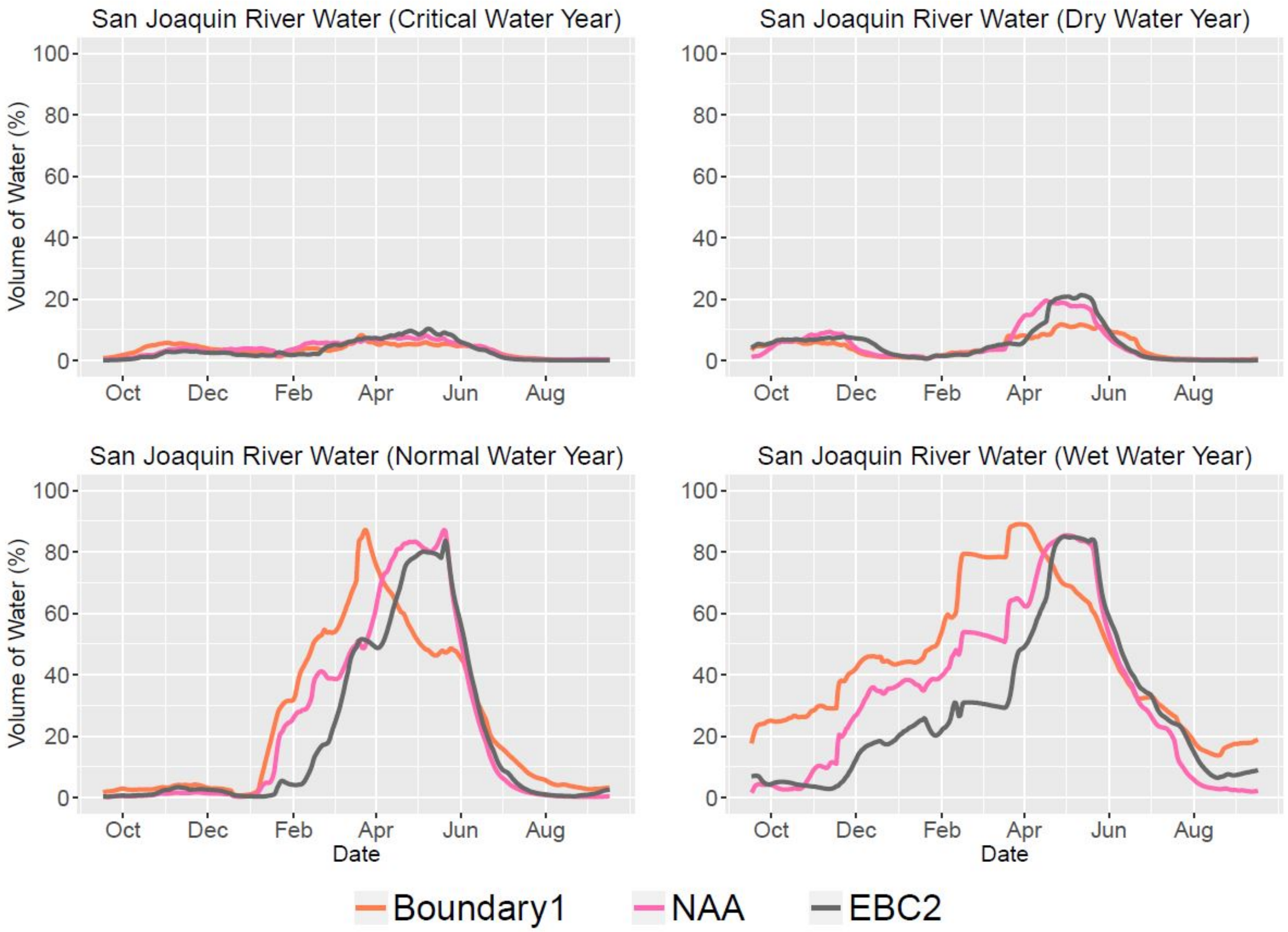

Figure 16. Source fractions of San Joaquin River water at PP#1 as modeled by DSM2. Each figure represents the average daily source fraction of San Joaquin River water averaged for a given water year type.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[33] See Exhibit DWR-61, pp. 8:3–8.

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

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

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

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

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

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

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

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

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

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[35] See Exhibit DWR-66, pp. 2:20–22.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

References

Brentwood. 2015. Technical Comments on the Draft Bay Delta Conservation Plan (BDCP) and associated Draft Environmental Impact Report and Environmental Impact Statement (RDEIR/SDEIS). Prepared by Exponent for the City of Brentwood. October 27, 2015. [Brentwood-104]

CALFED (CALFED Bay Delta Program) 2007. Conceptual Model for Salinity in the Central Valley and Sacramento-San Joaquin Delta. July 2007. [Brentwood-114]

CH2MHill. 2009. DSM2 Recalibration, prepared for California Department of Water Resources, October 2009. [Brentwood-105]

DISB (Delta Independent Science Board). 2015. Review of environmental documents for California WaterFix. Memorandum to Delta Stewardship Council and California Department of Fish and Wildlife. September 30, 2015. [SWRCB-49]

DWR (Department of Water Resources). 1978. Delta Water Facilities. Program for: Delta Protection and Water Transfer, Water Conservation, Water Recycling, Surface and Groundwater Storage. Bulletin No. 76. July 1978. State of California, Department of Water Resources. [DWR-110]

DWR (Department of Water Resources). 2005. California Water Plan Update 2005: A Framework for Action. Bulletin 160-05. Volume 3, Chapter 12: Sacramento-San Joaquin Delta Region. December 2005. [Brentwood-108]

DWR (Department of Water Resources). 2009. California Water Plan Update 2009: Integrated Water Management. Bulletin 160-09. [Brentwood-109]

DWR (Department of Water Resources). 2013. Draft Environmental Impact Report/Environmental Impact Statement Bay Delta Conservation Plan. Prepared by the U.S. Department of the Interior, Bureau of Reclamation and U.S. Department of Fish and Wildlife; the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); and the California Department of Water Resources. November 2013. [SWRCB-4]

DWR (Department of Water Resources). 2015(A). Draft Recirculated Environmental Impact Report/Supplemental Draft Environmental Impact Statement Bay Delta Conservation Plan. Prepared by the U.S. Department of the Interior, Bureau of Reclamation and U.S. Department of Fish and Wildlife; the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); and the California Department of Water Resources. July 2015. [SWRCB-3]

DWR (Department of Water Resources). 2015(B). Petition for water rights change. Petition for change in point of diversion and point of rediversion. August 25, 2015. [SWRCB-1]

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 [Brentwood-117]

ICF International. 2012. Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality. Public Draft. December. (ICF 00427.11.) Sacramento, CA. Prepared by State Water Resources Control Board, California Environmental Protection Agency, Sacramento, CA. Accessed online at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2012_sed/ [Brentwood-115]

ICF International. 2016. Biological Assessment for the California WaterFix. January. (ICF 00237.15.) Sacramento, CA. Prepared for United States Department of the Interior, Bureau of Reclamation, Sacramento, CA. [SVWU-1]

ICF International. 2016. Biological Assessment for the California WaterFix. July. (ICF 00237.15.) Sacramento, CA. Prepared for United States Department of the Interior, Bureau of Reclamation, Sacramento, CA. [SWRCB-104]

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. Volume 10, Issue 5, 323-352. October 2000. [Brentwood-107]

Mierzwa, M., J. Wilde, and B. Suits. 2006a. Long-Term Trends of Delta Residence Time. California Department of Water Resources. Bay-Delta Office. Modeling Support Branch. Delta Modeling Section. Accessed at: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/presentations/DeltaResidenceTimeResults_mmierzwa.pdf [Brentwood-111]

Mierzwa, M., J. Wilde, B. Suits, and T. Sommer. 2006b. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. Chapter 3: Developing a Residence Time Index to Study Changes in 1990-2004 Delta Circulation Patterns. 27th Annual Progress Report. October 2006. [Brentwood-112]

National Marine Fisheries Service. 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. National Marine Fisheries Service Southwest Region. June 4, 2009. [SWRCB-84]

SWRCB (State Water Resources Control Board) 2015. Notice of petition requesting changes in water rights of the Department of Water Resources and U.S. Bureau of Reclamation for the California WaterFix Project and the notice of public hearing and pre-hearing conference to consider the above petition. October 30, 2015. [Brentwood-103]

SWRCB (State Water Resources Control Board). 2000. Revised Water Right Decision 1641. Implementation of Water Quality Objectives for the San Francisco Bay/Sacramento-San

Joaquin Delta Estuary; A Petition to Change Points of Diversion of the Central Valley Project and the State Water Project in the Southern Delta; and A Petition to Change Places of Use and Purposes of Use of the Central Valley Project December 29, 1999. Revised in Accordance with Order WR 2000-02. March 15, 2000. SWRCB-21

U.S. Fish and Wildlife Service. 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP). December 15, 2008. [SWRCB-87]

Wilde, J., M. Mierzwa, and B. Suits. 2006c. Using particle tracking to indicate Delta residence time. Graphical Poster. California Department of Water Resources. Bay-Delta Office. Modeling Support Branch. Delta Modeling Section. Accessed at: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/presentations/DeltaResidenceTimeMethodology_wildej.pdf [Brentwood-113]

Appendix A

Additional Figures and Tables

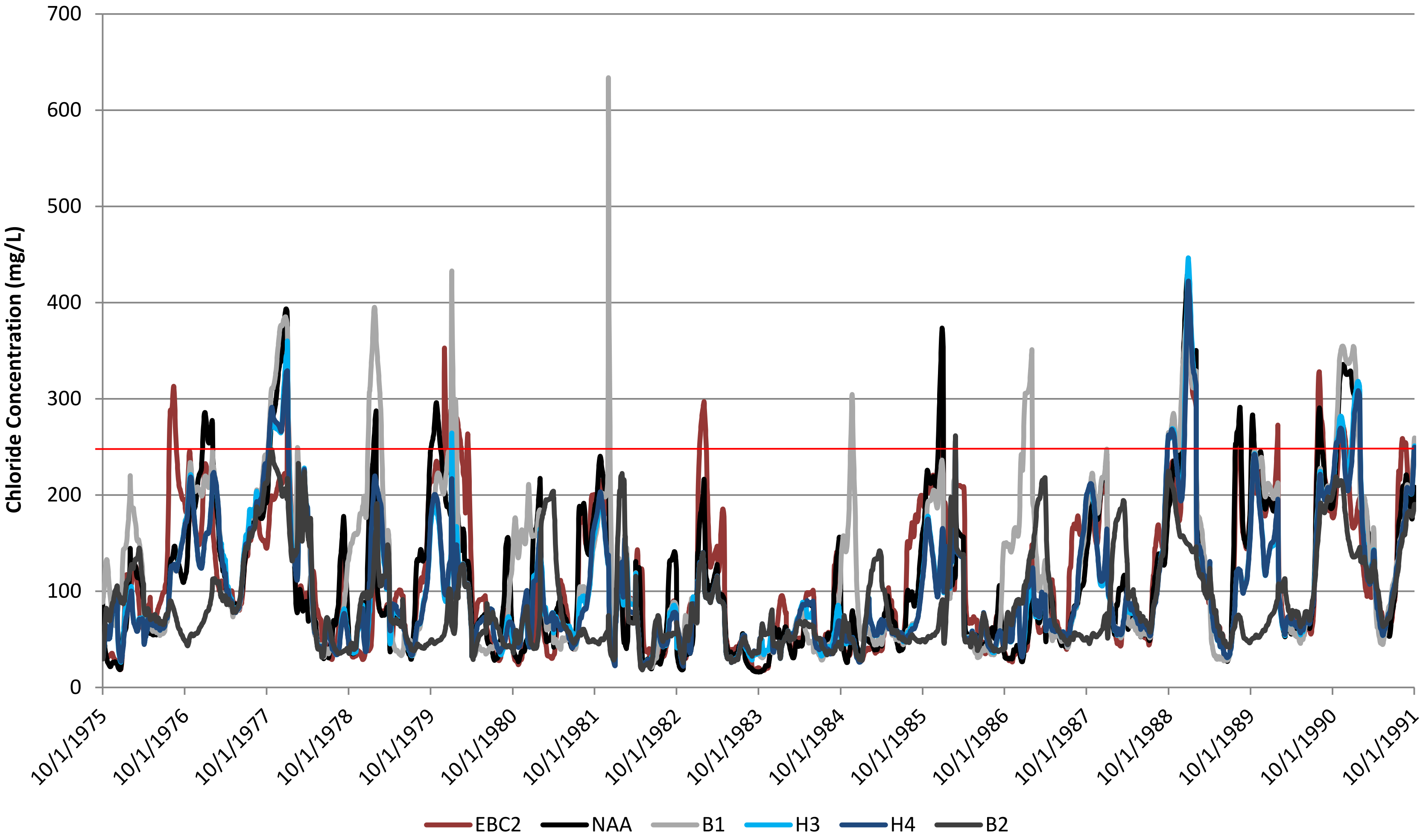


Figure A-4. Daily average chloride concentrations at PP#1 for WY 1975–WY 1991, from DWR's model results. The red line indicates the 250 mg/L chloride threshold of D-1641 (Note: colors may vary compared to Figure 4 in report, and entire modeled period included).

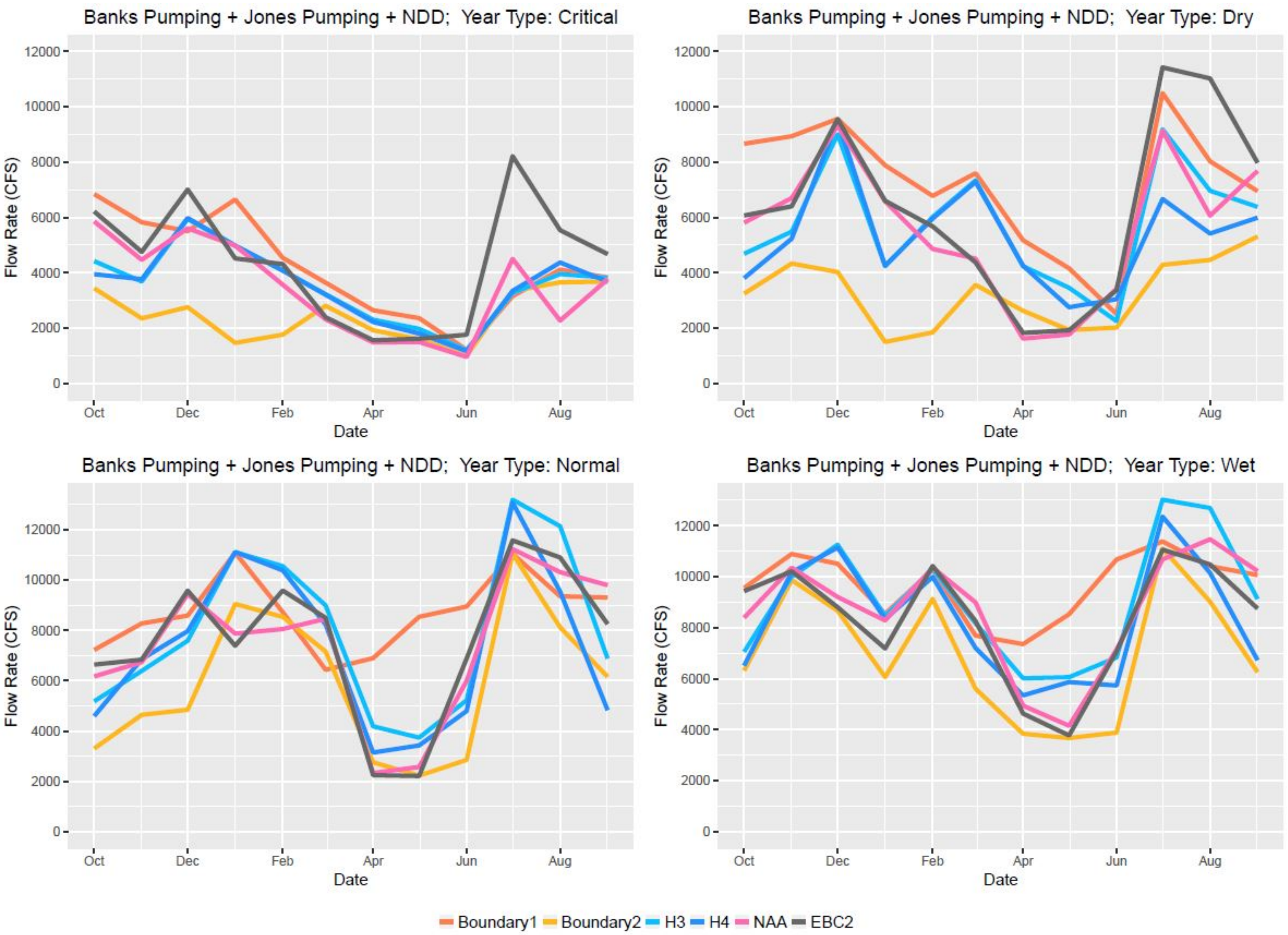


Figure A-1. Quantity of water that would be exported from the Delta under the model Scenarios EBC2, NAA, B1, H3, H4, and B2 as modeled by DSM2. Monthly average export flow rates are averaged by water year type (Note: The same data are included in Figure 14 of the report, but are presented differently).

Exhibit Brentwood-102 Appendix A

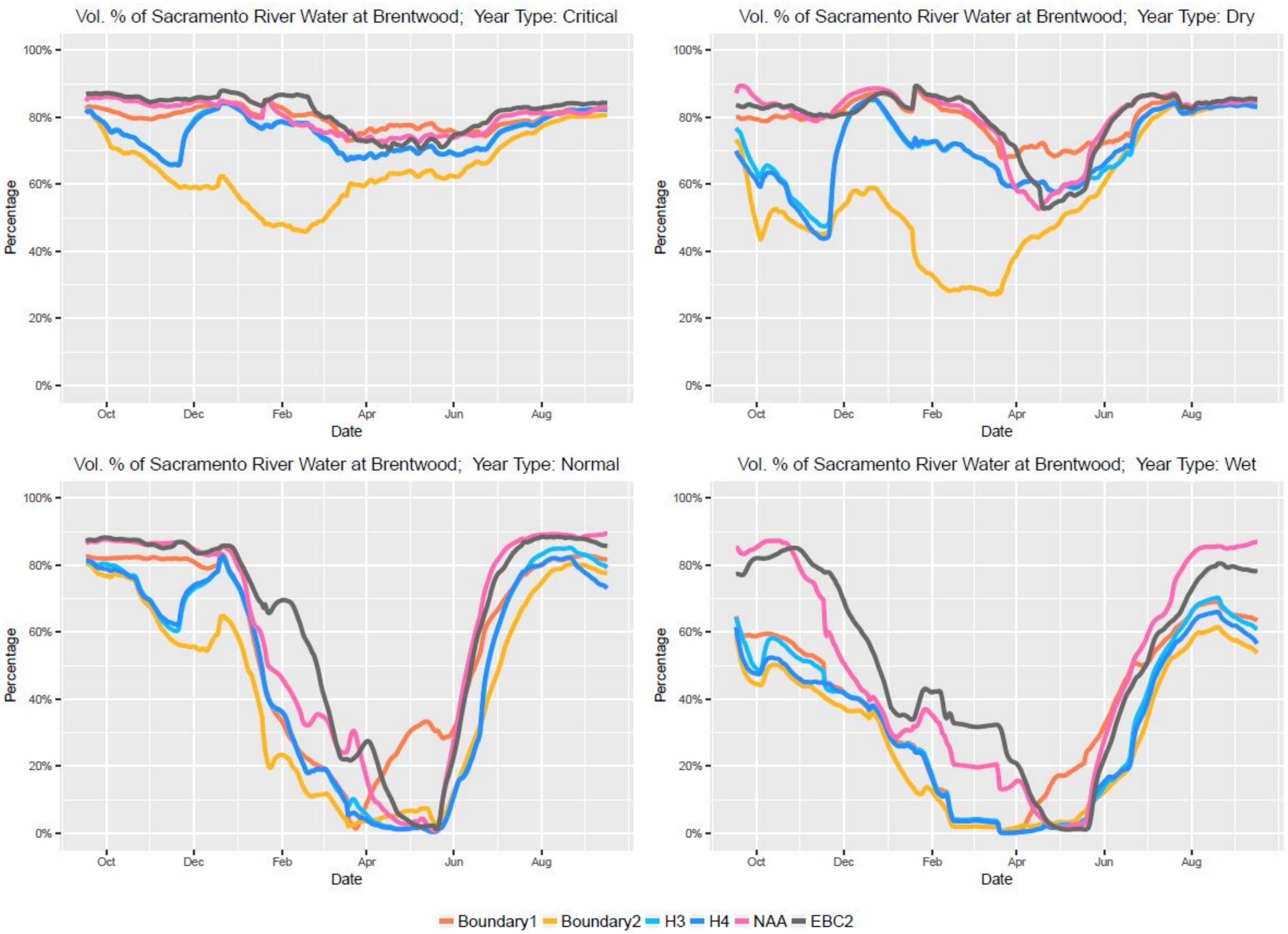
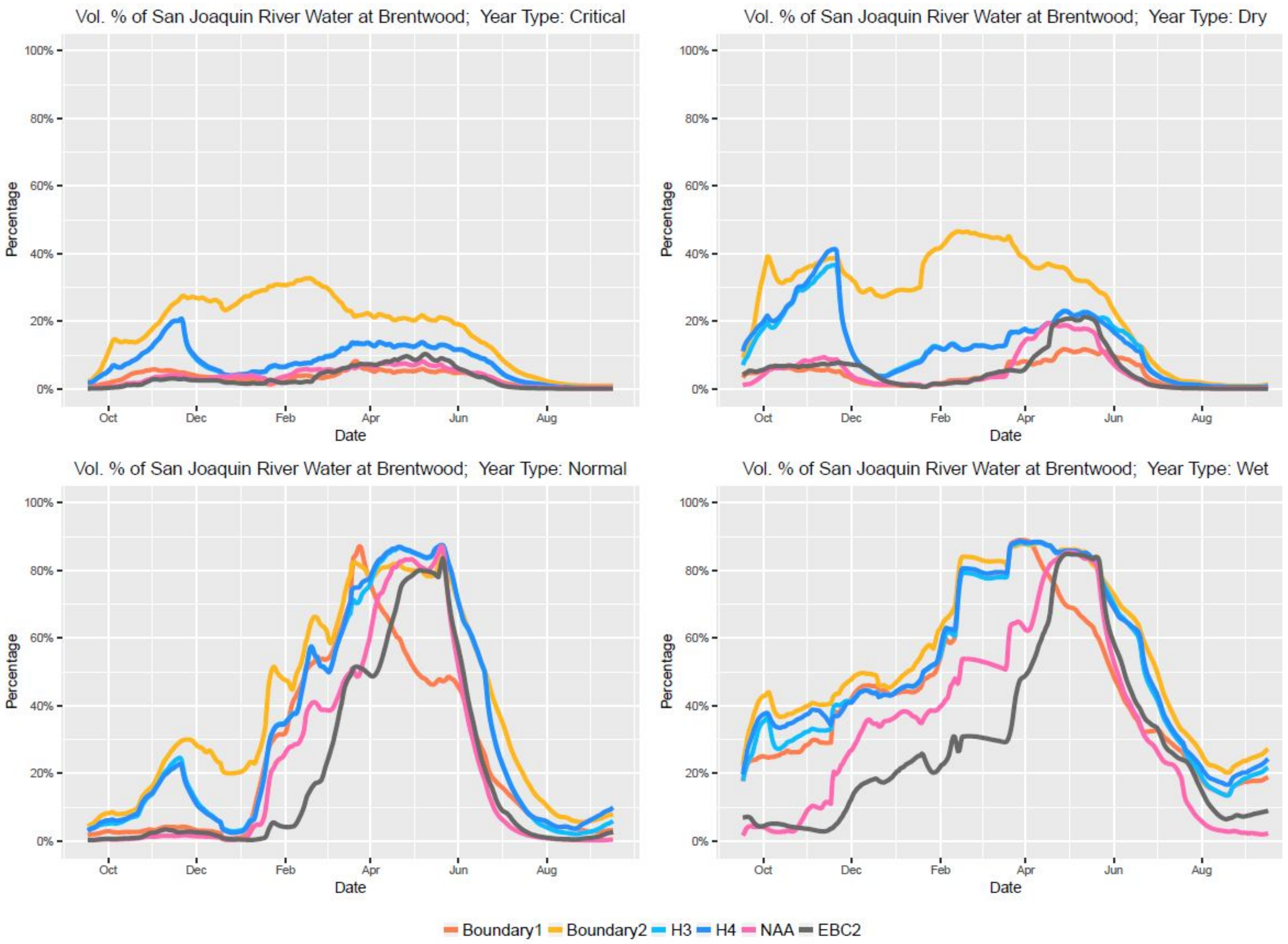


Figure A-2. Source fractions of Sacramento River water at the City's intake location as modeled by DSM2 using DWR's input files. Each figure represents the average daily source fraction of Sacramento River water averaged for a given water year type.



Vol. % of San Joaquin River Water at Brentwood; Year Type: Critical

Vol. % of San Joaquin River Water at Brentwood; Year Type: Dry

Vol. % of San Joaquin River Water at Brentwood; Year Type: Normal

Vol. % of San Joaquin River Water at Brentwood; Year Type: Wet

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

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

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

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

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

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

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

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

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

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

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

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

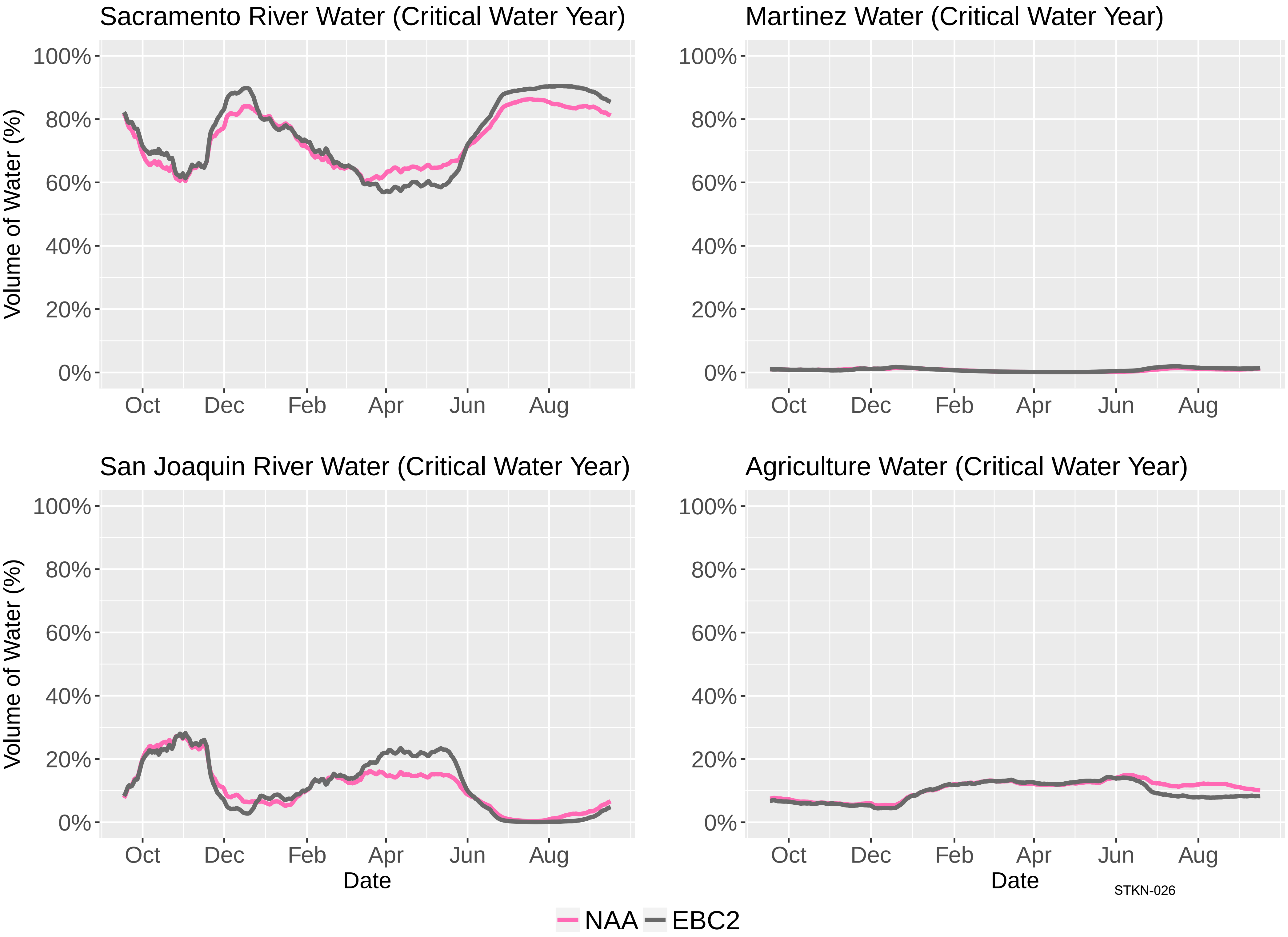
Scenario	EBC2	NAA	B1	H3	H4	B2
Redefined (E/I) excluding NDD flows	481 (8.2%)	349 (6.0%)	270 (4.6%)	144 (2.5%)	119 (2.0%)	32 (0.5%)
D-1641 specifications			850 (14.6%)	441 (7.6%)	359 (6.2%)	145 (2.5%)

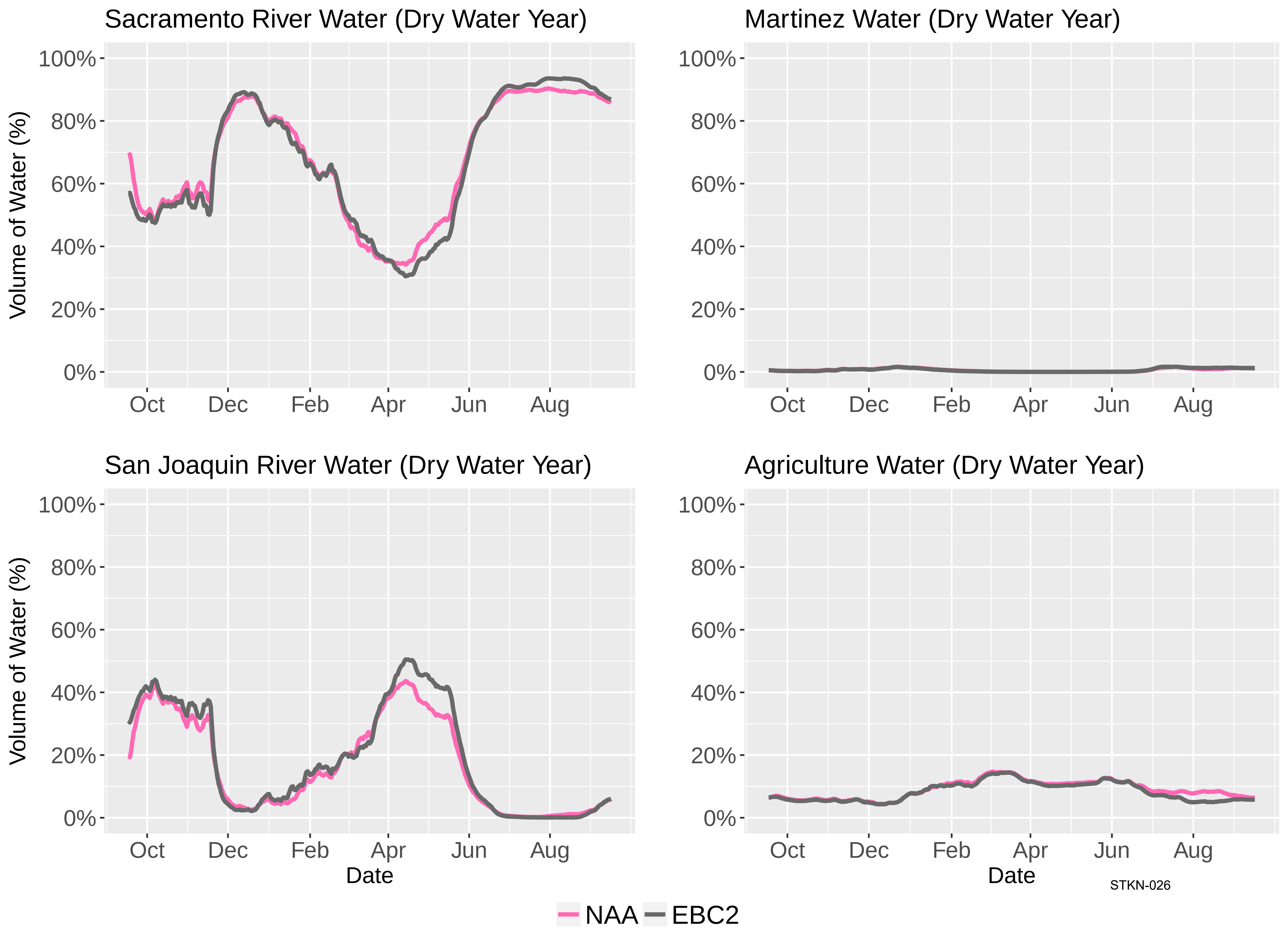
[a] Note that the E/I ratio does not change for the NAA and EBC2 scenarios because the NDD points do not exist for these scenarios.

Attachment 3

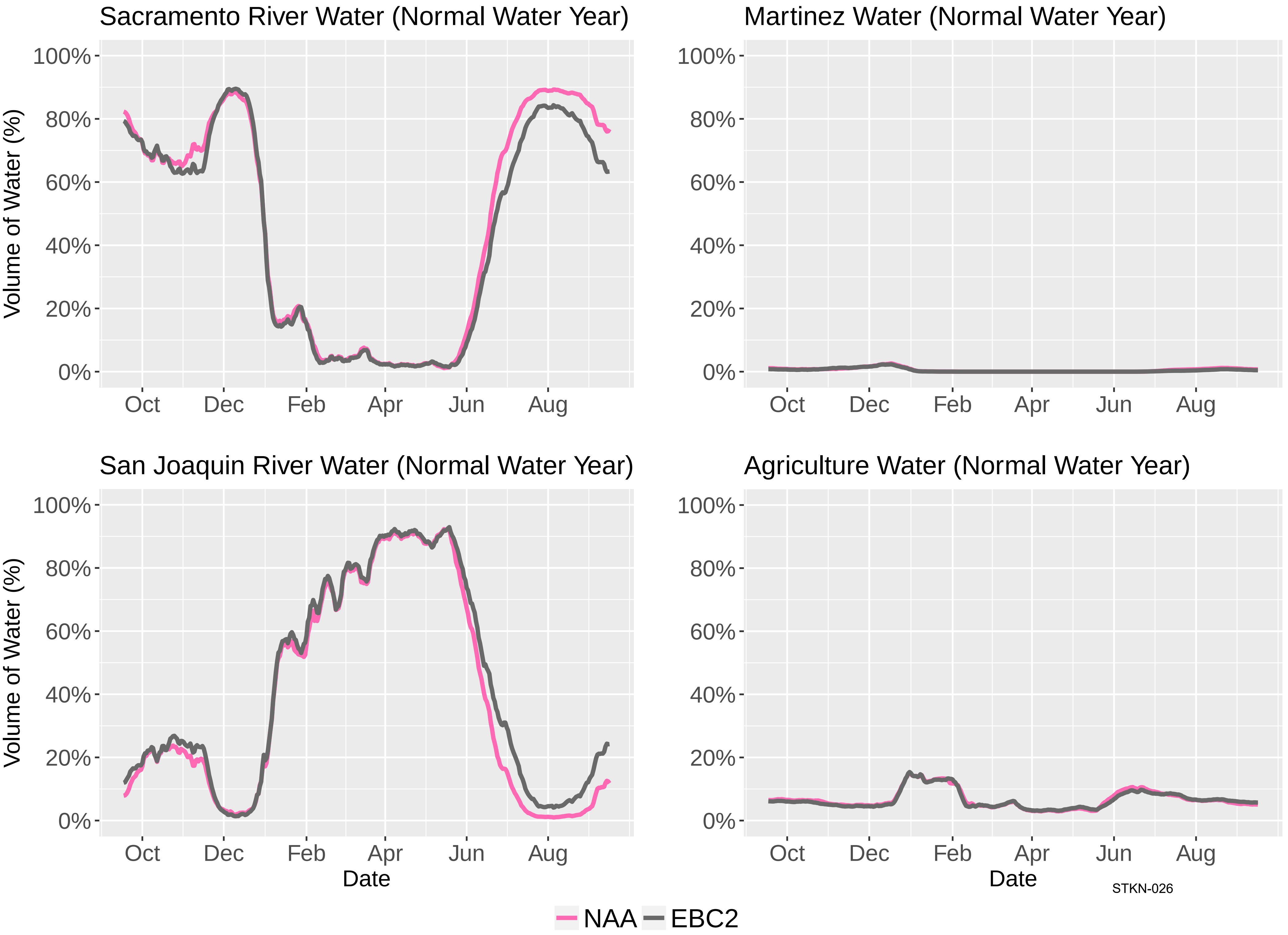
Source water fingerprinting at the City's intake and Buckley Cove for NAA and EBC2 scenarios during critical, dry, normal, and wet water year types

Source-water fingerprints at Stockton’s Intake


Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

STKN-026



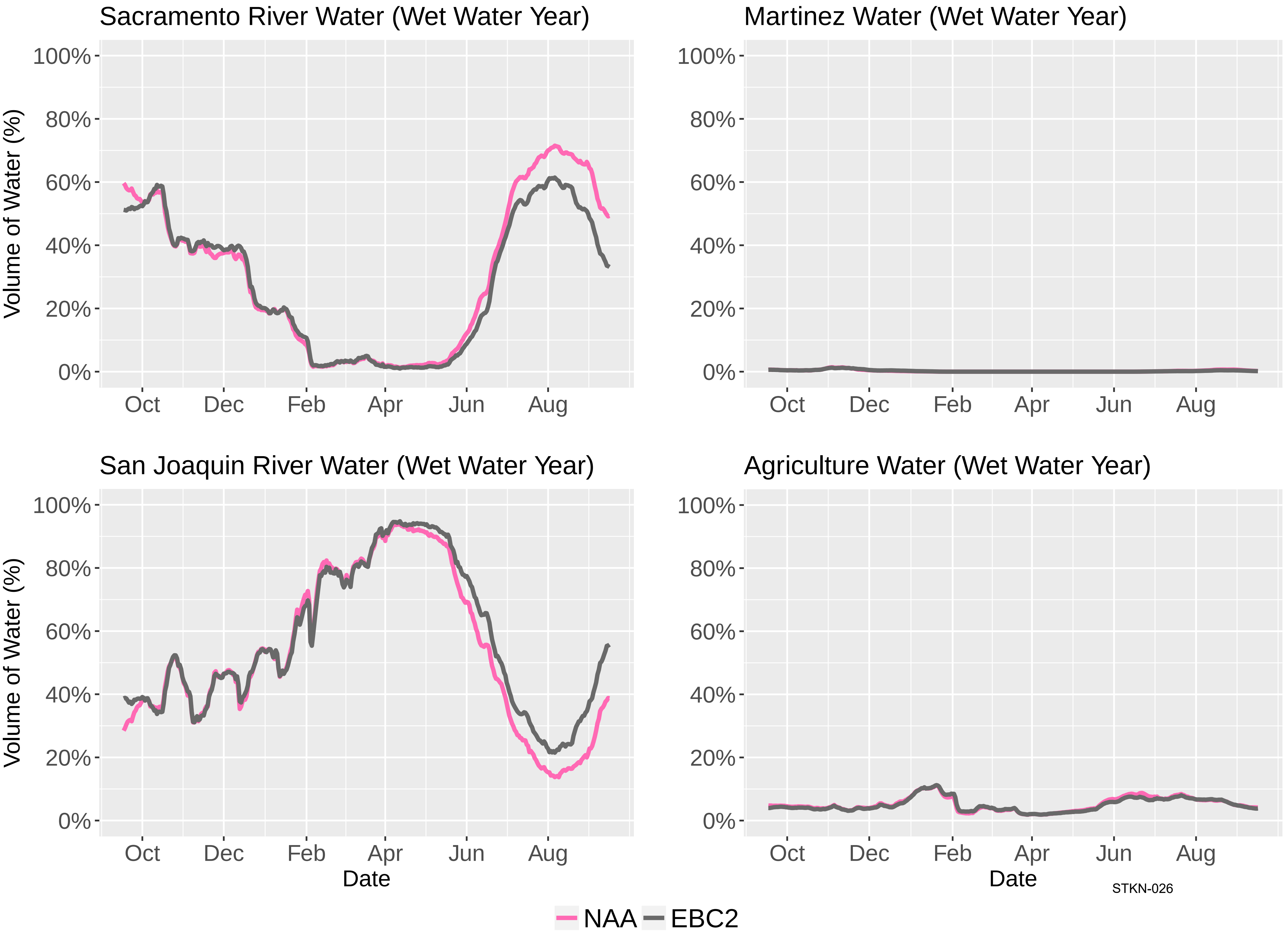
Sacramento River Water (Normal Water Year)

Martinez Water (Normal Water Year)

San Joaquin River Water (Normal Water Year)

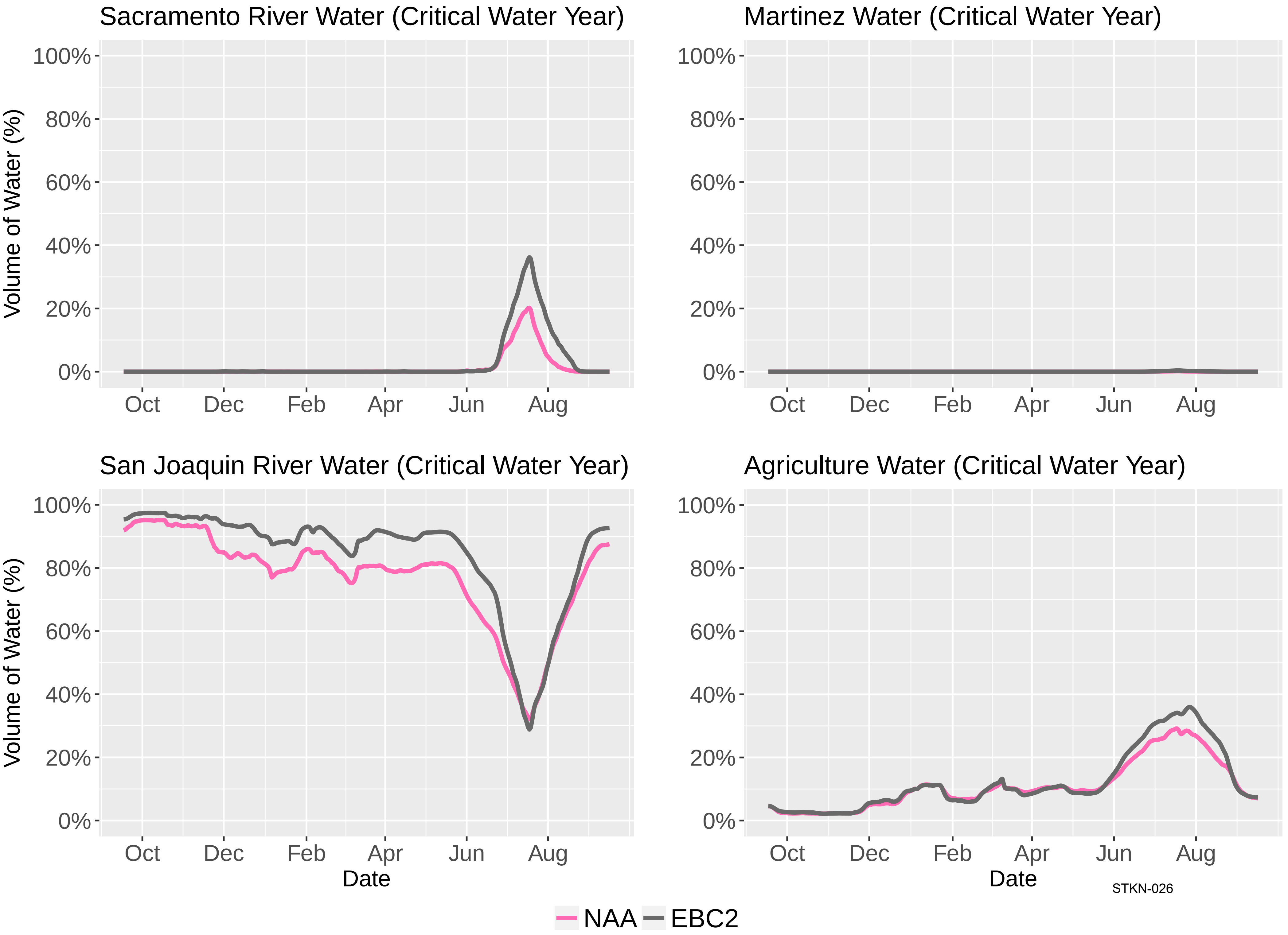
Agriculture Water (Normal Water Year)

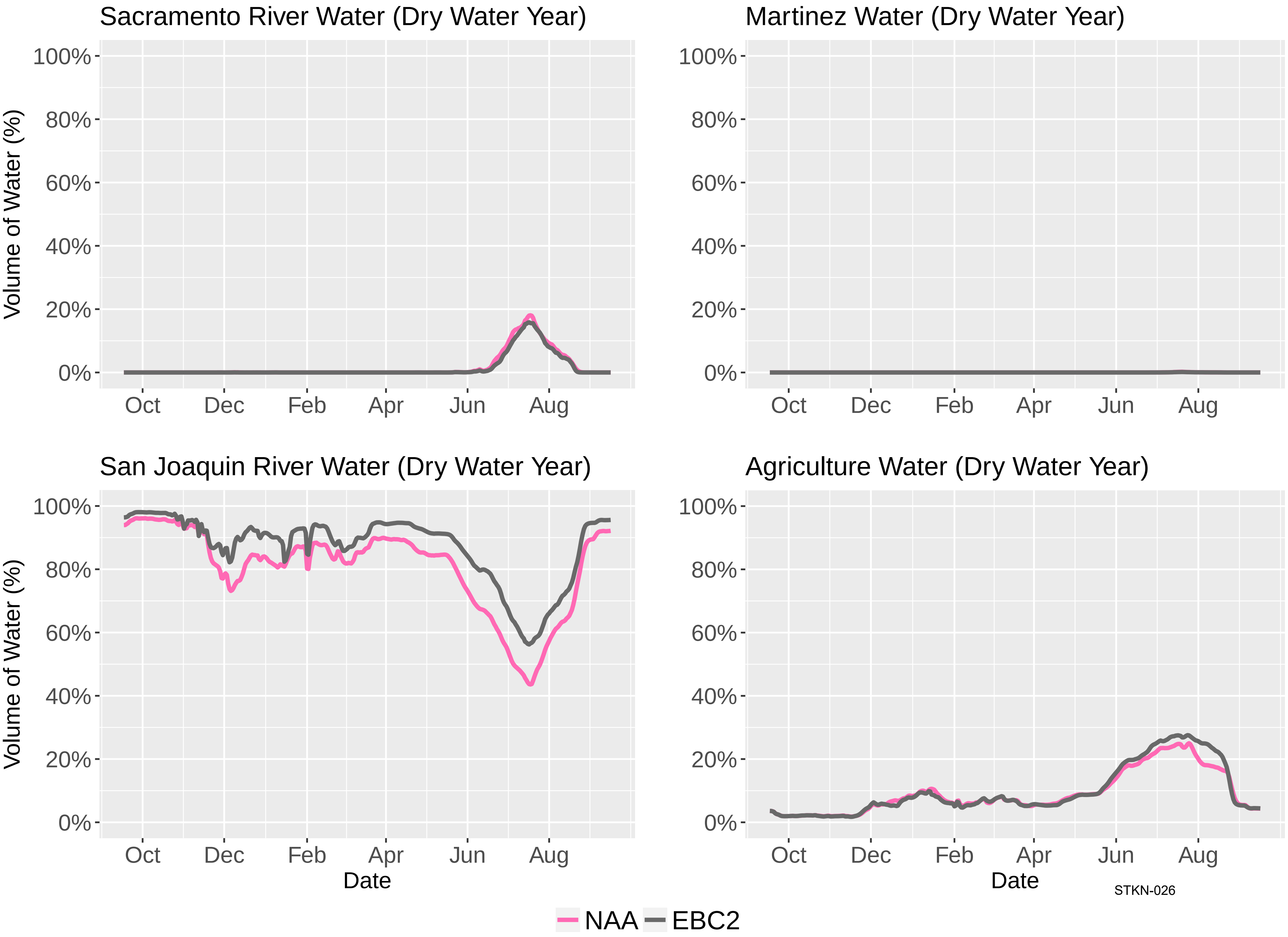
STKN-026


Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

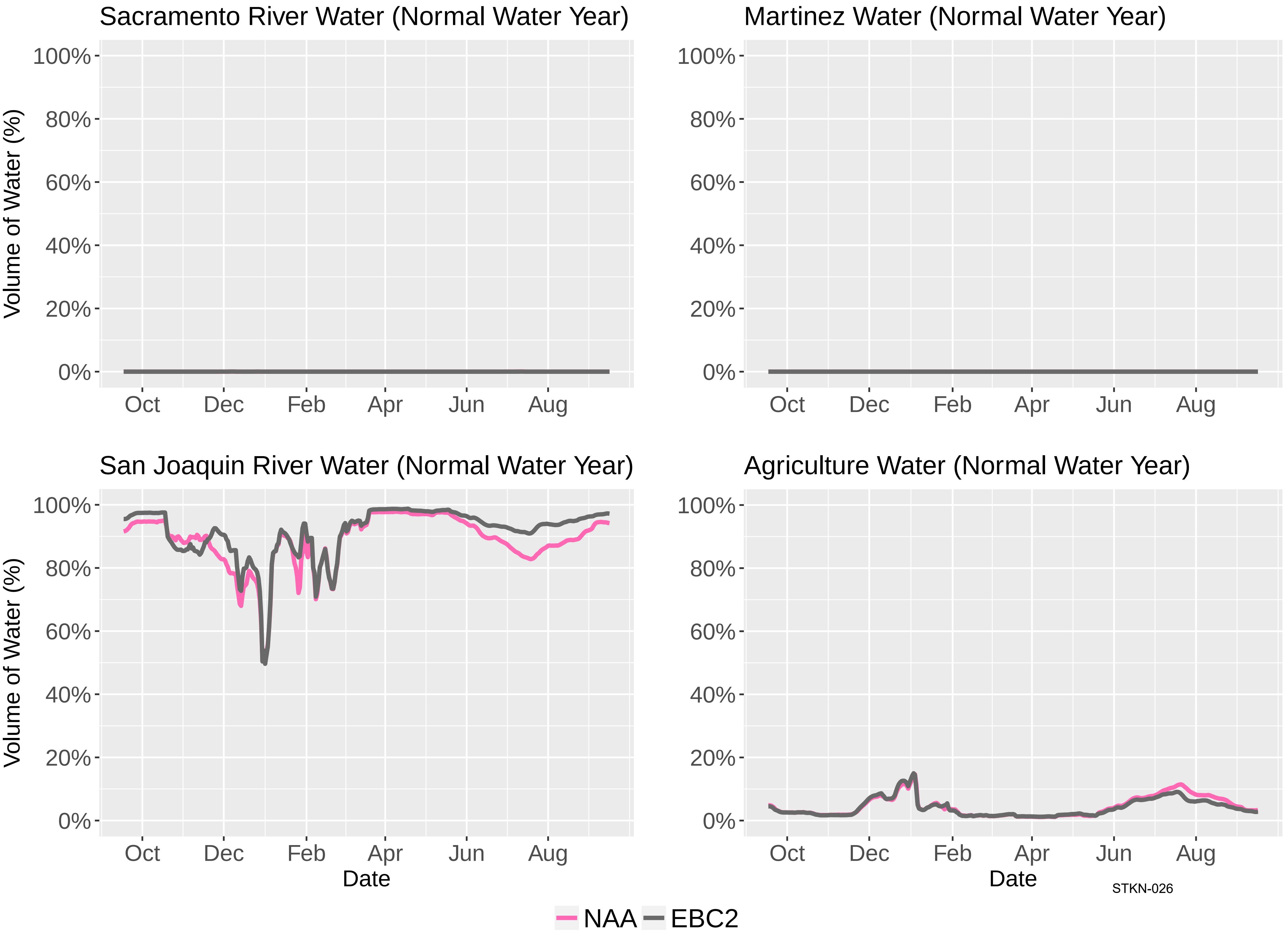
STKN-026

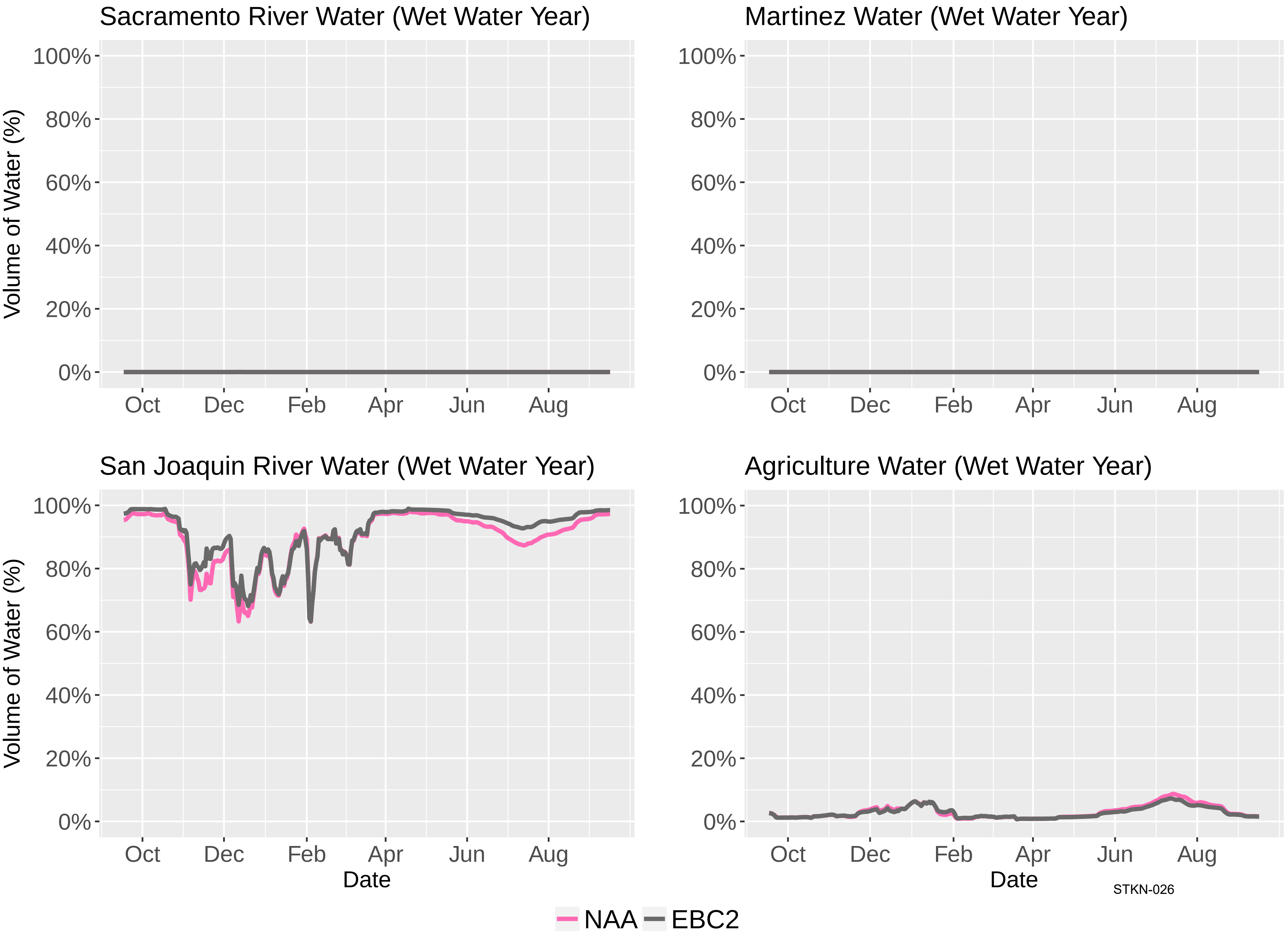
Source-water fingerprints at Buckley Cove


Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

STKN-026


Sacramento River Water (Normal Water Year)
Martinez Water (Normal Water Year)
San Joaquin River Water (Normal Water Year)
Agriculture Water (Normal Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
NAA
EBC2



Sacramento River Water (Wet Water Year)

Martinez Water (Wet Water Year)

San Joaquin River Water (Wet Water Year)

Agriculture Water (Wet Water Year)

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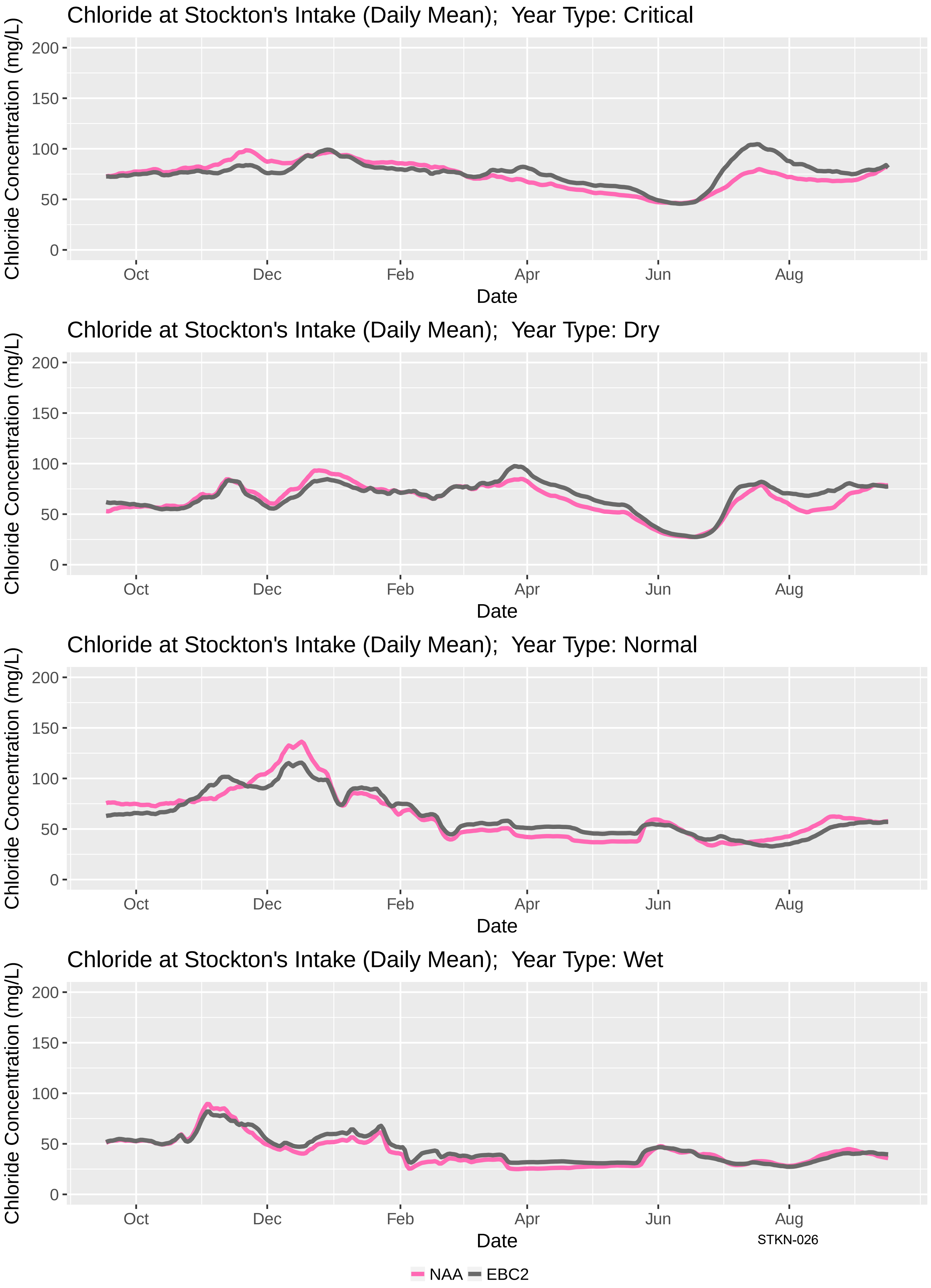
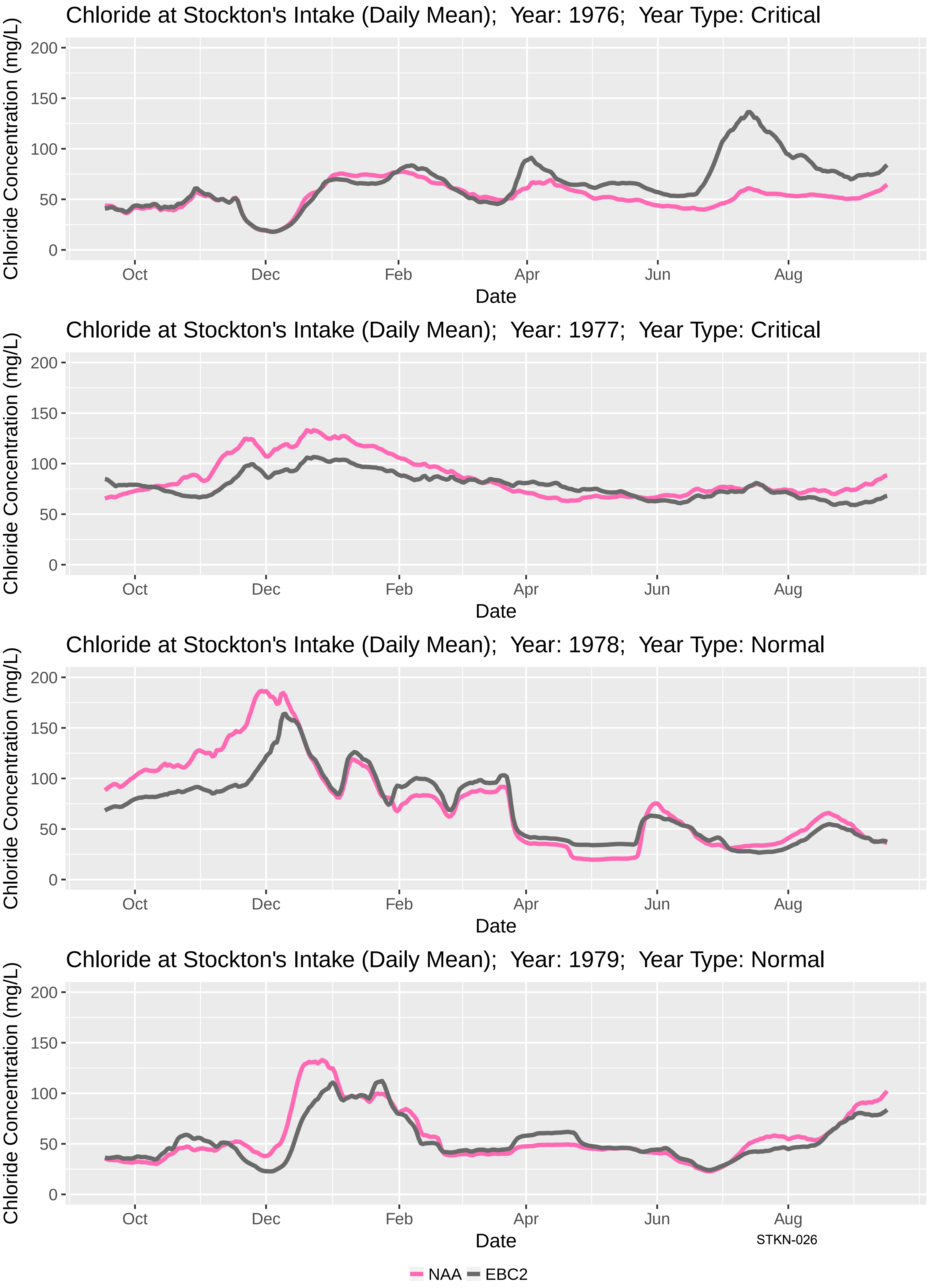
Attachment 4

Chloride concentrations at the City's intake and Buckley Cove for NAA and EBC2 scenarios during critical, dry, normal, and wet water year types


Chloride at Stockton's Intake (Daily Mean); Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year Type: Normal
Chloride at Stockton's Intake (Daily Mean); Year Type: Wet
Chloride Concentration (mg/L)
0
50
100
150
200
Date
Oct
Dec
Feb
Apr
Jun
Aug
NAA
EBC2

STKN-026


Chloride at Stockton's Intake (Daily Mean); Year: 1976; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1977; Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year: 1978; Year Type: Normal
Chloride at Stockton's Intake (Daily Mean); Year: 1979; Year Type: Normal
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

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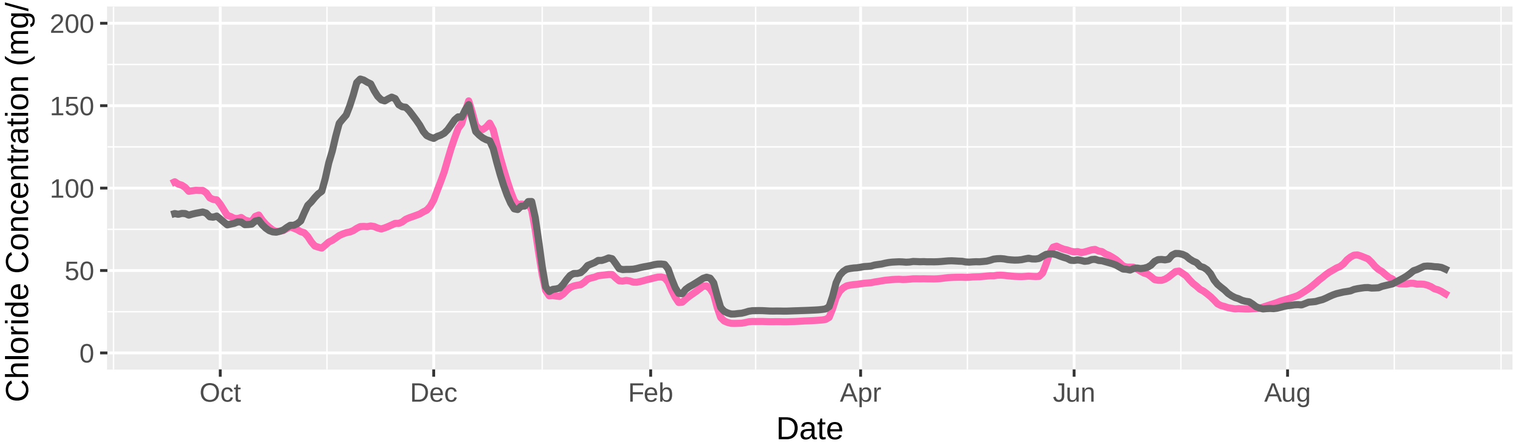
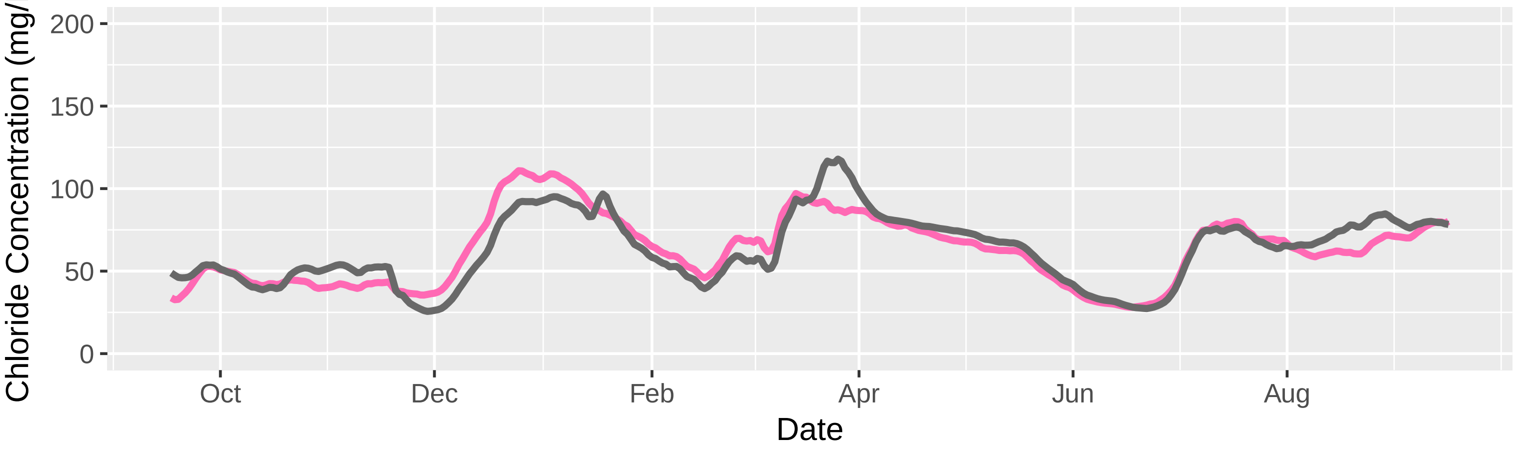
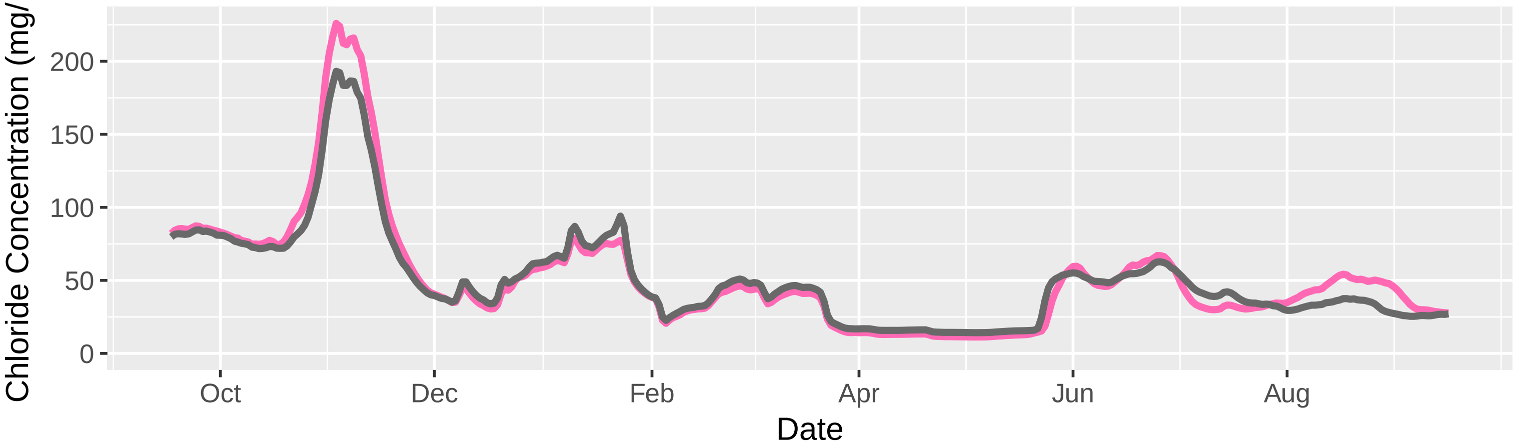
Chloride at Stockton's Intake (Daily Mean); Year: 1980; Year Type: Normal



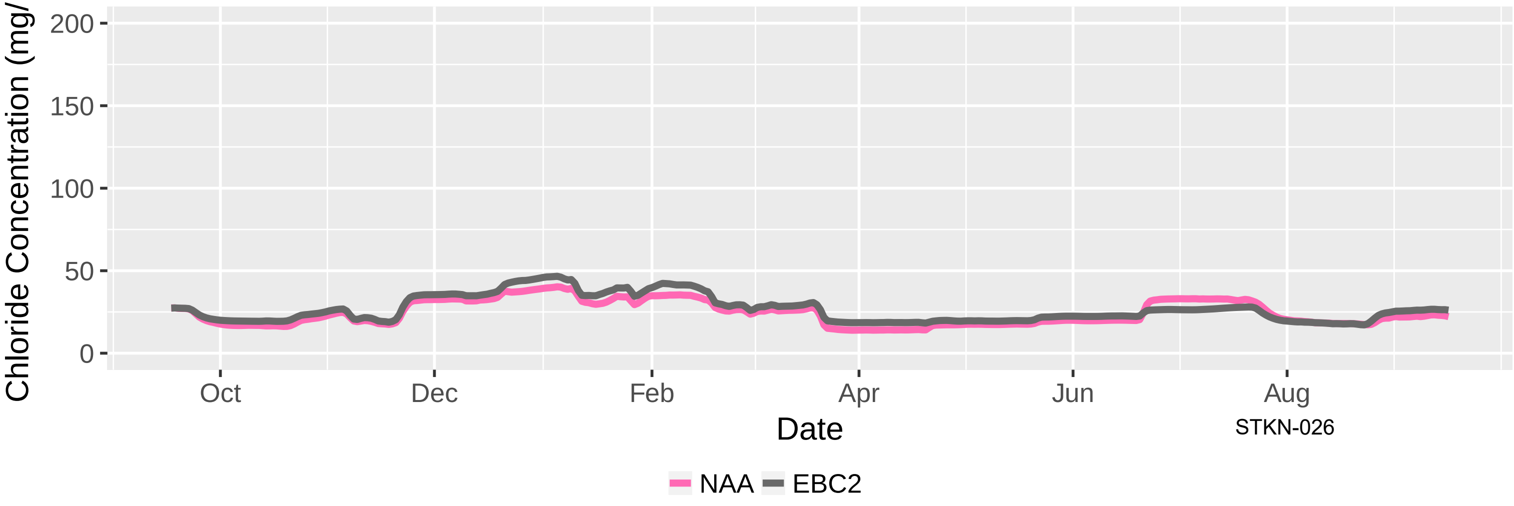
Chloride at Stockton's Intake (Daily Mean); Year: 1981; Year Type: Dry



Chloride at Stockton's Intake (Daily Mean); Year: 1982; Year Type: Wet



Chloride at Stockton's Intake (Daily Mean); Year: 1983; Year Type: Wet



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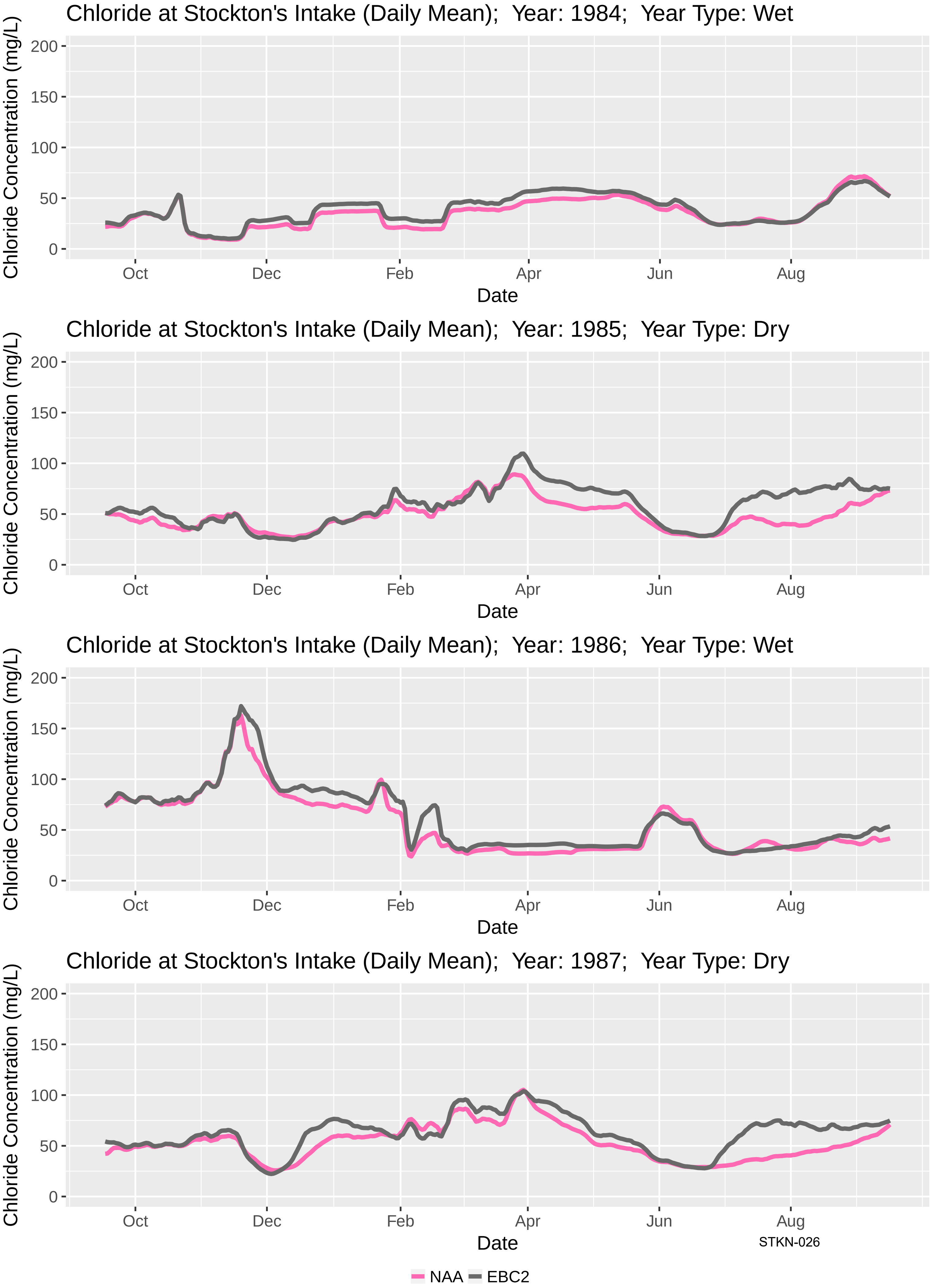
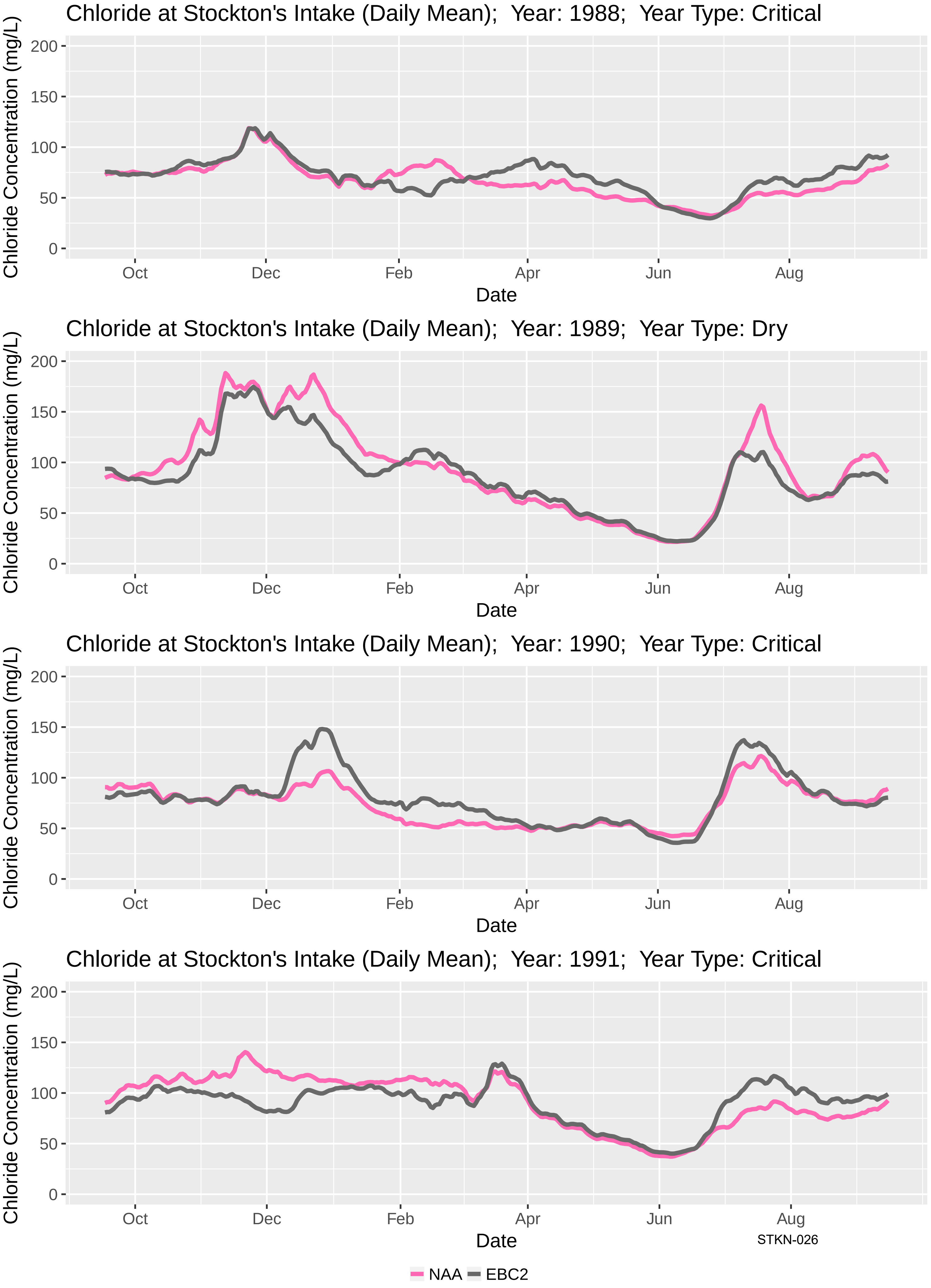

Chloride at Stockton's Intake (Daily Mean); Year: 1984; Year Type: Wet
Chloride at Stockton's Intake (Daily Mean); Year: 1985; Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year: 1986; Year Type: Wet
Chloride at Stockton's Intake (Daily Mean); Year: 1987; Year Type: Dry
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
NAA
EBC2

STKN-026



Chloride at Stockton's Intake (Daily Mean); Year: 1988; Year Type: Critical

Chloride at Stockton's Intake (Daily Mean); Year: 1989; Year Type: Dry

Chloride at Stockton's Intake (Daily Mean); Year: 1990; Year Type: Critical

Chloride at Stockton's Intake (Daily Mean); Year: 1991; Year Type: Critical

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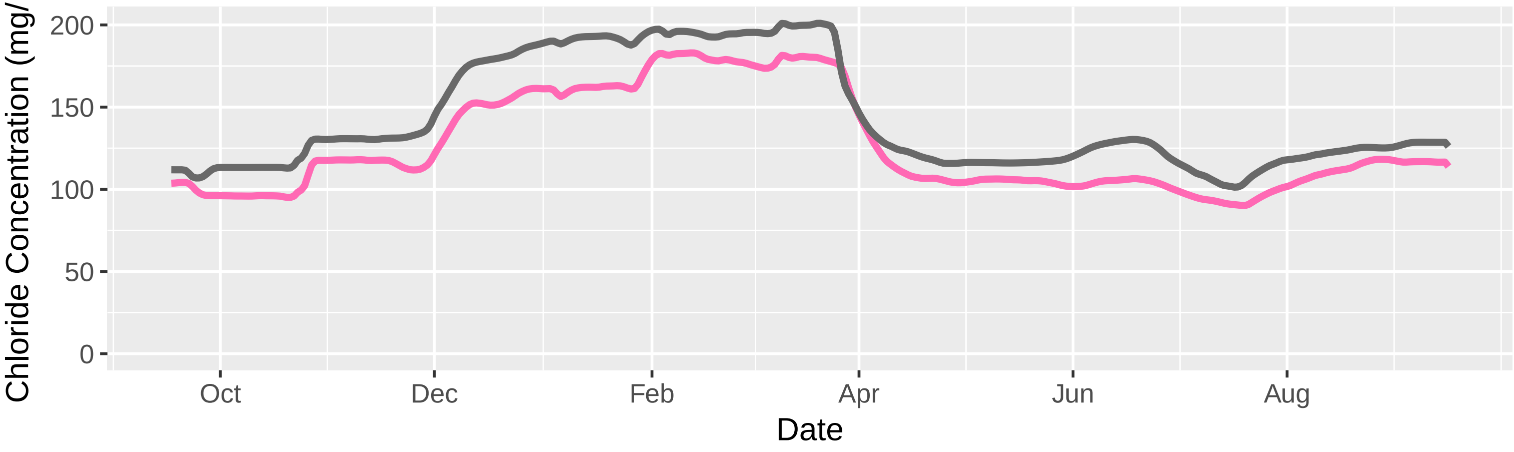
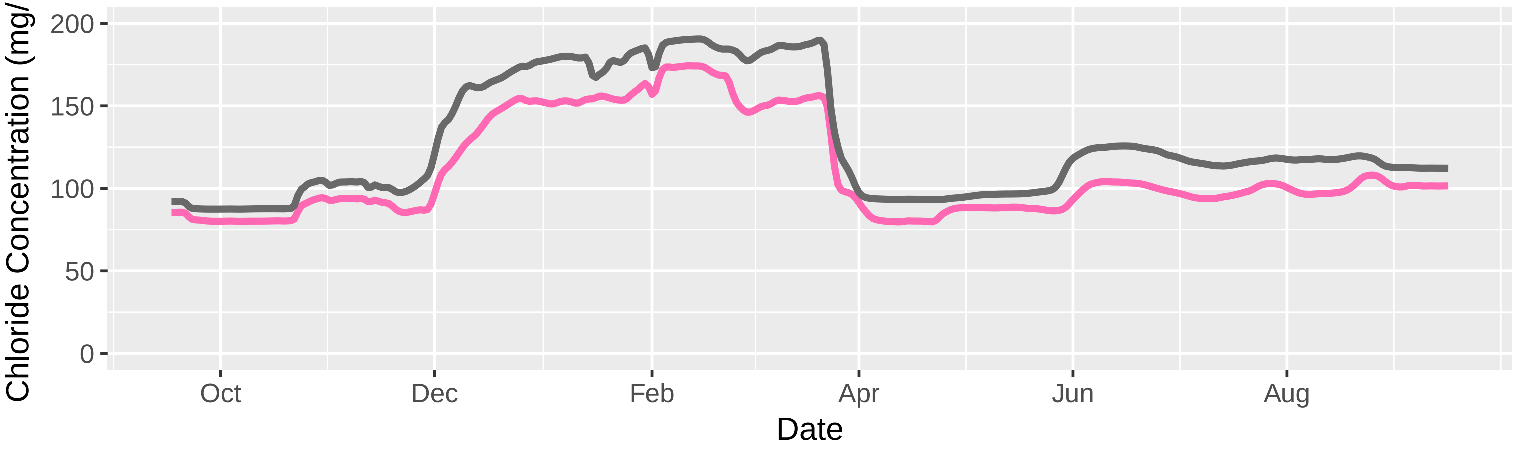
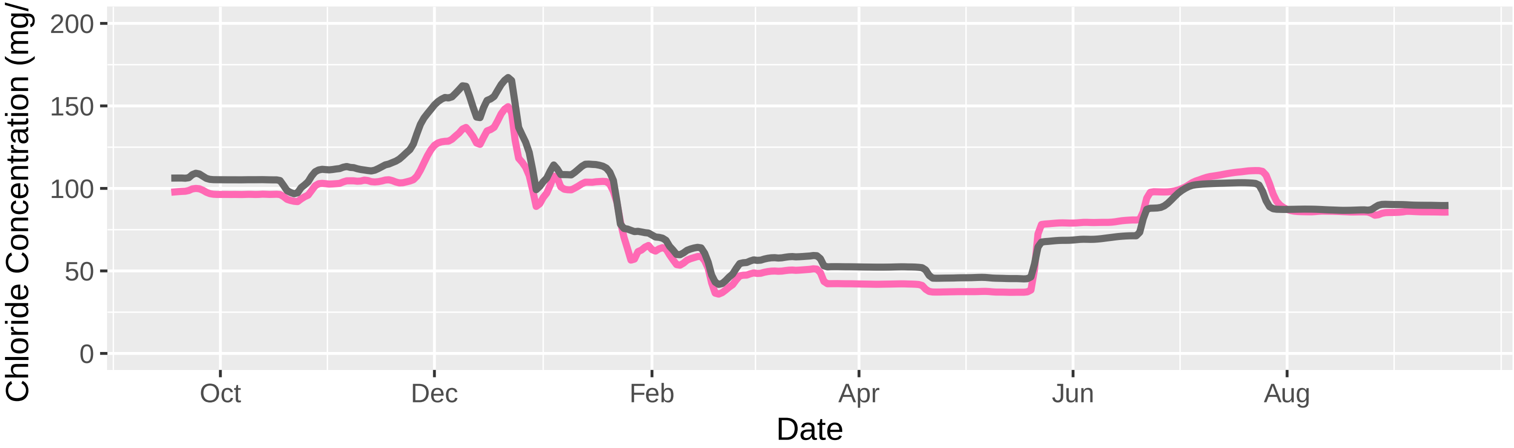
Chloride at Buckley Cove (Daily Mean); Year Type: Critical



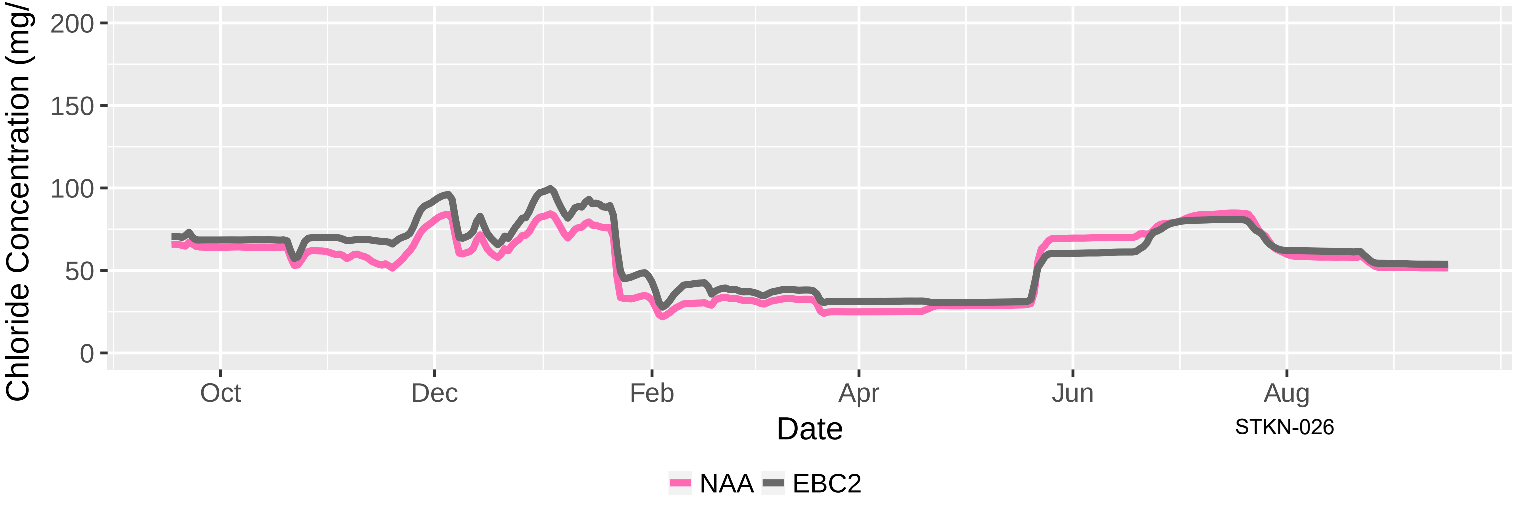
Chloride at Buckley Cove (Daily Mean); Year Type: Dry

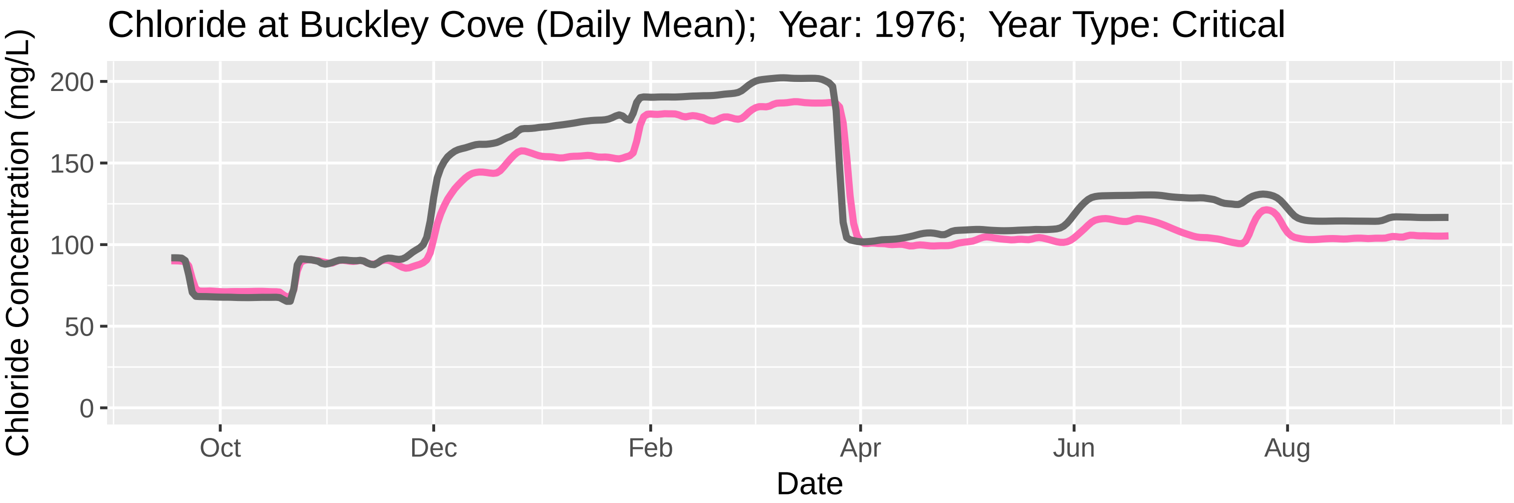


Chloride at Buckley Cove (Daily Mean); Year Type: Normal

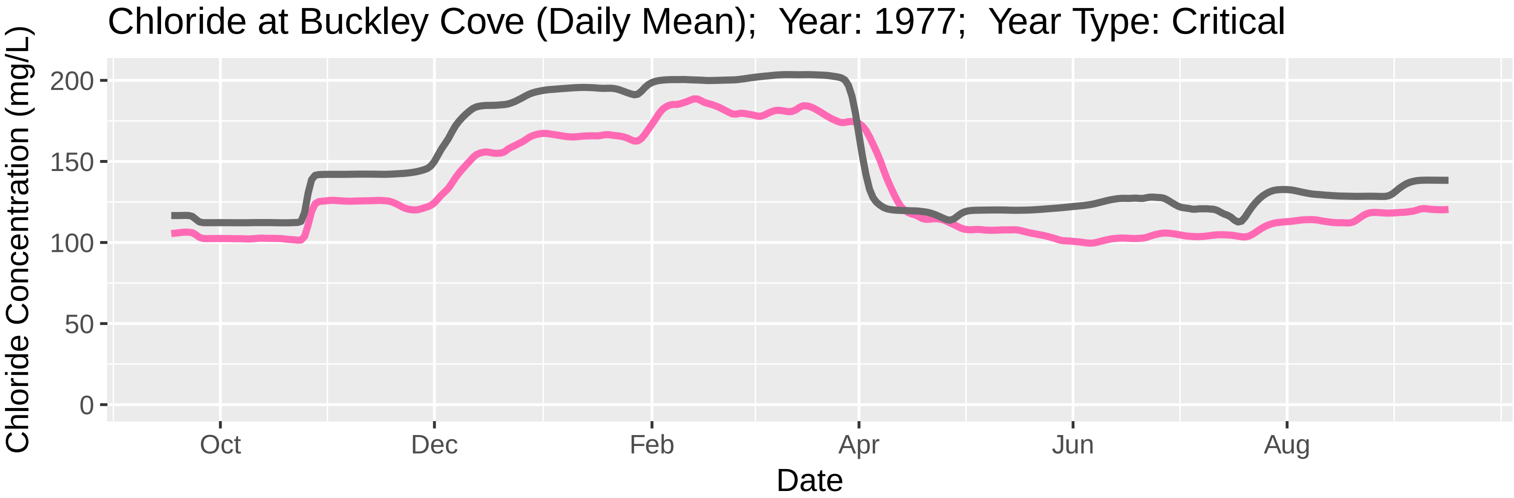


Chloride at Buckley Cove (Daily Mean); Year Type: Wet

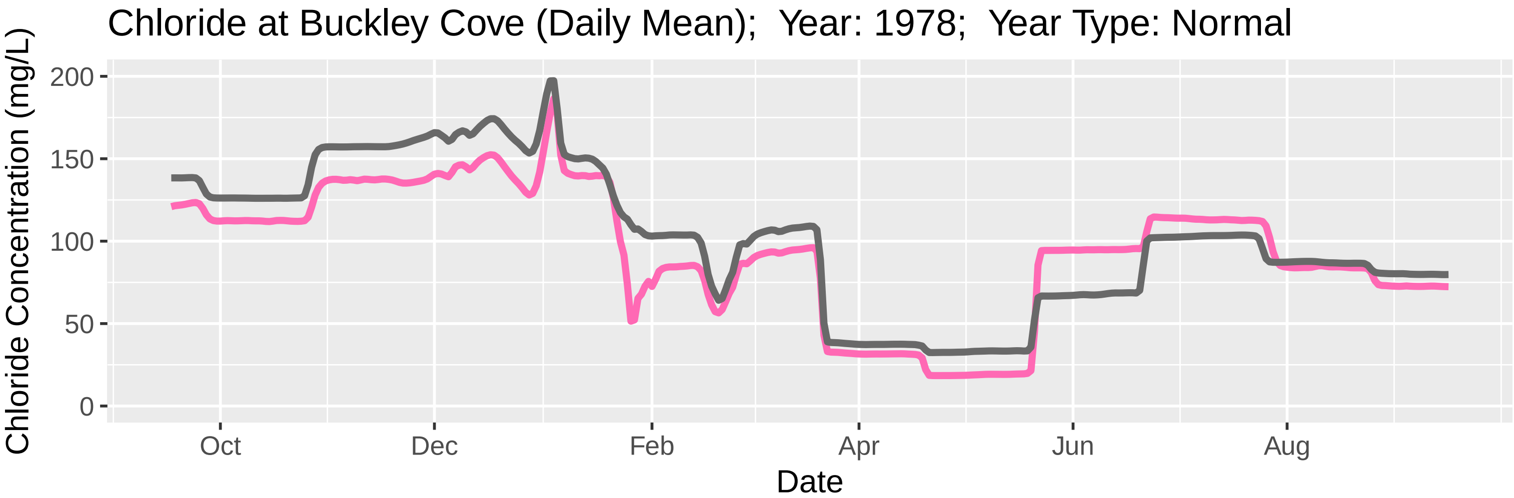




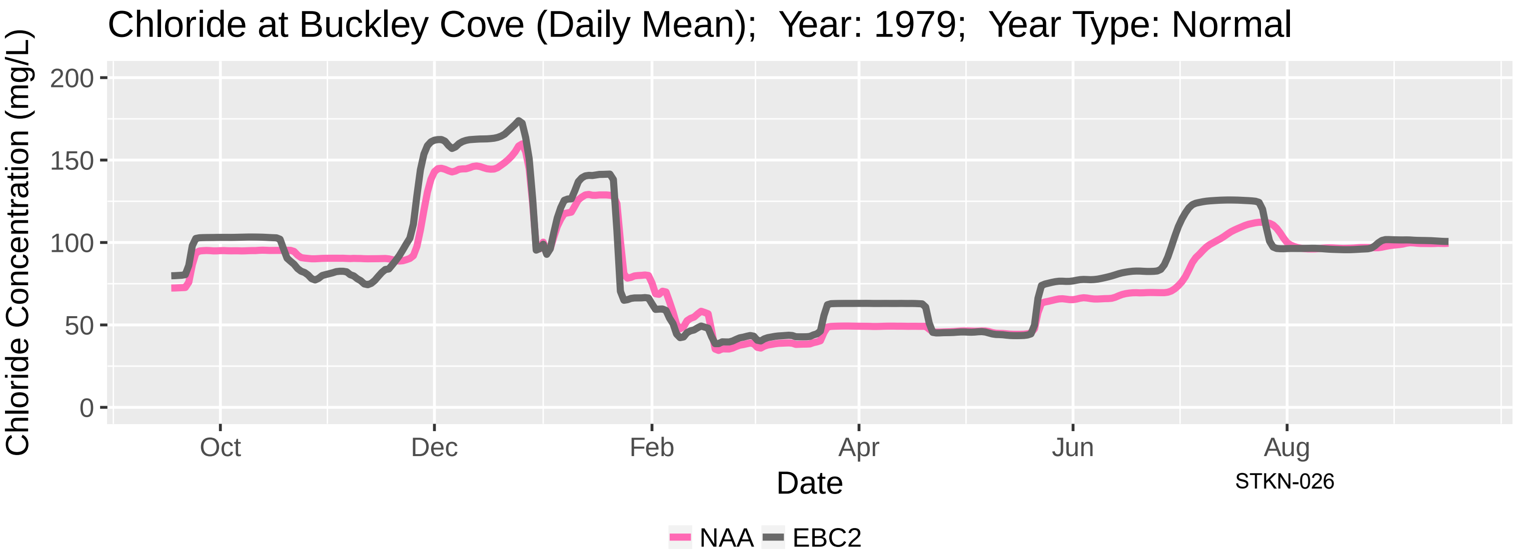
Chloride at Buckley Cove (Daily Mean); Year: 1976; Year Type: Critical



Chloride at Buckley Cove (Daily Mean); Year: 1977; Year Type: Critical



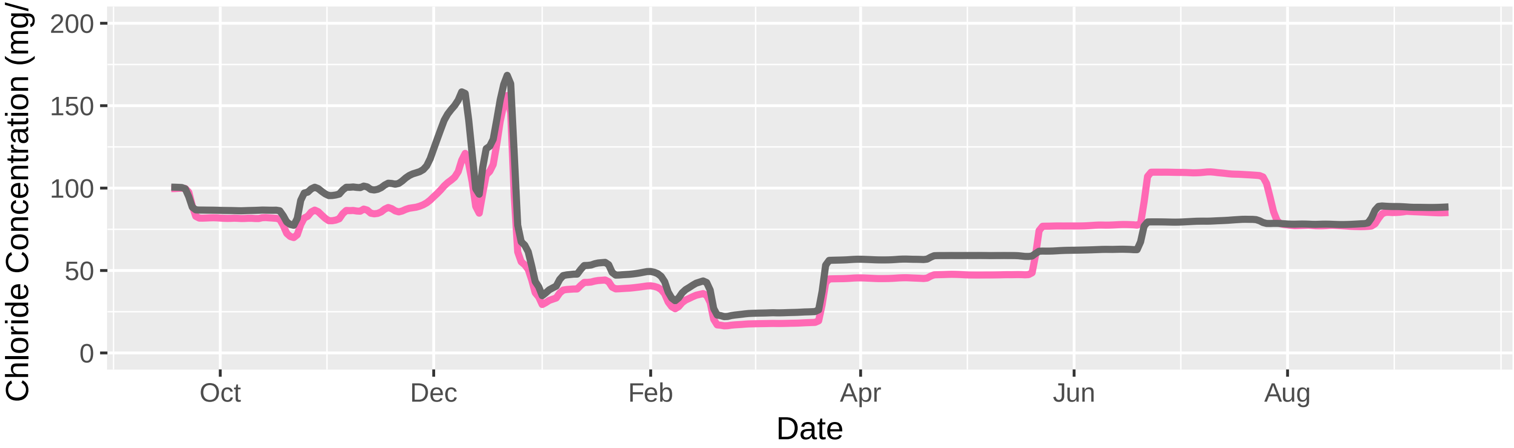
Chloride at Buckley Cove (Daily Mean); Year: 1978; Year Type: Normal



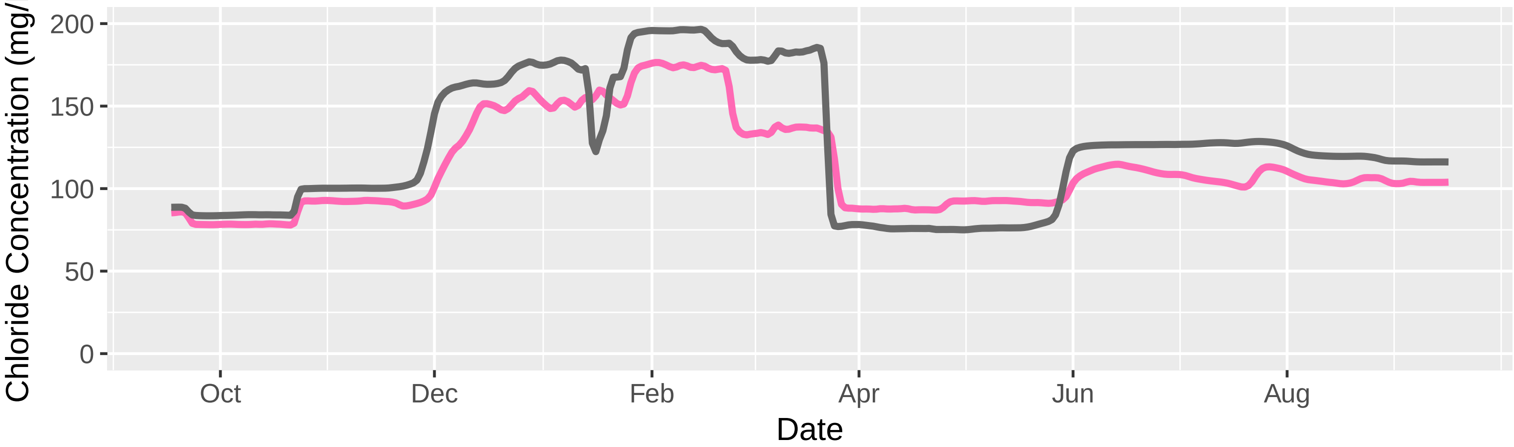
Chloride at Buckley Cove (Daily Mean); Year: 1979; Year Type: Normal

STKN-026

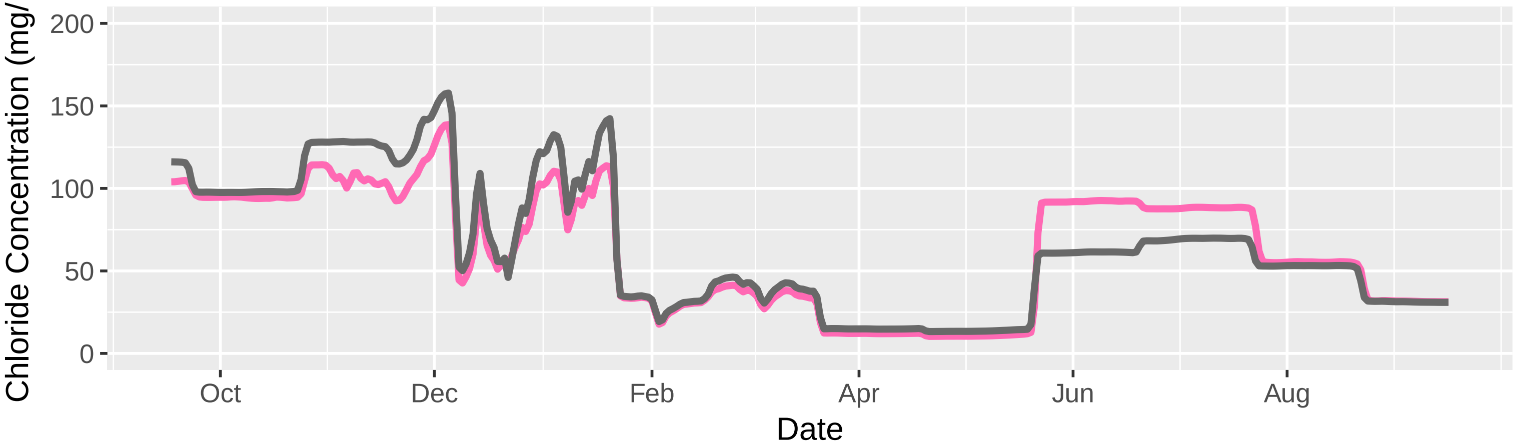
Chloride at Buckley Cove (Daily Mean); Year: 1980; Year Type: Normal



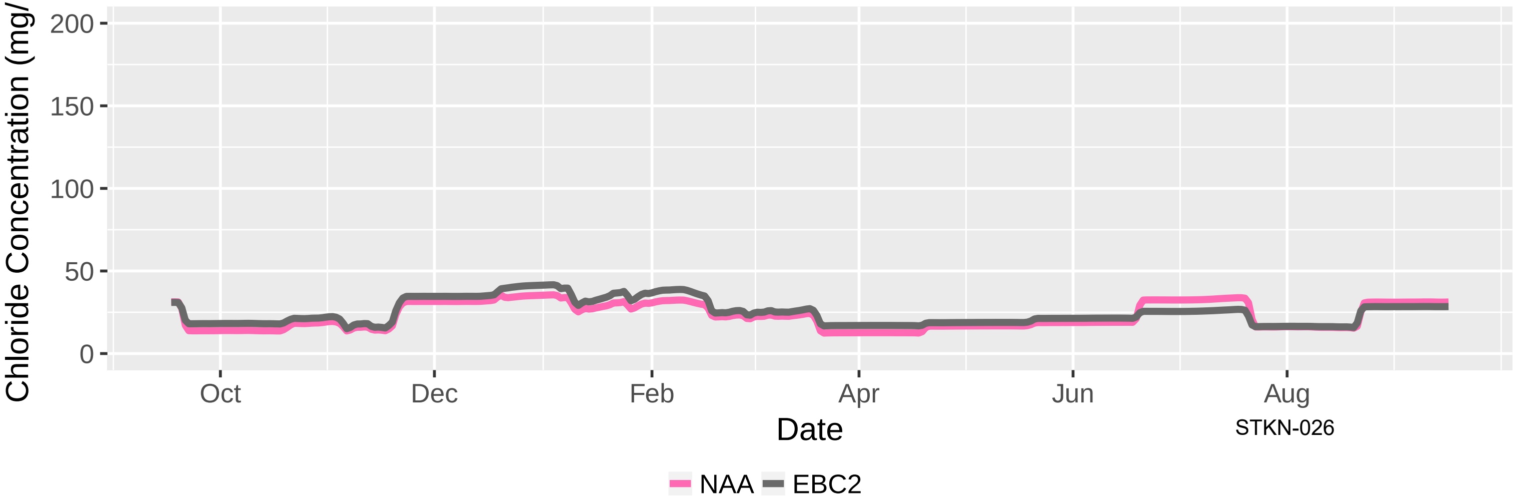
Chloride at Buckley Cove (Daily Mean); Year: 1981; Year Type: Dry



Chloride at Buckley Cove (Daily Mean); Year: 1982; Year Type: Wet

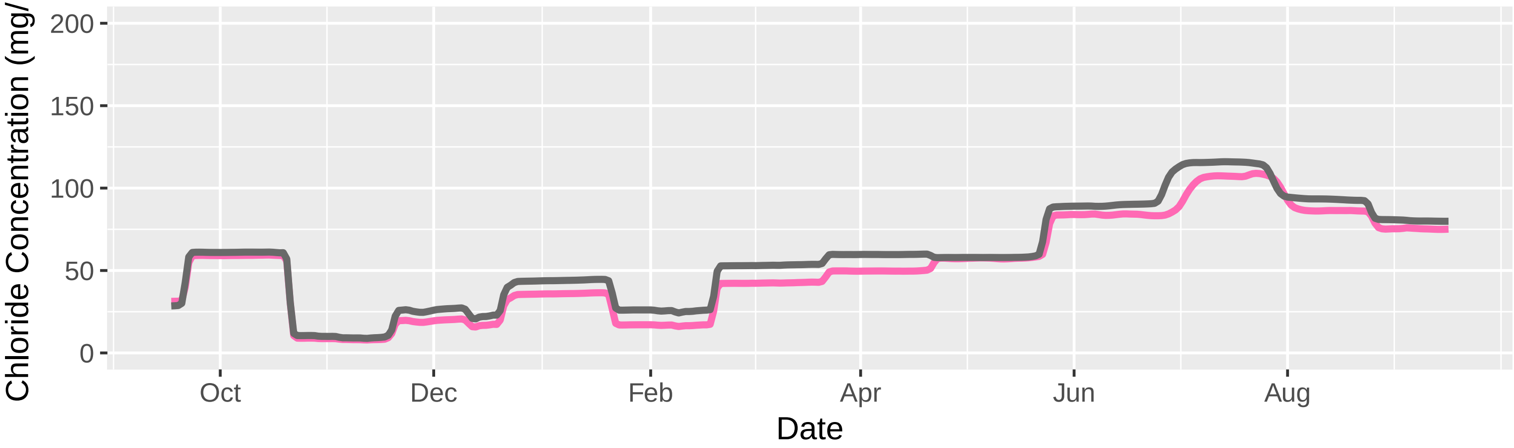


Chloride at Buckley Cove (Daily Mean); Year: 1983; Year Type: Wet

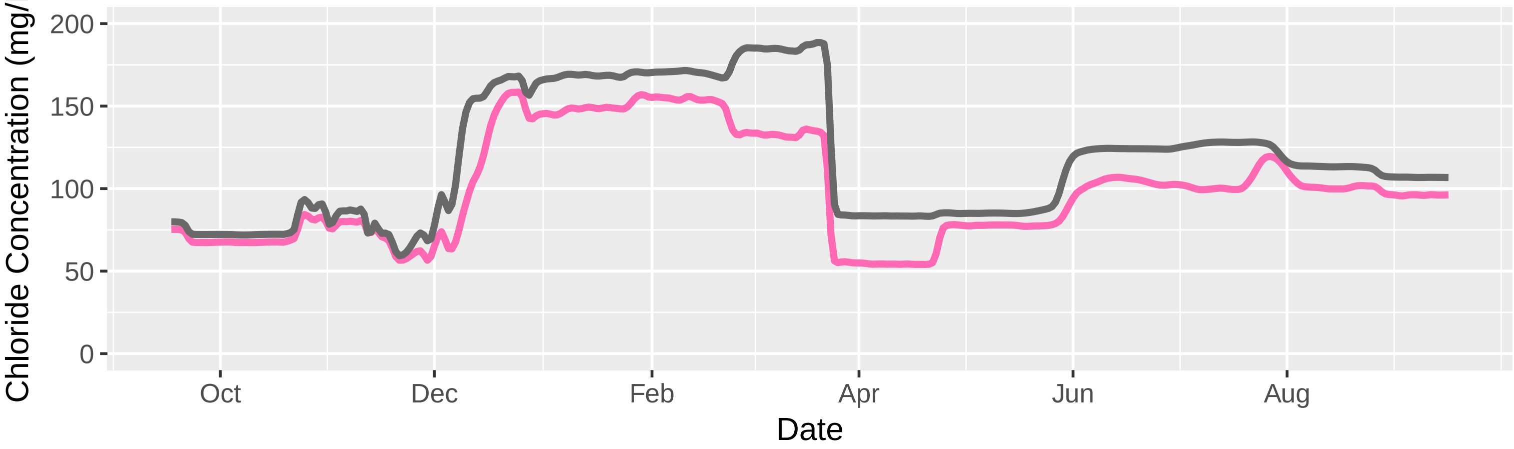


STKN-026

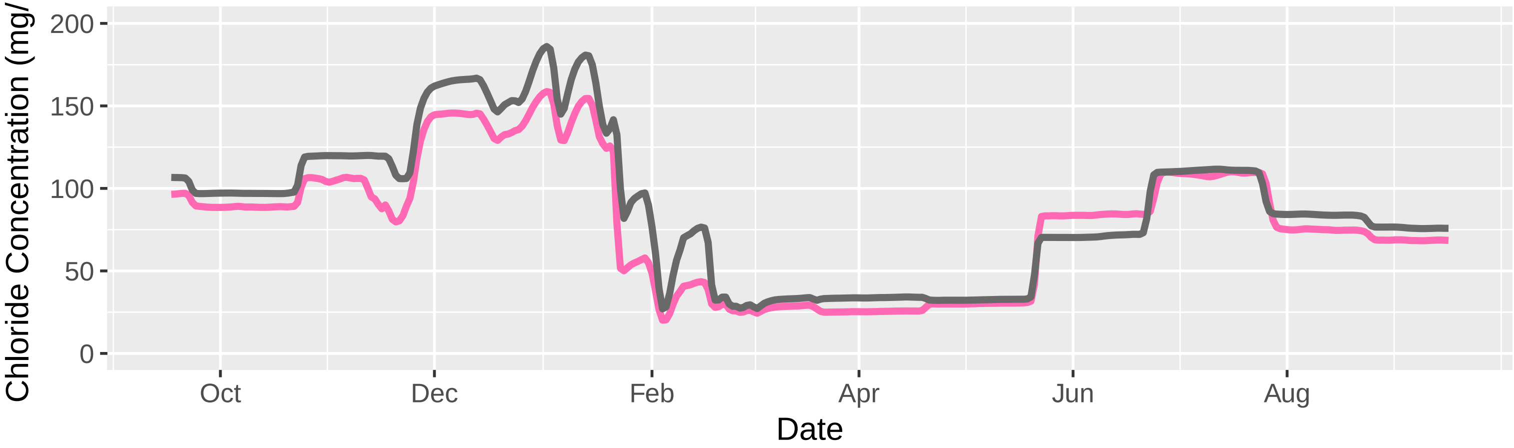
Chloride at Buckley Cove (Daily Mean); Year: 1984; Year Type: Wet



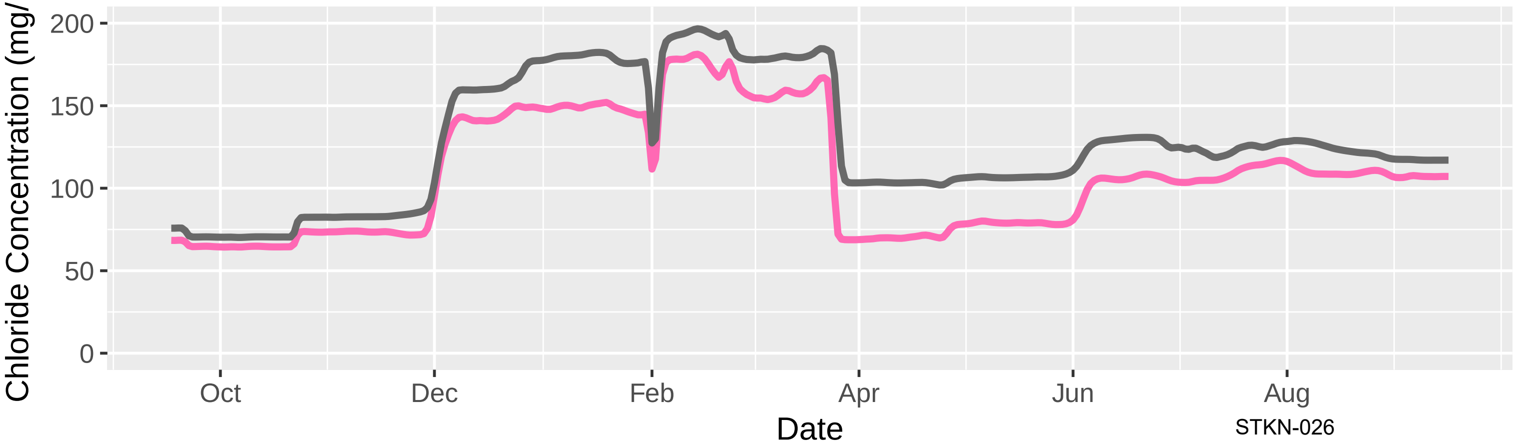
Chloride at Buckley Cove (Daily Mean); Year: 1985; Year Type: Dry



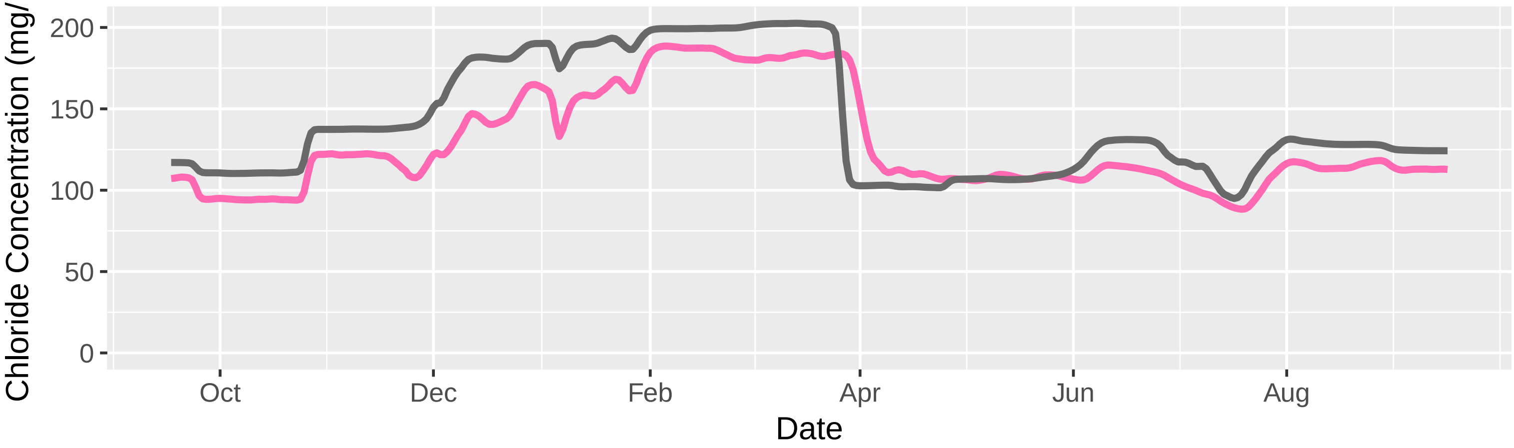
Chloride at Buckley Cove (Daily Mean); Year: 1986; Year Type: Wet



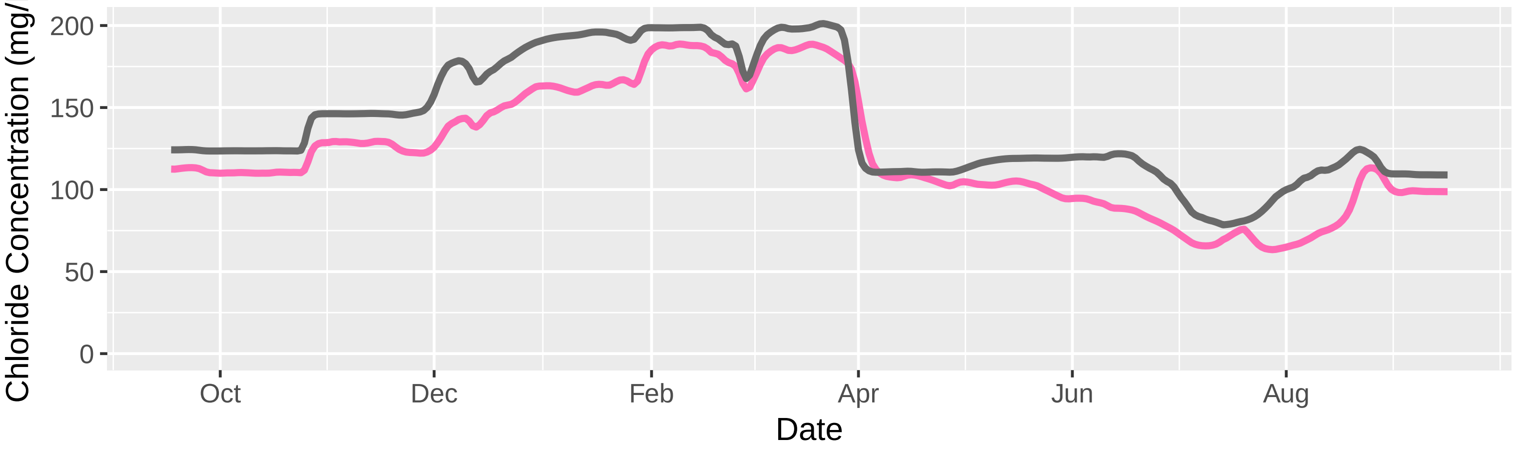
Chloride at Buckley Cove (Daily Mean); Year: 1987; Year Type: Dry



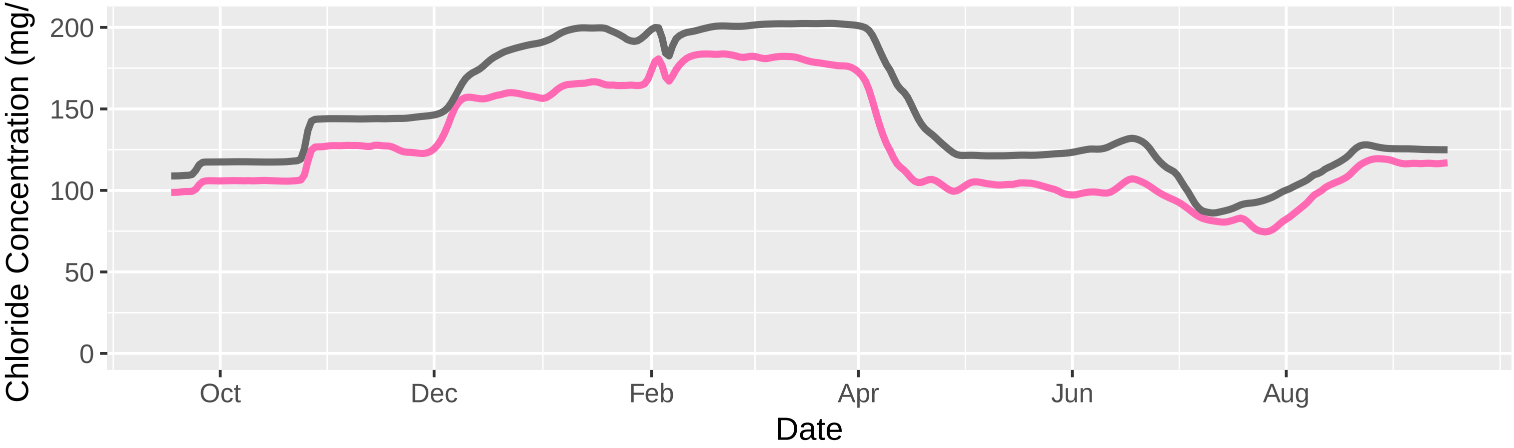
Chloride at Buckley Cove (Daily Mean); Year: 1988; Year Type: Critical



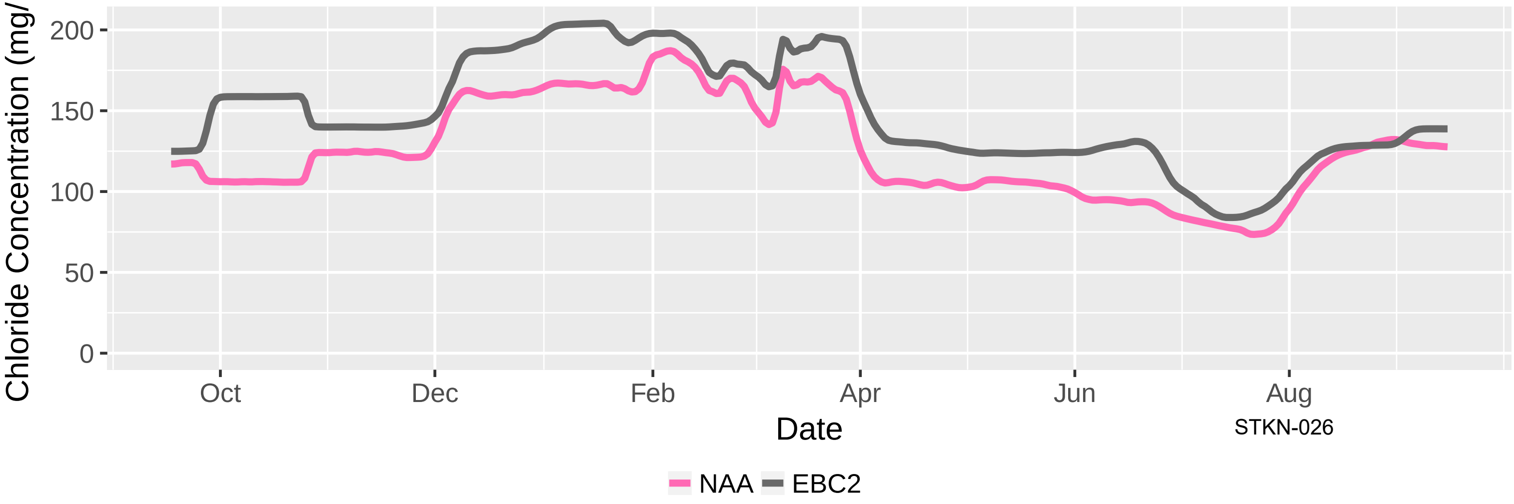
Chloride at Buckley Cove (Daily Mean); Year: 1989; Year Type: Dry



Chloride at Buckley Cove (Daily Mean); Year: 1990; Year Type: Critical



Chloride at Buckley Cove (Daily Mean); Year: 1991; Year Type: Critical



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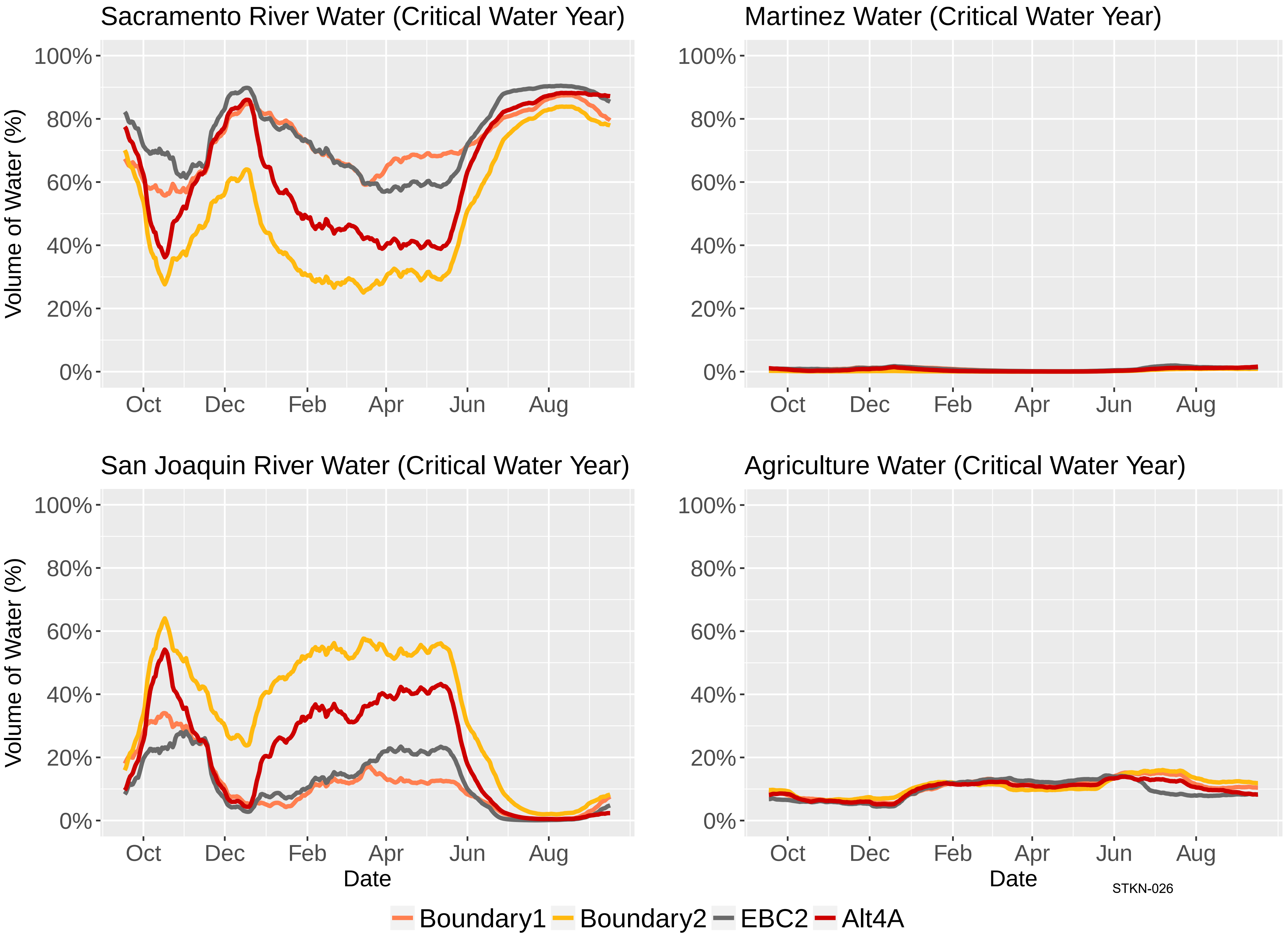
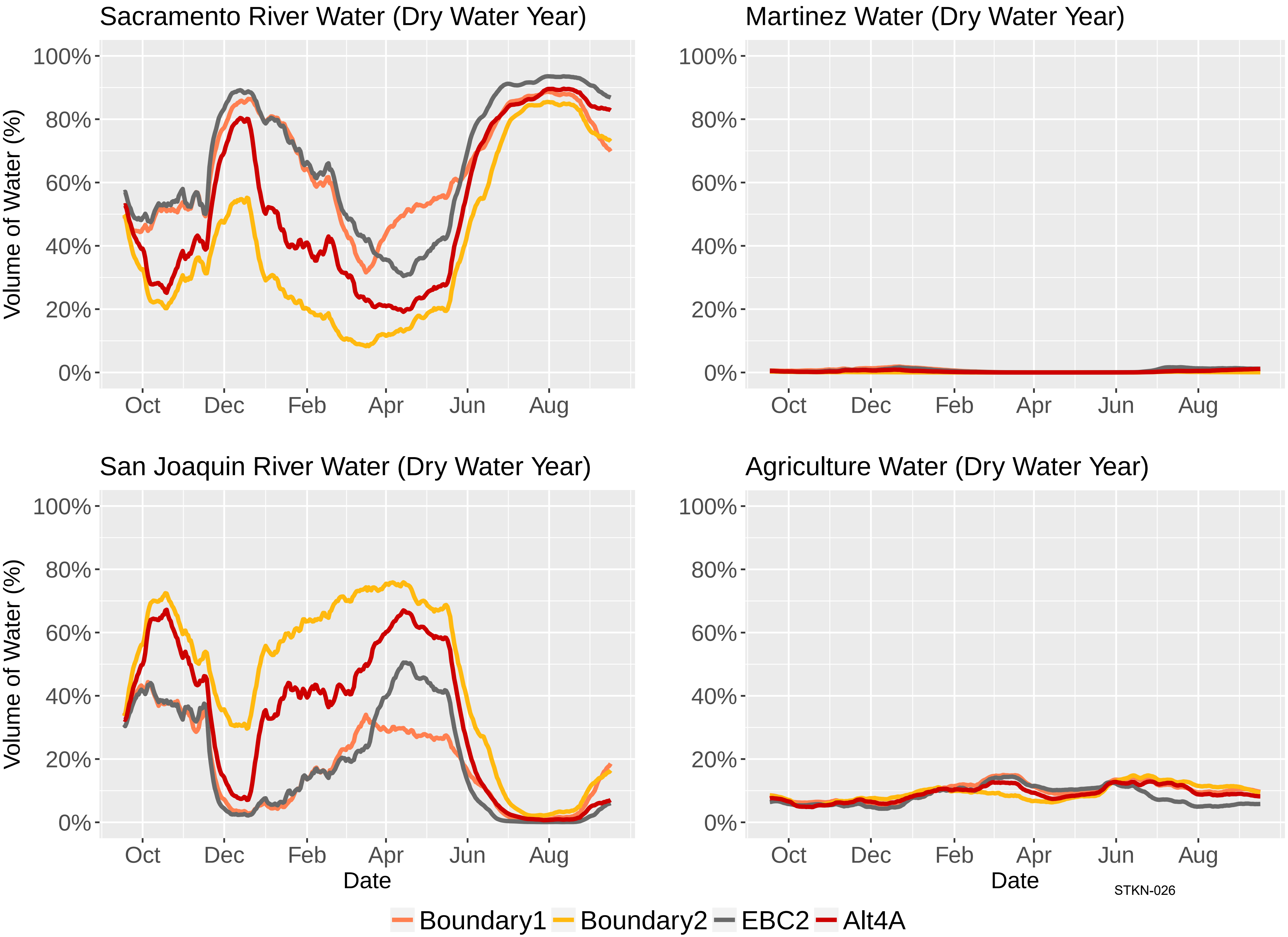
Attachment 5

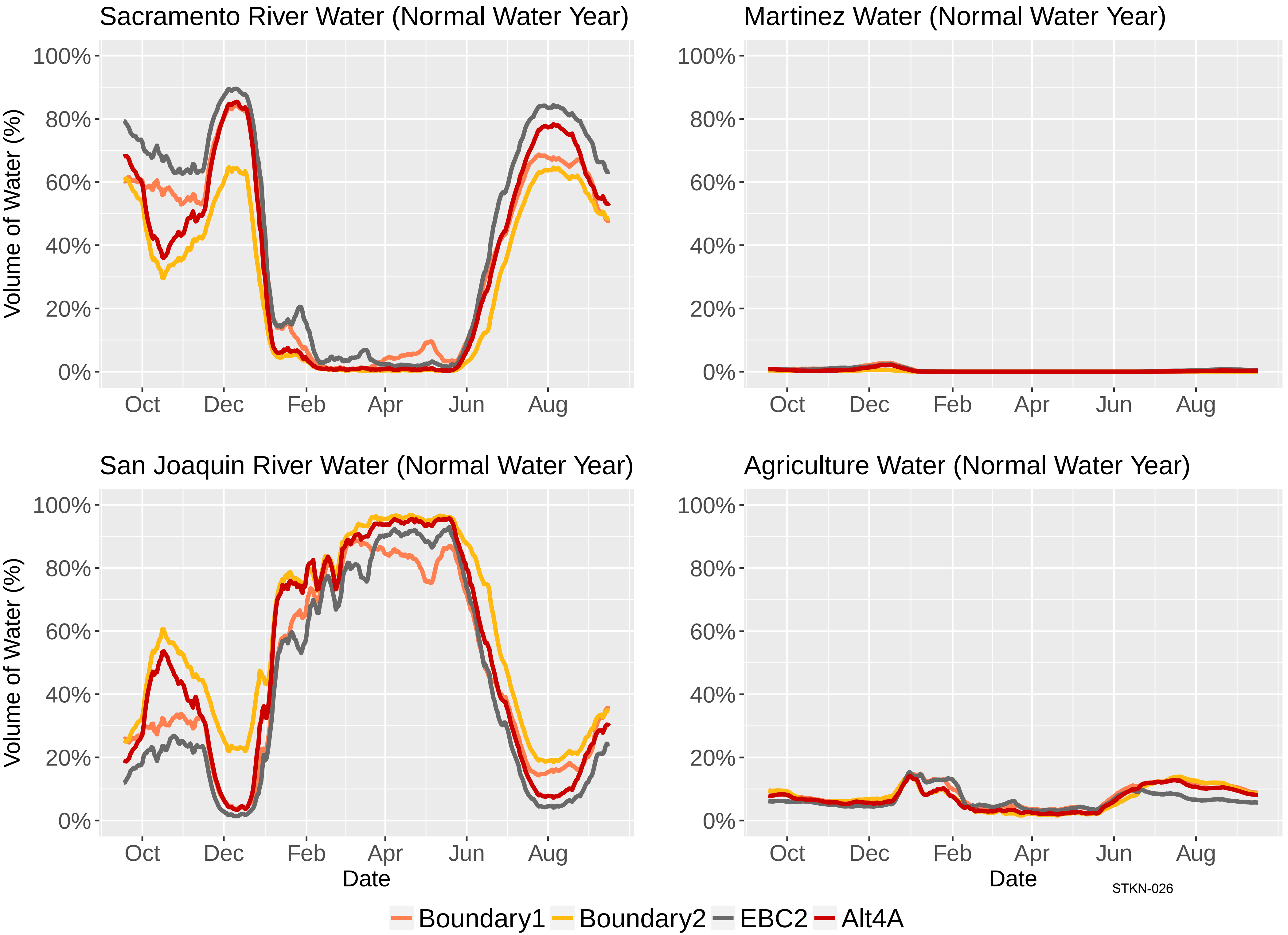
Source water fingerprinting at the City’s intake and Buckley Cove for Boundary 1, Boundary 2, Alternative 4A, and EBC2 scenarios during critical, dry, normal, and wet water year types

Source-water fingerprints at Stockton’s Intake


Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
EBC2
Alt4A

STKN-026


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
Boundary1
Boundary2
EBC2
Alt4A



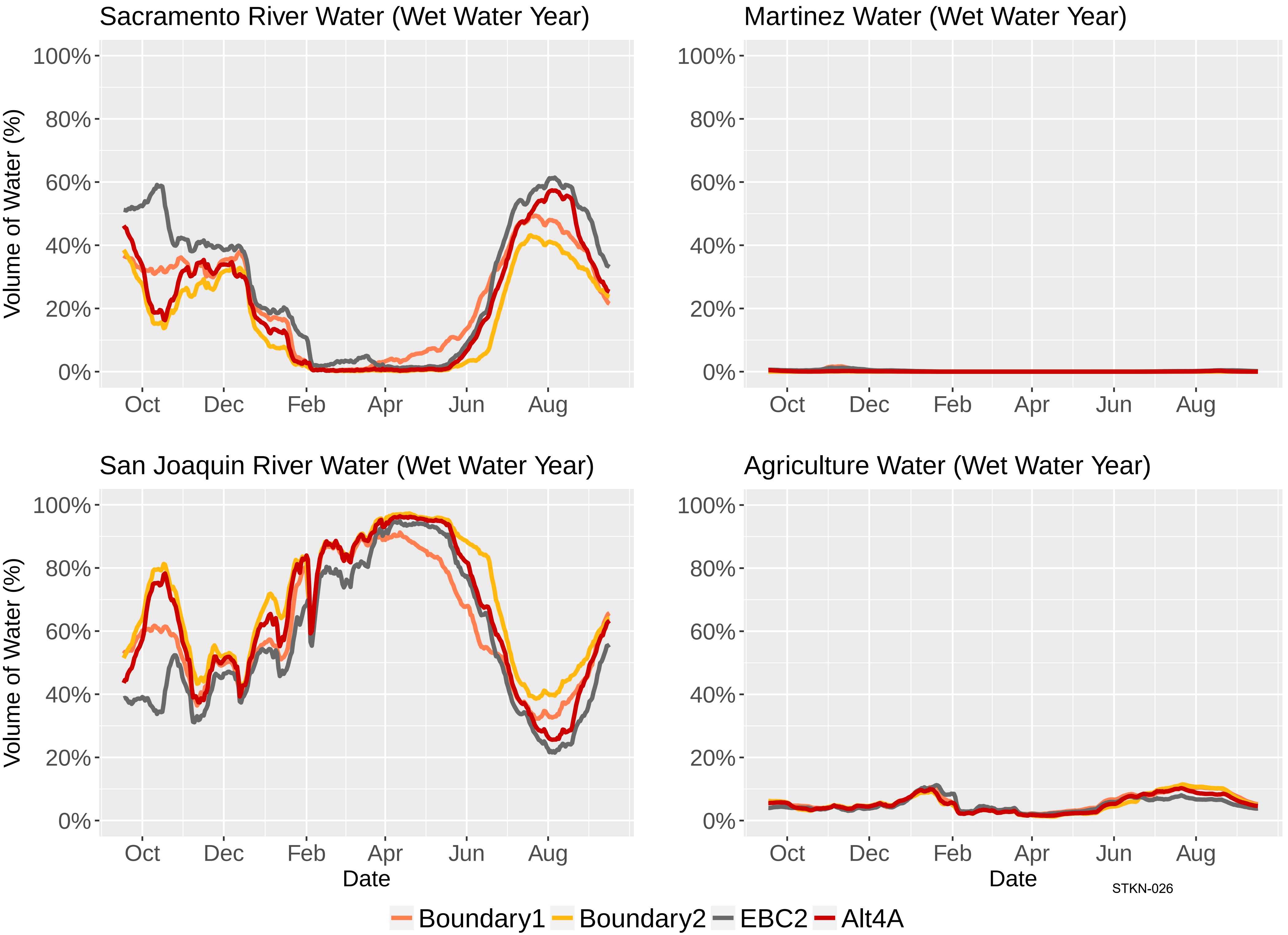
Sacramento River Water (Normal Water Year)

Martinez Water (Normal Water Year)

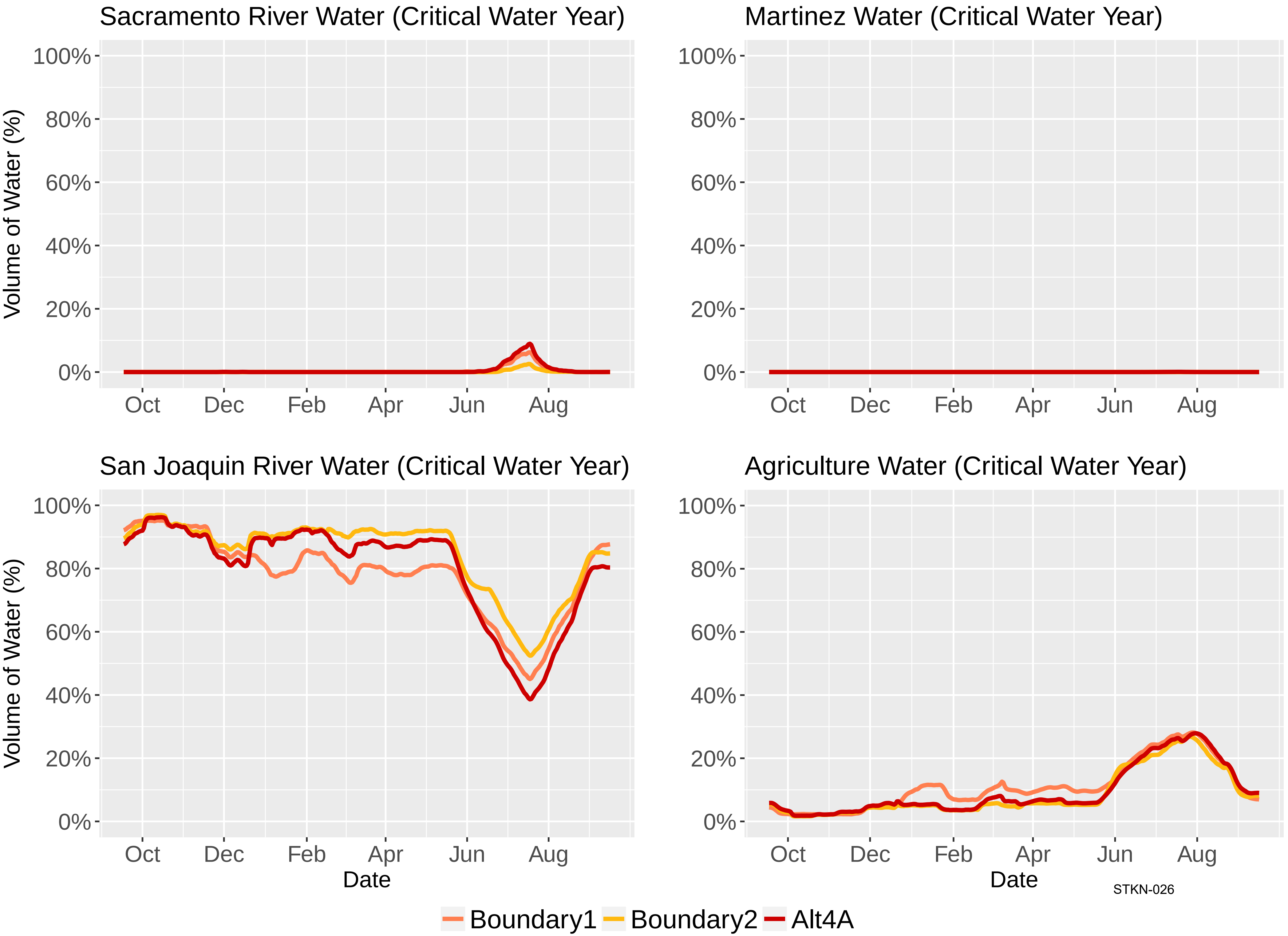
San Joaquin River Water (Normal Water Year)

Agriculture Water (Normal Water Year)

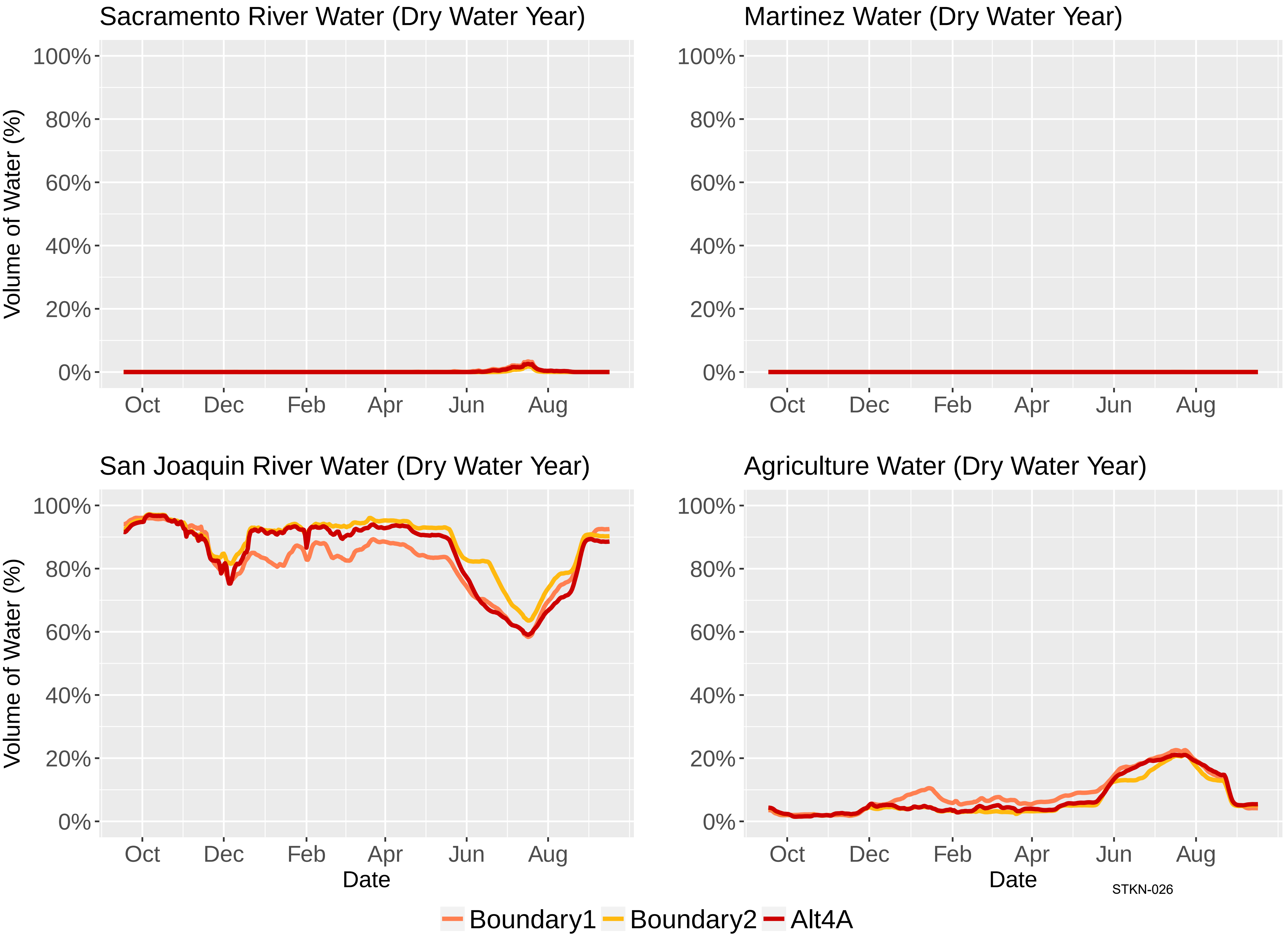
STKN-026


Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
Boundary1
Boundary2
EBC2
Alt4A

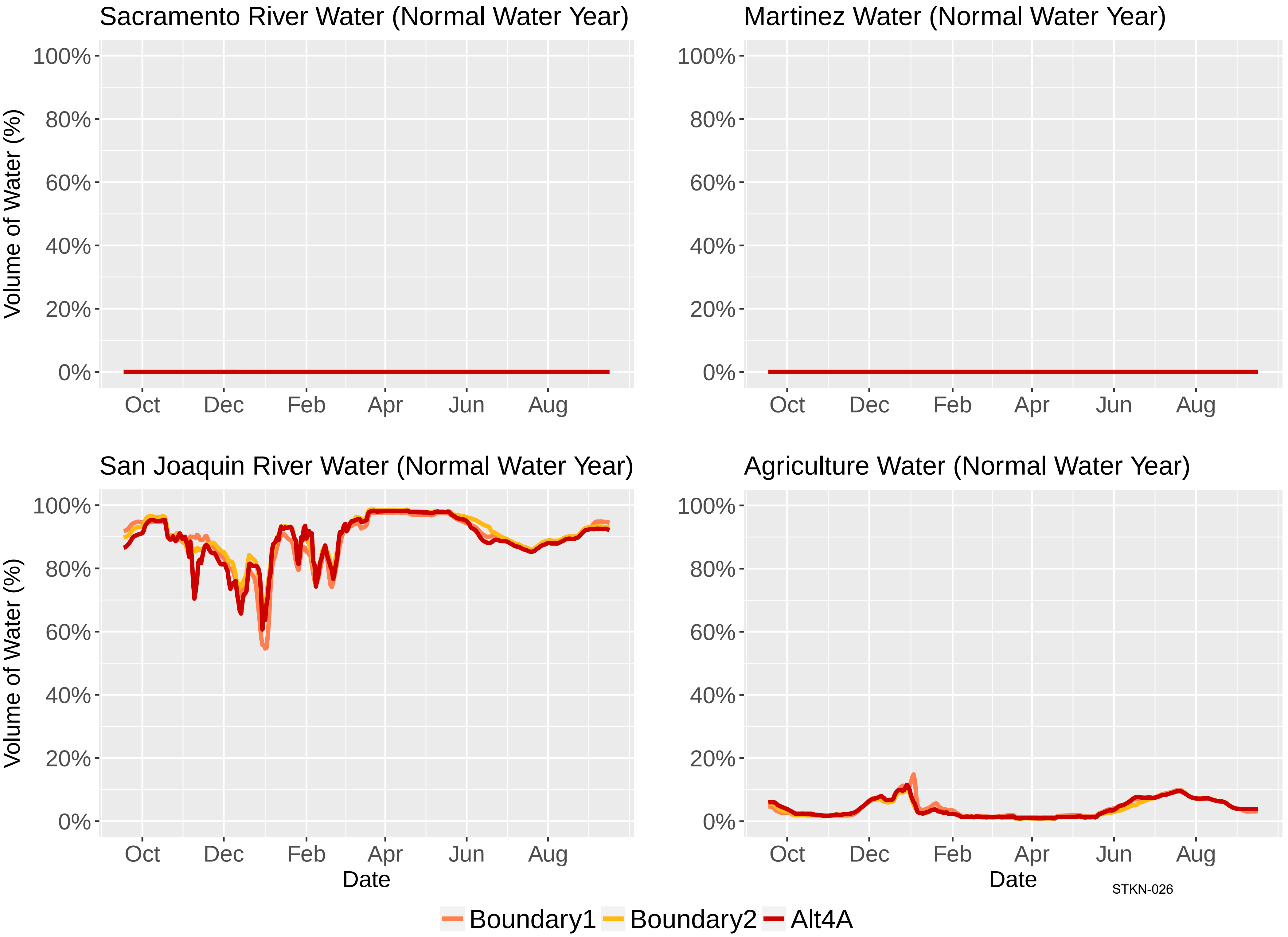
Source-water fingerprints at Buckley Cove

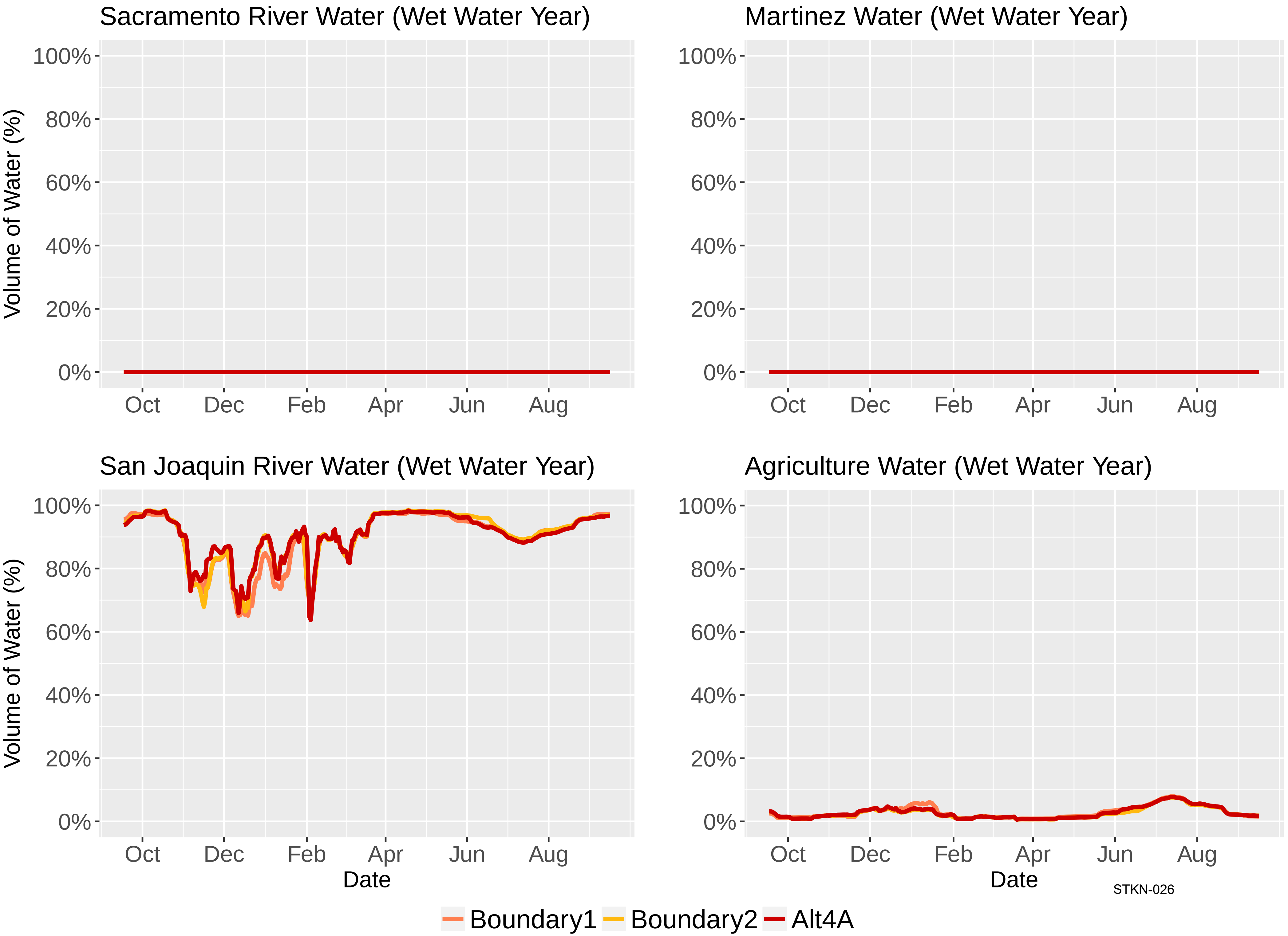

Sacramento River Water (Critical Water Year)
Martinez Water (Critical Water Year)
San Joaquin River Water (Critical Water Year)
Agriculture Water (Critical Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
Alt4A

STKN-026


Sacramento River Water (Dry Water Year)
Martinez Water (Dry Water Year)
San Joaquin River Water (Dry Water Year)
Agriculture Water (Dry Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
Alt4A

STKN-026

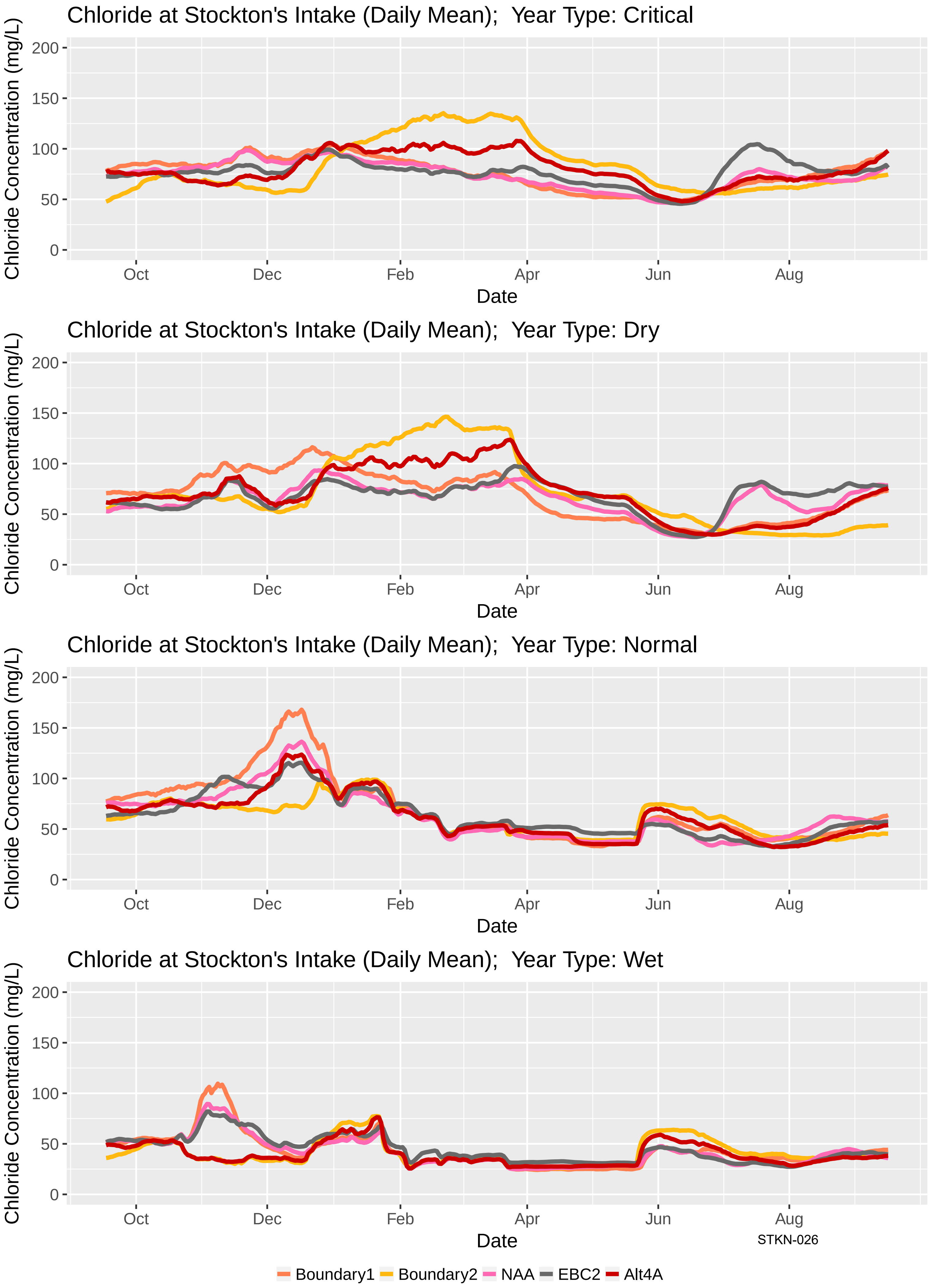

Sacramento River Water (Normal Water Year)
Martinez Water (Normal Water Year)
San Joaquin River Water (Normal Water Year)
Agriculture Water (Normal Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
Alt4A

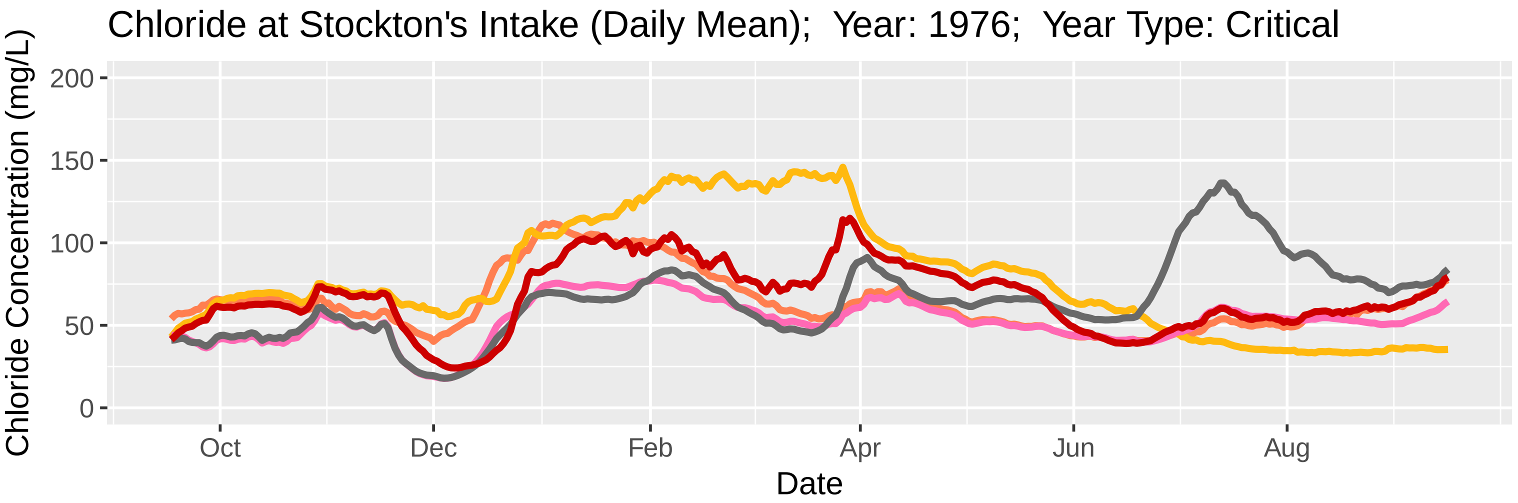

Sacramento River Water (Wet Water Year)
Martinez Water (Wet Water Year)
San Joaquin River Water (Wet Water Year)
Agriculture Water (Wet Water Year)
Volume of Water (%)
100%
80%
60%
40%
20%
0%
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
Alt4A

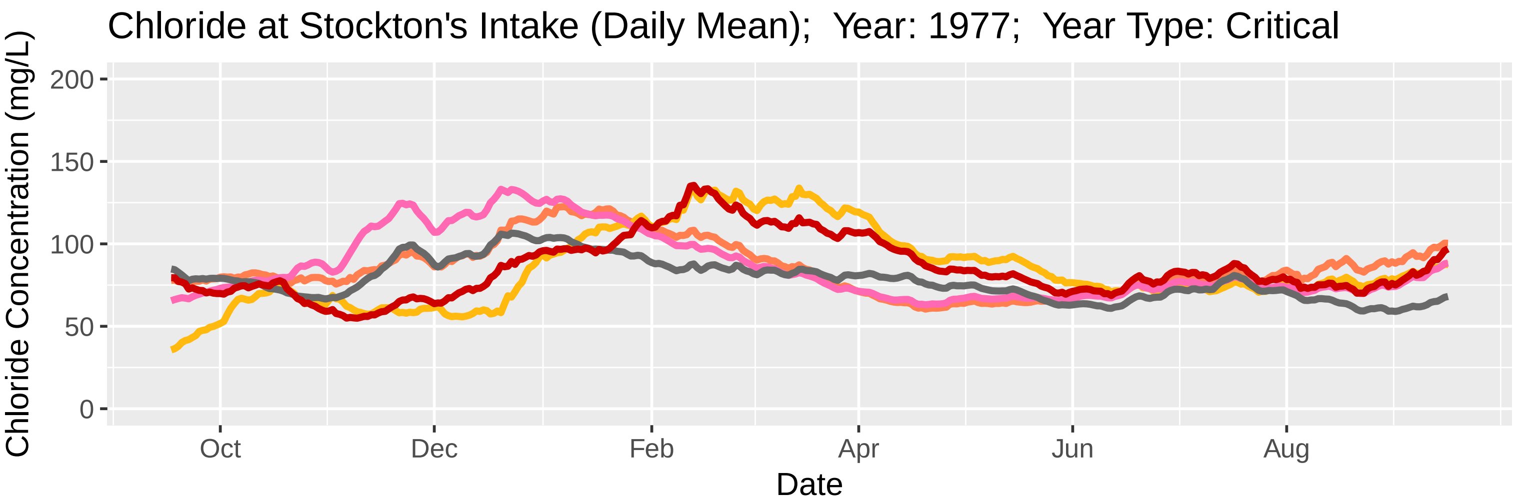
STKN-026

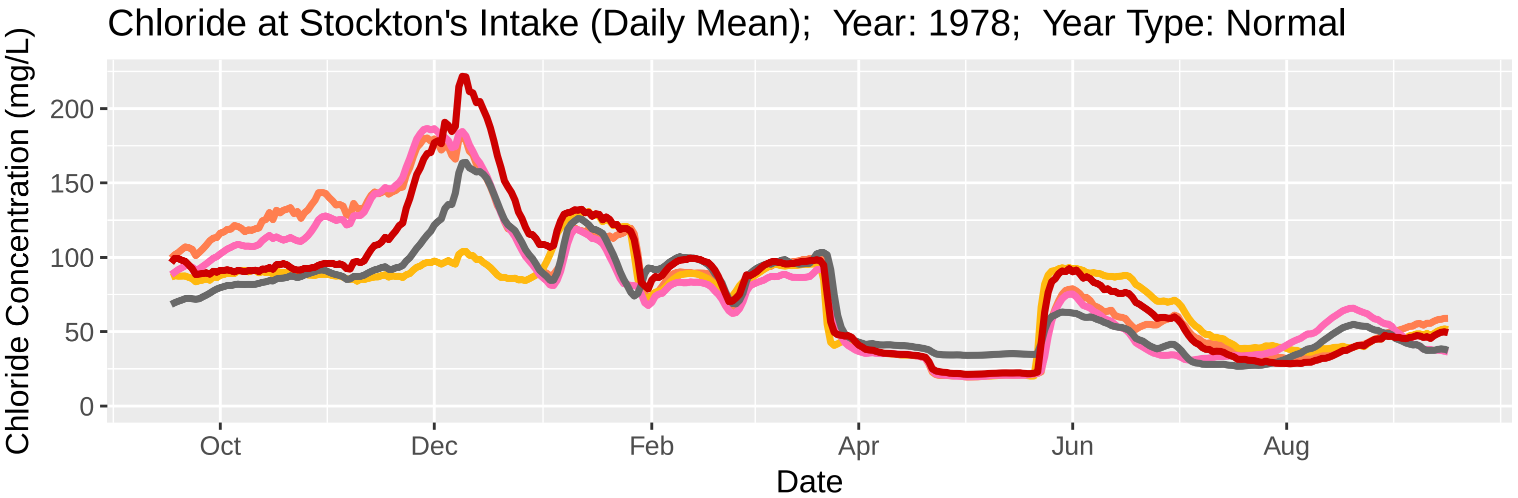
Attachment 6

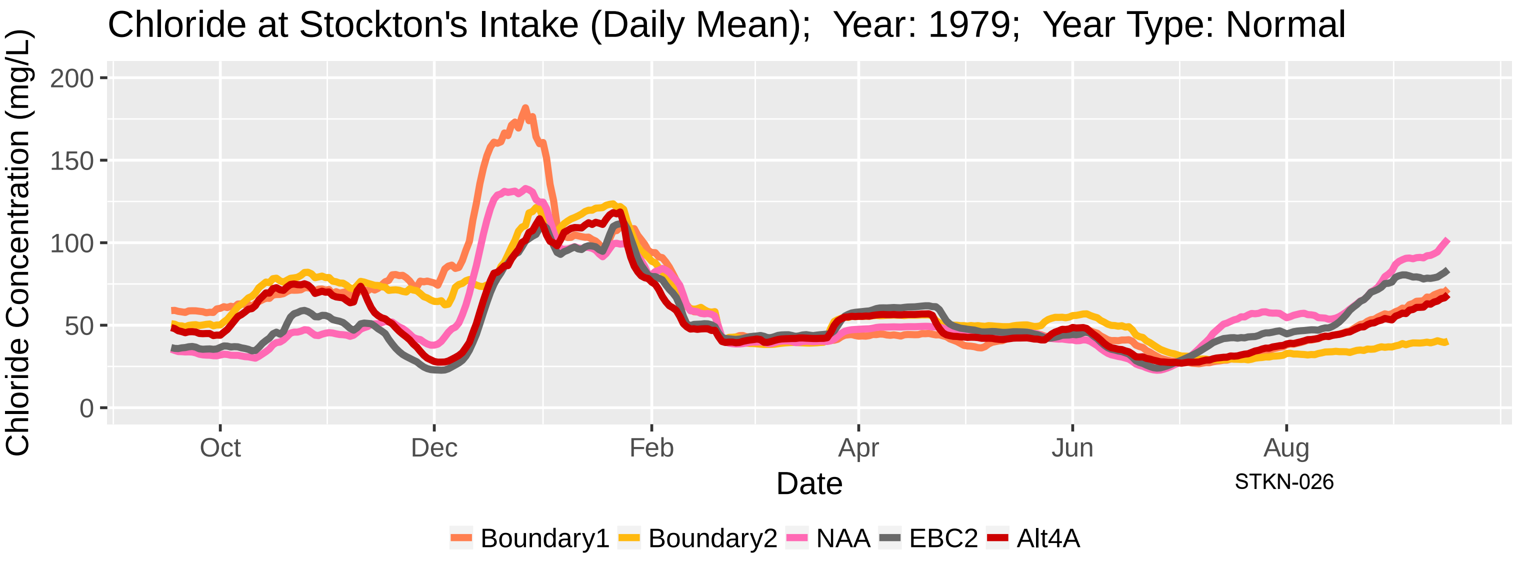
Chloride concentrations at the City's intake and Buckley Cove for Boundary 1, Boundary 2, Alternative 4A, NAA, and EBC2 scenarios during critical, dry, normal, and wet water year types


Chloride at Stockton's Intake (Daily Mean); Year Type: Critical
Chloride at Stockton's Intake (Daily Mean); Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year Type: Normal
Chloride at Stockton's Intake (Daily Mean); Year Type: Wet
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
STKN-026
Boundary1
Boundary2
NAA
EBC2
Alt4A

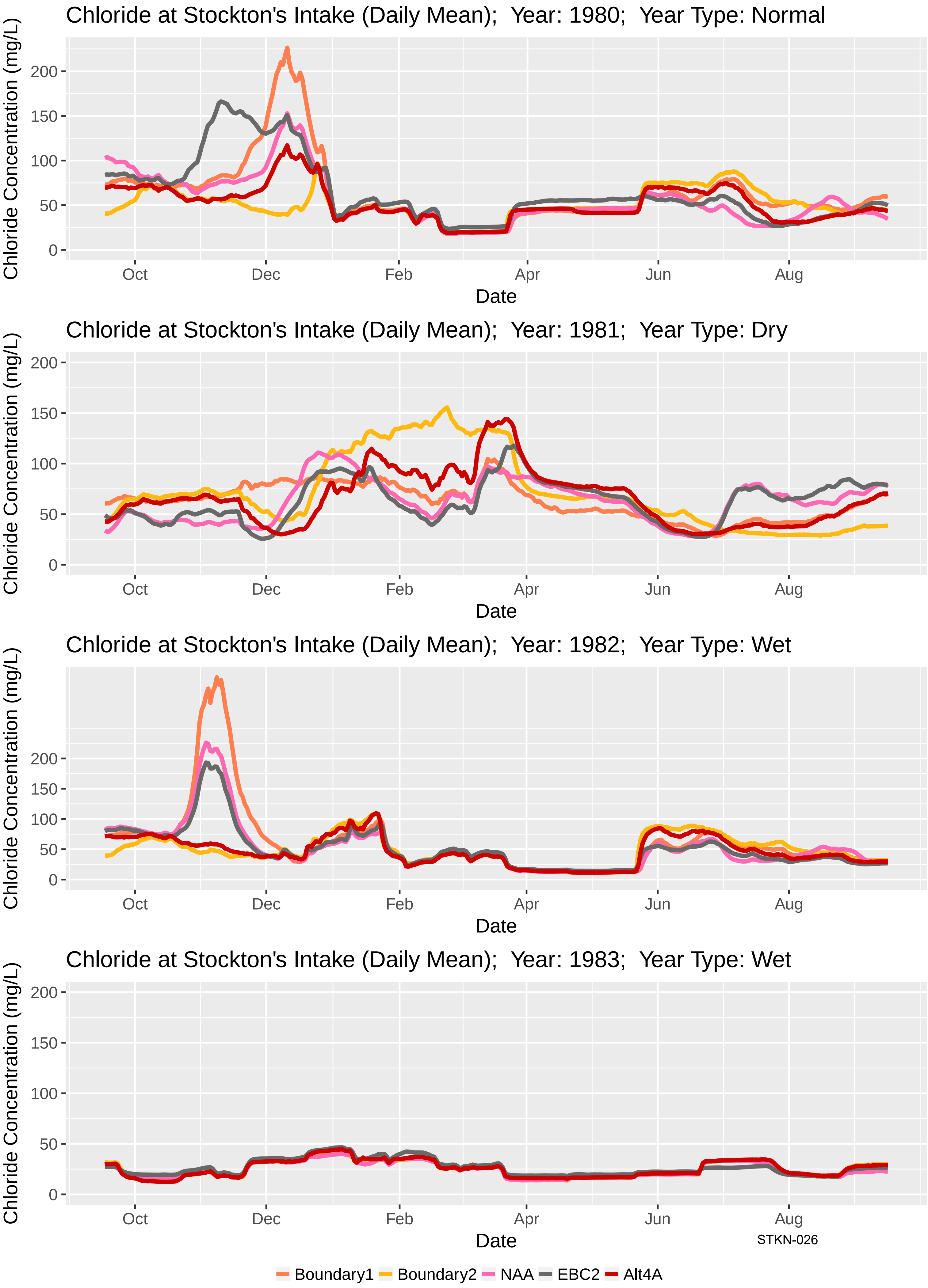

Chloride at Stockton's Intake (Daily Mean); Year: 1976; Year Type: Critical
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date


Chloride at Stockton's Intake (Daily Mean); Year: 1977; Year Type: Critical
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date


Chloride at Stockton's Intake (Daily Mean); Year: 1978; Year Type: Normal
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date


Chloride at Stockton's Intake (Daily Mean); Year: 1979; Year Type: Normal
Chloride Concentration (mg/L)
0
50
100
150
200
Oct
Dec
Feb
Apr
Jun
Aug
Date
Boundary1
Boundary2
NAA
EBC2
Alt4A

STKN-026


Chloride at Stockton's Intake (Daily Mean); Year: 1980; Year Type: Normal

Chloride at Stockton's Intake (Daily Mean); Year: 1981; Year Type: Dry

Chloride at Stockton's Intake (Daily Mean); Year: 1982; Year Type: Wet

Chloride at Stockton's Intake (Daily Mean); Year: 1983; Year Type: Wet

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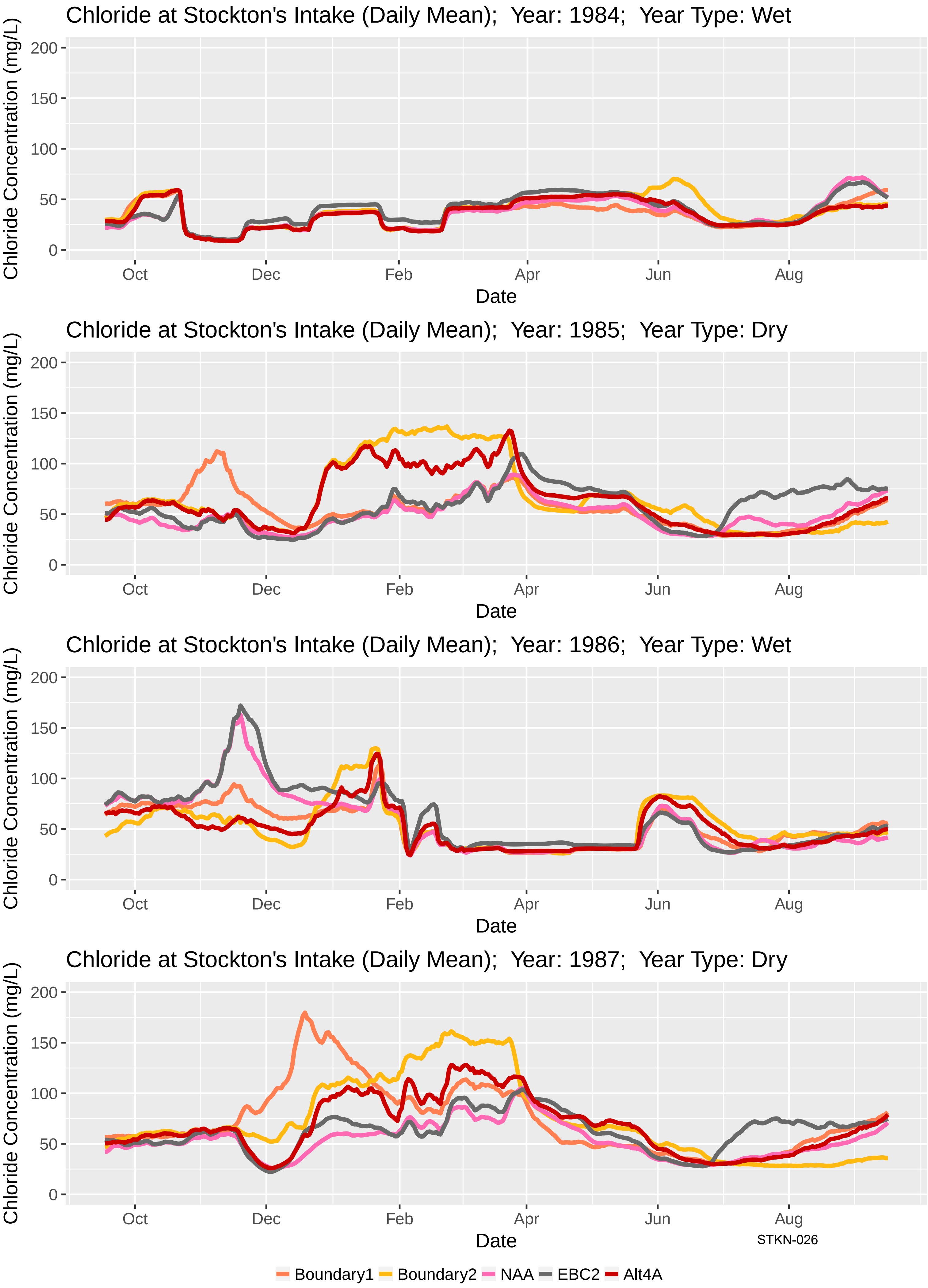
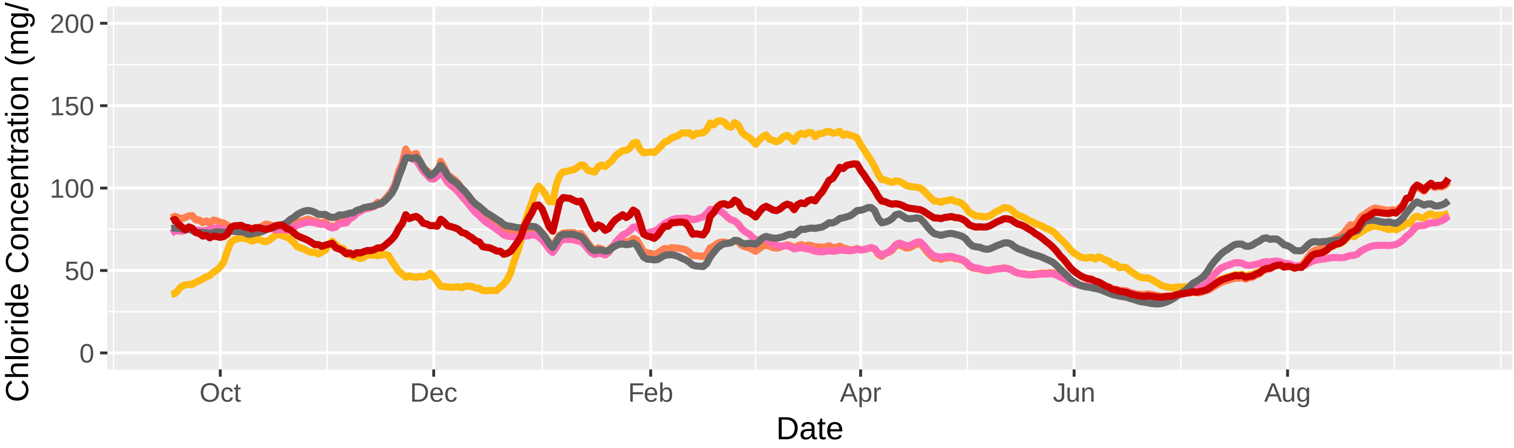
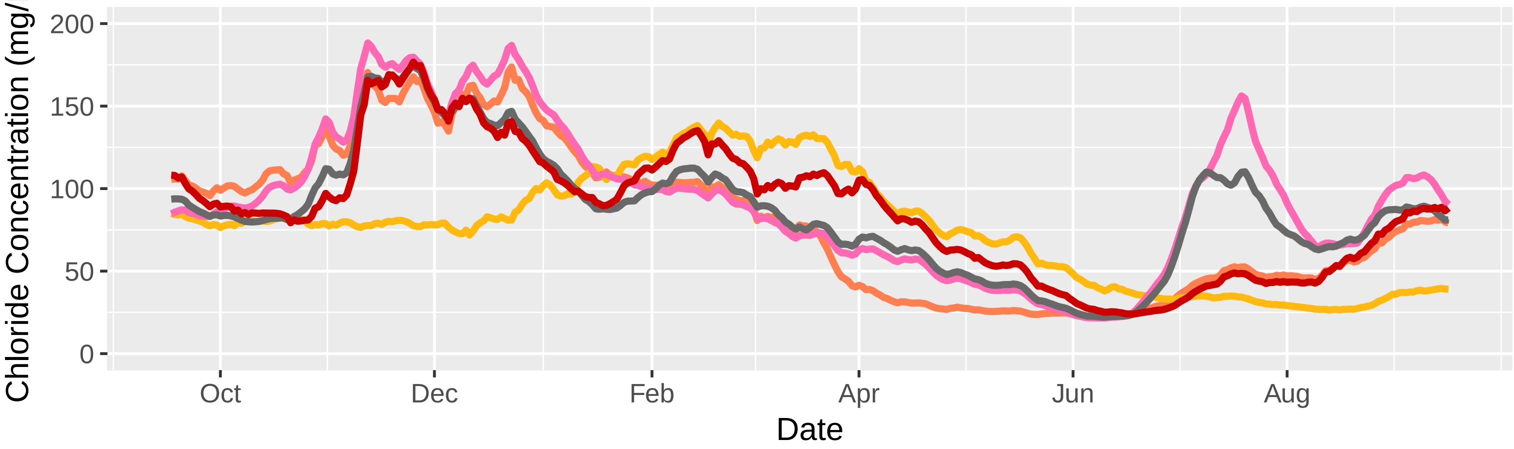

Chloride at Stockton's Intake (Daily Mean); Year: 1984; Year Type: Wet
Chloride at Stockton's Intake (Daily Mean); Year: 1985; Year Type: Dry
Chloride at Stockton's Intake (Daily Mean); Year: 1986; Year Type: Wet
Chloride at Stockton's Intake (Daily Mean); Year: 1987; Year Type: Dry
Chloride Concentration (mg/L)
0
50
100
150
200
Date
Oct
Dec
Feb
Apr
Jun
Aug
Boundary1
Boundary2
NAA
EBC2
Alt4A

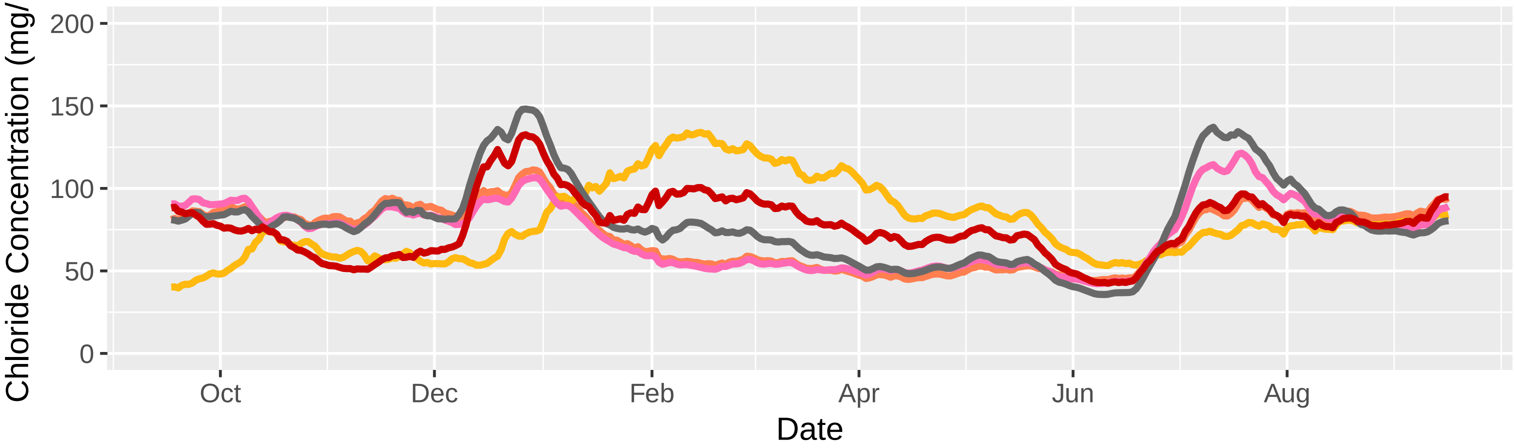
STKN-026



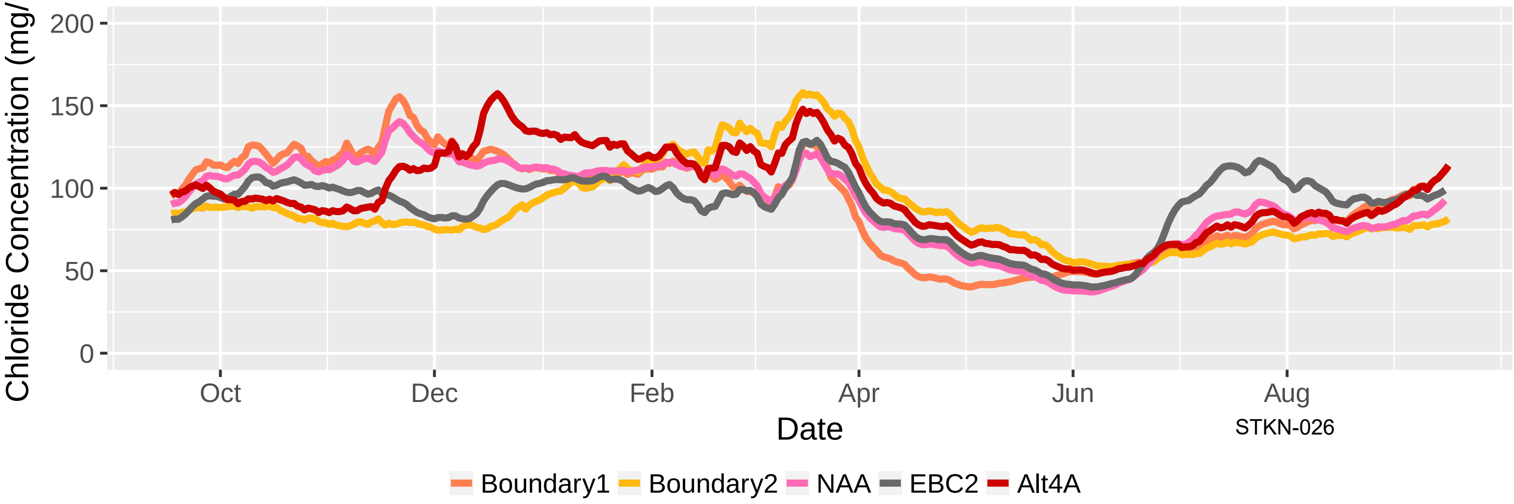
Chloride at Stockton's Intake (Daily Mean); Year: 1988; Year Type: Critical



Chloride at Stockton's Intake (Daily Mean); Year: 1989; Year Type: Dry

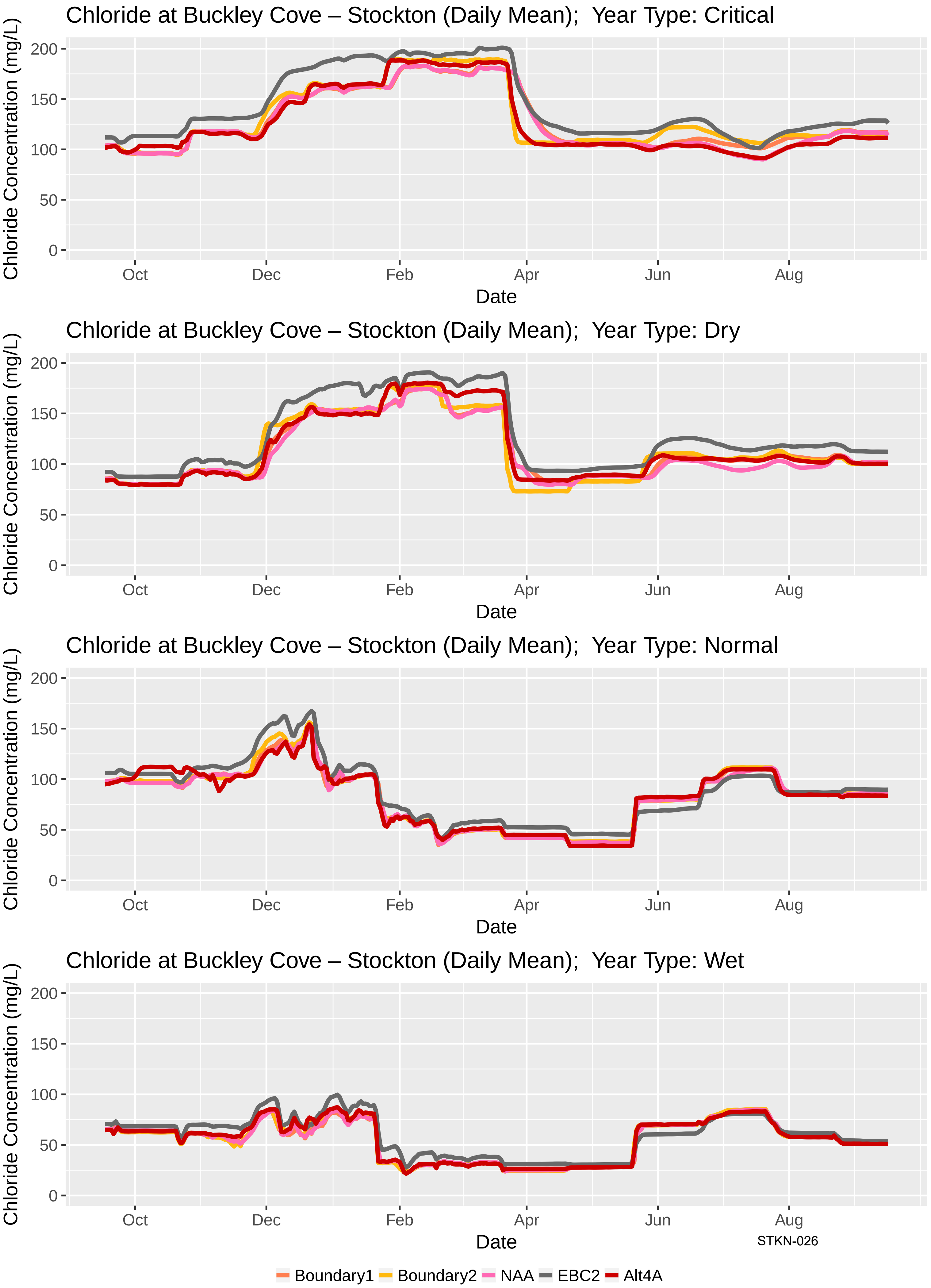


Chloride at Stockton's Intake (Daily Mean); Year: 1990; Year Type: Critical



Chloride at Stockton's Intake (Daily Mean); Year: 1991; Year Type: Critical

STKN-026

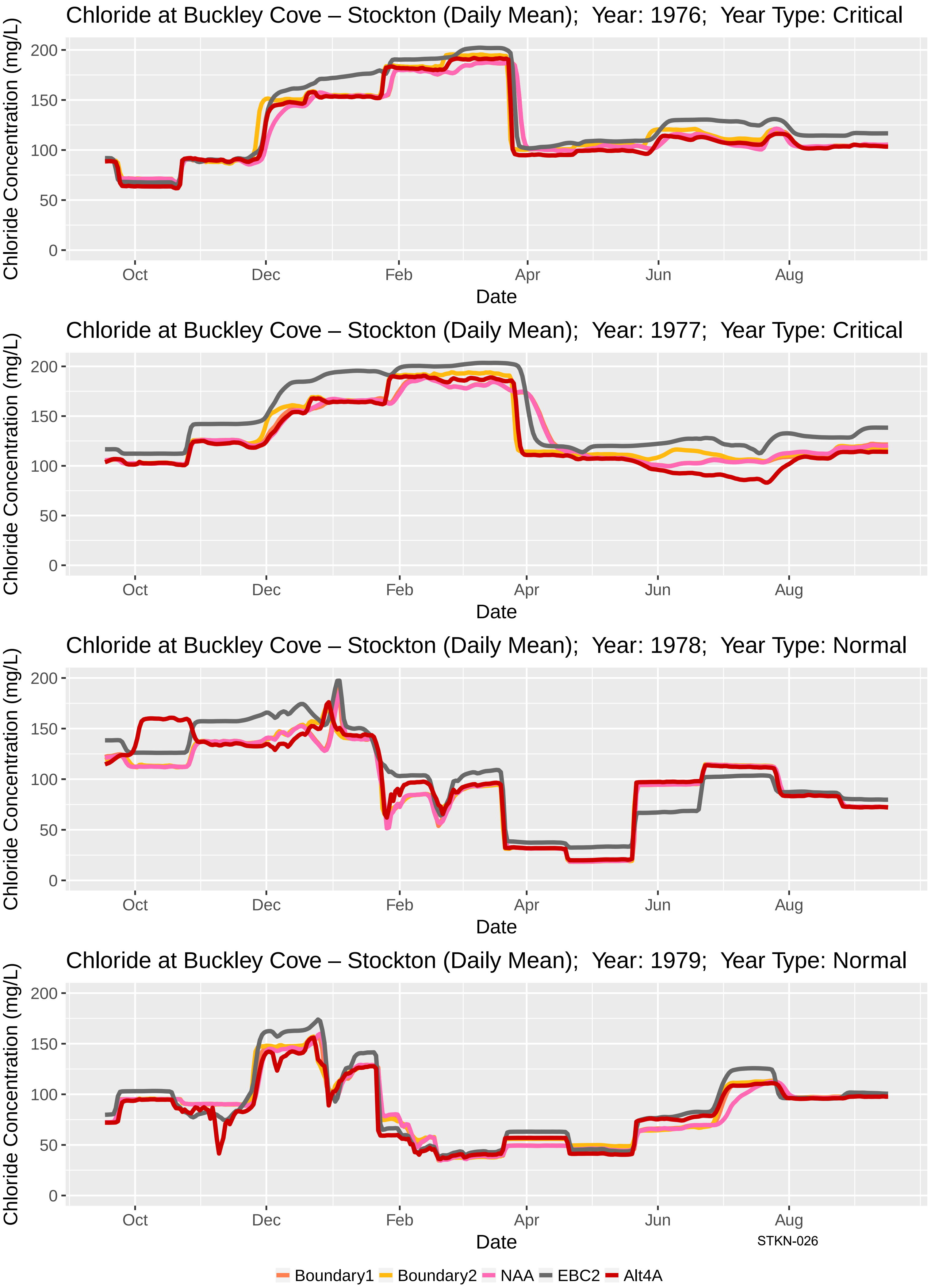


Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Critical

Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Dry

Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Normal

Chloride at Buckley Cove – Stockton (Daily Mean); Year Type: Wet



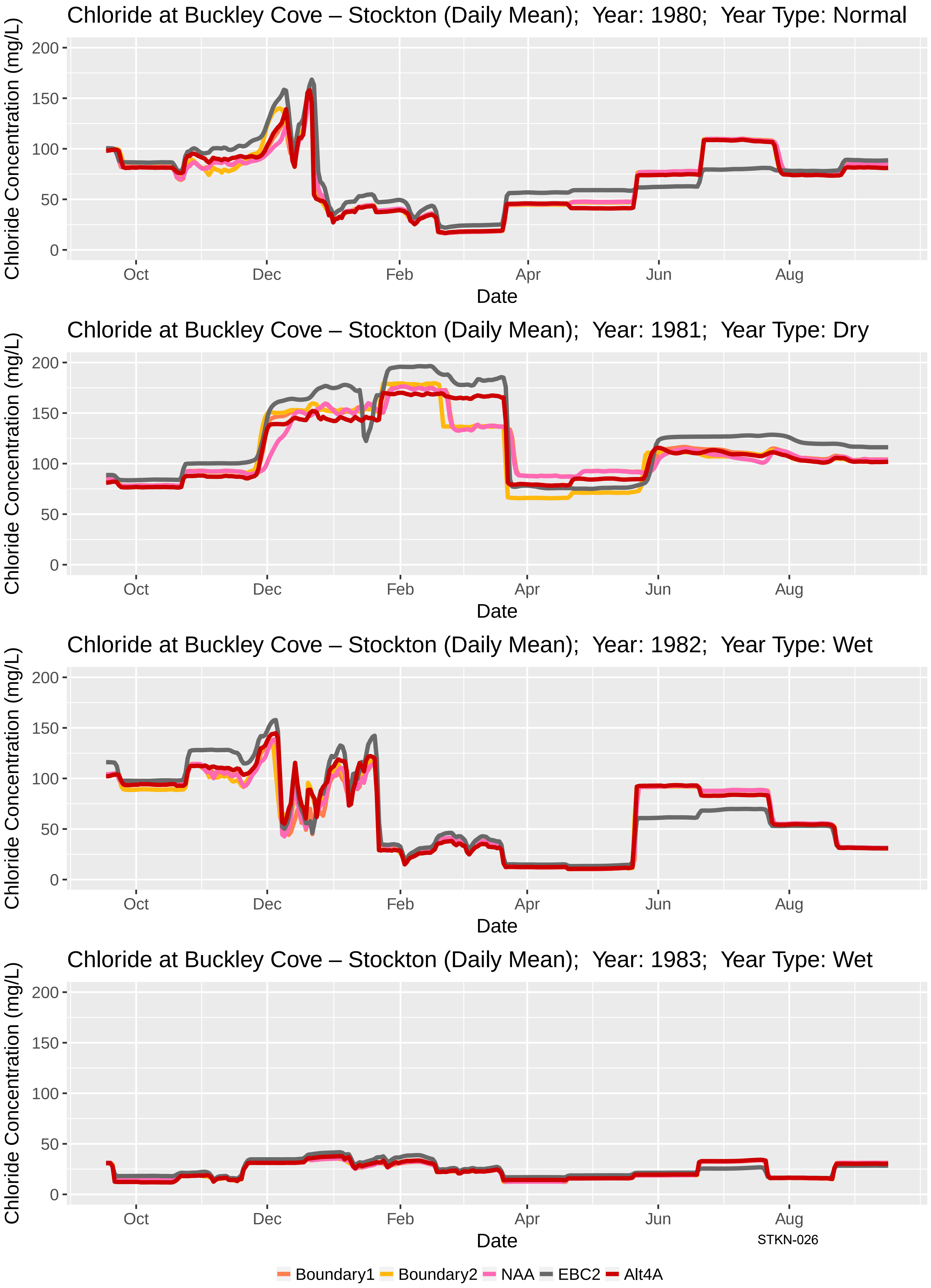
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1976; Year Type: Critical

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1977; Year Type: Critical

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1978; Year Type: Normal

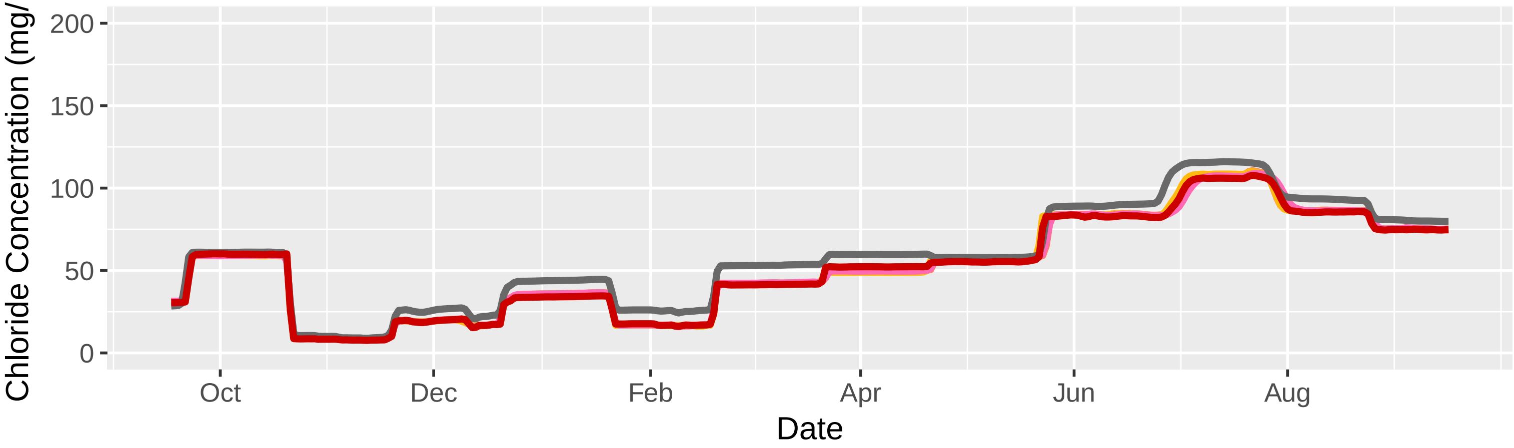
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1979; Year Type: Normal

STKN-026

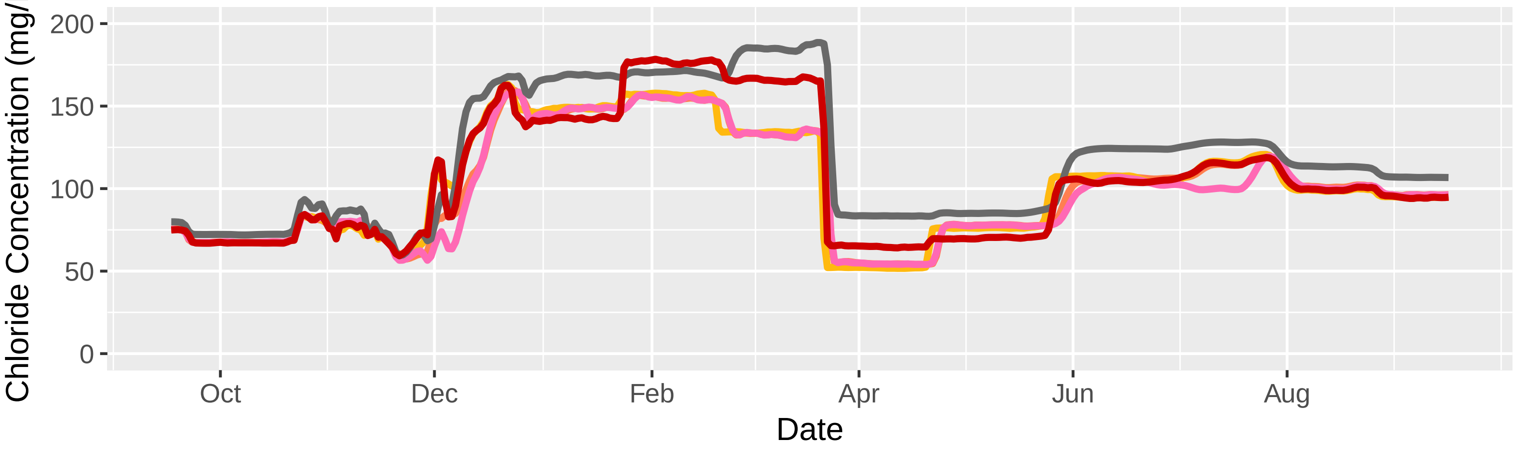

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1980; Year Type: Normal
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1981; Year Type: Dry
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1982; Year Type: Wet
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1983; Year Type: Wet
Chloride Concentration (mg/L)
0
50
100
150
200
Date
Oct
Dec
Feb
Apr
Jun
Aug
Boundary1
Boundary2
NAA
EBC2
Alt4A

STKN-026

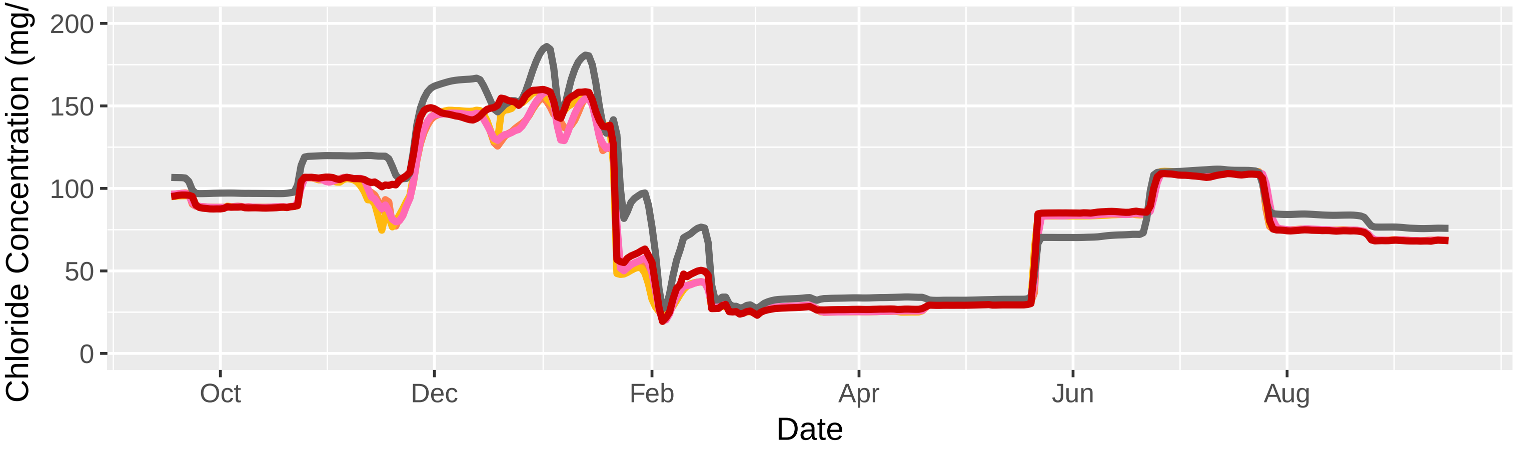
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1984; Year Type: Wet



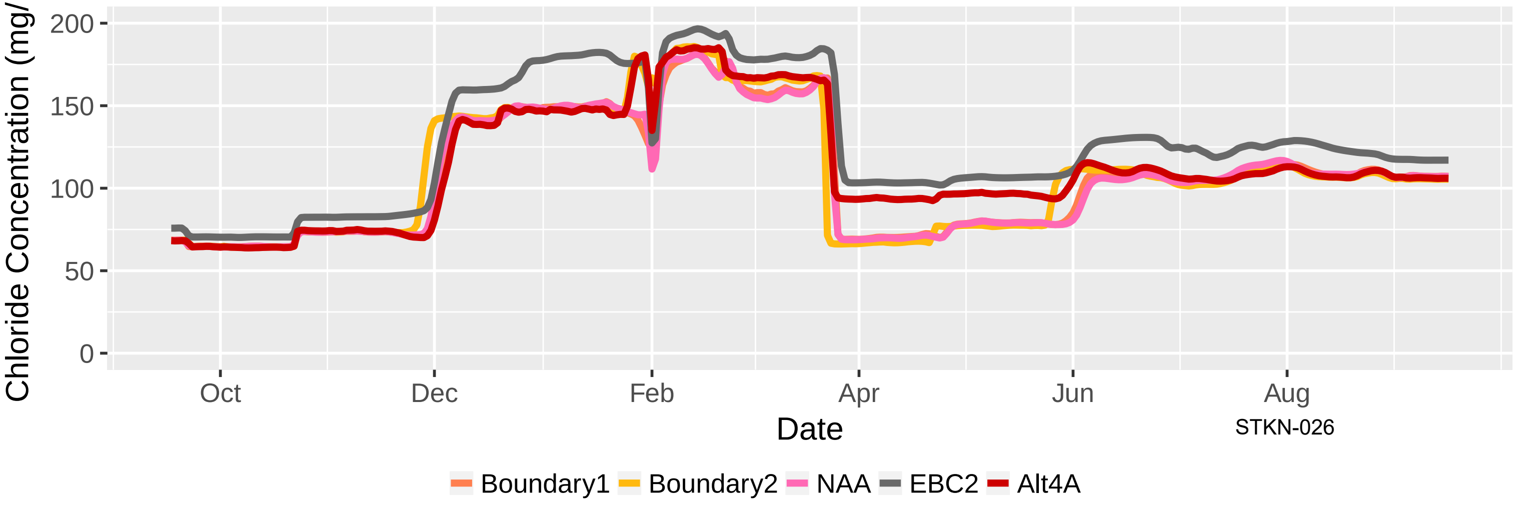
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1985; Year Type: Dry



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1986; Year Type: Wet



Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1987; Year Type: Dry



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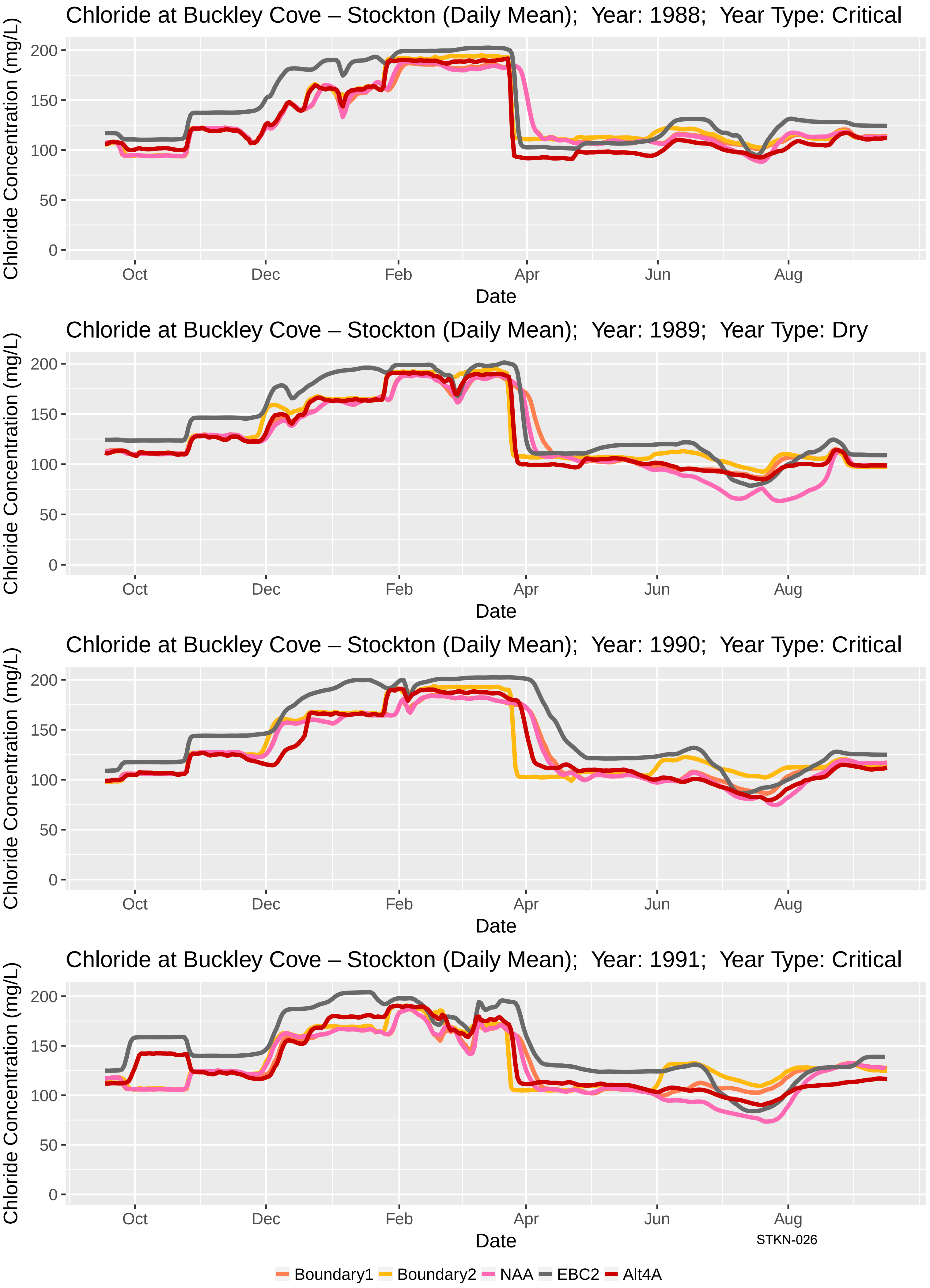
Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1988; Year Type: Critical

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1989; Year Type: Dry

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1990; Year Type: Critical

Chloride at Buckley Cove – Stockton (Daily Mean); Year: 1991; Year Type: Critical

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Appendix H

Excerpts from the FEIR/EIS for the California WaterFix Project

3.2.3.3 Adaptive Management and Monitoring Program

As described above, the BDCP conservation strategy under all the BDCP alternatives consists of 21 conservation measures that are designed to achieve the biological goals and objectives described in BDCP Chapter 3, Section 3.3, *Biological Goals and Objectives*. The conservation measures include actions to improve flow conditions, increase aquatic food production, restore habitat for the covered species, and reduce the adverse effects of many biological and physical stressors on those species. This strategy also recognizes the considerable uncertainty that exists regarding the understanding of the Delta ecosystem and the likely outcomes of implementing the conservation measures, in terms of both the nature and the magnitude of the response of covered species and of ecosystem processes that support the species.

As a component of the conservation strategy, the adaptive management and monitoring program has been designed to use new information and insight gained during the course of Plan implementation to develop and implement alternative strategies to achieve the biological goals and objectives. It is possible that some of the conservation measures will not achieve their expected outcomes, while others will produce better results than expected. The adaptive management process describes how changes to the conservation measures will be made to improve the effectiveness of the Plan over time.

Monitoring and research will be used to confirm Plan implementation and to measure the Plan's effectiveness, as well as to assess uncertainties and increase understanding of Delta ecosystems. Extensive monitoring and research are currently underway in the Delta. To address the specific requirements of the Plan, some of these monitoring activities will continue and, in some cases, be expanded. In other cases, existing monitoring activities will be modified to reflect specific implementation needs of the Plan. The BDCP will also require that new types of monitoring activities be conducted in the Delta to support Plan implementation. To guide these efforts, detailed monitoring and research plans will be developed that identify specific metrics and protocols.

Adaptive management and monitoring activities will be implemented through a single, comprehensive program. Information obtained from monitoring and research activities will be used by decision makers to improve the effectiveness of the conservation measures toward advancing the biological goals and objectives. The adaptive management and monitoring program is directly related to several key components of the BDCP, as fully described in BDCP Chapter 3Section 3.6, and BDCP Chapter 7, *Implementation Structure*.

3.2.4 Development of the California WaterFix

Among the comments received on the Draft EIR/EIS were suggestions that DWR should pursue permit terms shorter than 50 years, and that the proposed conveyance facilities should be untethered from the habitat restoration components of the BDCP, with the latter to be pursued separately. These comments highlighted two major challenges associated with the original 50-year term for the proposed Bay Delta Conservation Plan, which would be an HCP under the ESA and an NCCP under California law. The first such challenge related to the inherent difficulties in trying to predict the future status of the target aquatic species and other future environmental conditions over a 50-year period in light of climate change and other variables. The second challenge related to the difficulties, over such a long period, in trying to accurately predict the benefits of long-term conservation in contributing to the recovery of such species. Other comments questioned DWR's and/or its tributaries that would then motivate a change to project implementation. The product of Phase 3 is an assessment report.

The collaborative science effort is expected to inform operational decisions within the ranges established by the biological opinion and 2081b permit for the proposed project. However, if new science suggests that operational changes may be appropriate that fall outside of the operational ranges evaluated in the biological opinion and authorized by the 2081b permit, the appropriate agencies will determine, within their respective authorities, whether those changes should be implemented. An analysis of the biological effects of any such changes will be conducted to determine if those effects fall within the range of effects analyzed and authorized under the biological opinion and 2081b permit. If NMFS, USFWS, or CDFW determine that impacts to listed species are greater than those analyzed and authorized under the biological opinion and 2081b permit, consultation may need to be reinitiated and/or the permittees may need to seek a 2081b permit amendment. Likewise, if an analysis shows that impacts to water supply are greater than those analyzed in the EIR/EIS, it may be necessary to complete additional environmental review to comply with CEQA or NEPA.

The collaborative science process will also inform the design and construction of the fish screens on the new intakes. This requires active study to maximize water supply, ensure flexibility in their design and operation, and minimize effects to covered species. The collaborative science process will similarly inform adaptive management of habitat restoration and other mitigation measures required by the existing and new biological opinions and 2081b permit.

Within Phase 3, the objective of Scoping_is to determine whether assessment feedback is significant enough to trigger consideration of changes to a management action and the monitoring and research program, if so, then to diagnose the resources and actions needed to implement the change. Scoping is accomplished via a structured dialogue involving managers, scientists and stakeholders. The goal of the dialogue is to develop a common interpretation and understanding of the monitoring and research products. If it is determined that the new understanding is a significant insight or change in understanding that is relevant to making a change in implementation of management actions, the agencies will then develop management measures, and more effective management approaches.

The final activity associated with Phase 3 is the formulation of a management recommendation during which alternative approaches are evaluated in Phase 1 and 2 as appropriate and a management action recommendation is made. The final product is a report submitted to the Five Agency Directors for approval (Phase 4).

Phase 4 – Adapt and Adopt

The fourth phase of the adaptive management framework revolves around the decision to implement a management change through adjustments in water operations, restoration tactics, or monitoring and research support related to the project. Recommendations from Phase 3 are used to make management decisions.

The agencies, based on their authorities related to CVP/SWP (Existing BiOps/CESA, Coordinated Operations Agreement, California WaterFix) as implementing or regulatory agencies, would consider management changes, such as:

- Changes in project operations within BiOps and CESA authorizations, consistent with WQCP.

Master Response 14: Water Quality

A number of comments were received regarding the assessment methodology and water quality data sources for the EIR/EIS. Other comments questioned the water quality analyses and effects related to salinity, dissolved organic carbon, selenium, mercury, pesticides, temperature and Microcystis*. This master response addresses these topics.*

Because of the length of this master response, a short outline is presented to facilitate review of specific components of this response.

1. *Assessment Methodology and Data Sources*
    a. *Qualitative Assessments in Delta Region*
    b. *Qualitative Assessments in the Upstream of Delta Region*
    c. Qualitative Assessments in the San Francisco and San Pablo Bays
    d. *Water Quality Setting Data*
2. *Modeling for RDEIR/SDEIS and Final EIR/EIS - Alternatives 4A, 2D, and 5A*
3. *Salinity Effects Analysis*
4. *Contra Costa Water District and Antioch Intakes Water Quality Analysis*
    a. *Modeling Data Averaging Periods*
    b. *Delta Assessment Locations*
    c. *Los Vaqueros Reservoir*
    d. *CCWD Chloride Goal*
5. *Selenium Effects Analysis*
6. *Mercury Effects Analysis*
7. *Pesticides Effects Analysis*
8. *Temperature Effects on Drinking Water*
9. *Antidegradation Analysis*
10. Microcystis *Analysis*
    a. *Adequacy of the Assessment in the Upstream of Delta Region*
    b. *Adequacy of Assessment in the Delta Region*
    c. *Potential for Harmful Microcystin Levels in the San Francisco Bay*

Assessment Methodology and Data Sources

Multiple comments were received regarding the scope and adequacy of the water quality assessment presented in Chapter 8, *Water Quality*. Comments stated that constituents assessed qualitatively in the Delta should have been assessed quantitatively, that the constituent assessments conducted for the Upstream of the Delta region should have been conducted using quantitative methods, and that more detailed assessment between Emmaton and Veterans Bridge should have been provided. Multiple comments were also received indicating that additional data should have been compiled for the affected environment/environmental setting and to support the assessment presented in Chapter 8, *Water Quality*.

Commenters also raised issues regarding the analysis regarding water quality impacts and the feasibility and/or level of detail related to proposed Best Management Practices (BMPs), mitigation measures and Environmental Commitments.

Qualitative Assessments in Delta Region

Comments stated that additional quantitative models should have been used or developed for those constituents assessed qualitatively for the Delta region. To the extent that a constituent assessment could be conducted quantitatively, using models currently developed and validated for the Delta, those tools were utilized for the water quality assessment. For some constituents, the state of the science is such that quantitative models do not exist and cannot be developed in a way that would provide reliable, meaningful results that would allow for evaluating the effects of changing source water fractions in the Delta due to the alternatives.

Commenters stated that dissolved oxygen should have been modeled. The variables that affect dissolved oxygen concentrations are numerous and include atmospheric reaeration rates, sediment oxygen demand rates, and biochemical oxygen demands of constituents in the water column. Further, dissolved oxygen rates vary daily in response to photosynthesis and respiration of algae and plants, and temperature also affects the saturation level. The fact that there are numerous variables contributes to the difficulty in applying a numerical dissolved oxygen model in this assessment. Each of these variables would have to be known, some of which are also assessed qualitatively (e.g., nutrient-related parameters, oxygen demand). While there has been work to calibrate DSM2-QUAL for dissolved oxygen modeling, work remains to allow for its use. Because the factors that affect dissolved oxygen are known, the assessment of the alternatives focused on considering how the alternatives would affect these factors in a qualitative manner and identified whether changes to these factors would contribute to a lowering of dissolved oxygen concentrations.

Similarly, for turbidity and total suspended solids (TSS), known factors that affect levels of these parameters, including river inflow rates and channel velocities, sediment loading, were considered relative to the potential for the alternative to affect these factors in an adverse direction. For turbidity and TSS, a qualitative analysis considering how the project alternatives would affect these sources and transport processes was the best available information from which to identify potential water quality changes associated with the project alternatives.

For other constituents, qualitative methods based on flow changes, sources and transport processes can fully assess potential impacts of the project on the constituent, and thus quantitative models would not add useful information to the assessment. For example, for trace metals, a qualitative assessment using historical monitoring data, which accounts for existing sources and transport processes, assesses the potential water quality changes without the need for a quantitative fate and transport model.

In summary, quantitative models are not always necessary or useful in determining effects of a project. The water quality assessment used the best available models when there was a need to use those models to assess effects of the project alternatives, and did not use quantitative models when they were not available or necessary.

Qualitative Assessments in the Upstream of Delta Region

Similarly, the qualitative methodology used for the upstream of the Delta water quality assessment is sufficient for the purposes of the EIR/EIS given the nature of the types of changes this region is expected to experience as a result of the project alternatives. The primary effects of the alternatives on water bodies in the Upstream of Delta region are reservoir storage and releases, and thus river flows. Consideration of reservoir storage and river flow ranges under the alternatives relative to baseline conditions, and consideration to upstream sources of constituents of concern, provided the most effective assessment approach relative to the information available.

Regarding effects on the Sacramento River from Emmaton upstream to Veterans Bridge, this reach is addressed by both the assessment for the Upstream of the Delta assessments and the Delta Region assessments. The Upstream of the Delta assessments address the reach from Veterans Bridge down to Freeport/Hood. This reach is outside the domain of DSM2, and thus was addressed qualitatively. The Delta Region assessment addresses effects downstream of Freeport/Hood to Emmaton. This reach was assessed quantitatively or qualitatively, depending on constituent (see first part of response above), with modeling results provided for the Sacramento River at Emmaton.

Qualitative Assessments in the San Francisco and San Pablo Bays

Since completion of the Draft EIR/EIS, analyses of alternatives' effects on areas downstream of the Plan Area in the San Francisco and San Pablo bays was included in the RDEIR/SDEIS and this Final EIR/EIS in Chapter 8, *Water Quality*, and Chapter 11, *Fish and Aquatic Resources*. Impacts on sediment transport and turbidity were specifically analyzed in Chapter 11, Impact AQUA-218, and indicate that Alternative 4A would have a less-than-significant impact on aquatic habitat in the bay downstream of the Plan Area.

Water quality impacts on San Francisco Bay is analyzed in Chapter 8, Impact WQ-34. As stated therein, no substantial changes in DO, pathogens, pesticides, trace metals, turbidity or TSS, and *Microcystis* are anticipated in the Delta due to the implementation of Alternative 4A, relative to Existing Conditions, therefore, no substantial changes to these constituents' levels in the Bay are anticipated. Changes in Delta salinity would not contribute to measurable changes in Bay salinity, as the change in Delta outflow would be two to three orders of magnitude lower than (and thus minimal compared to) the Bay's tidal flow and thus, have minimal influence on salinity changes. Changes in nutrient load, relative to Existing Conditions, are expected to have minimal effect on water quality degradation, primary productivity, or phytoplankton community composition. As with Alternative 4, the change in mercury and methylmercury load (which is based on source water and Delta outflow), relative to Existing Conditions, would be within the level of uncertainty in the mass load estimate and not expected to contribute to water quality degradation, make the Clean Water Act Section 303(d) mercury impairment measurably worse or cause mercury/methylmercury to bioaccumulate to greater levels in aquatic organisms that would, in turn, pose substantial health risks to fish, wildlife, or humans. Similarly, based on Alternative 4 estimates, the increase in selenium load would be minimal, and total and dissolved selenium concentrations would be expected to be the same as Existing Conditions, and less than the target associated with white sturgeon whole-body fish tissue levels for the North Bay. For more information regarding updated selenium analysis please see Chapter 8, Section 8.3.1.7, *Constituent-Specific Considerations Use in the*

Assessment. These analyses described above indicate that potential effects on water quality in the San Francisco and San Pablo bays would be less than significant.

For more information on the *Microcystis* analysis, please see discussion below.

Water Quality Setting Data

The data sets compiled for the setting and assessment were selected based on availability, scope of analyses addressed, locations addressed, and period of record. The setting presents a comprehensive description of existing conditions complete with citations to current literature and data summaries. Additional data would not contribute to an appreciably altered characterization of existing conditions. The data that were compiled were of sufficient quantity and quality to characterize conditions for all constituents of concern to all beneficial uses that would be affected by the project alternatives throughout the study area and support the qualitative and quantitative assessments. Collection of additional field data is not part of the scope of the setting nor was it necessary given the extent of data that was available.

Modeling for RDEIR/SDEIS and Final EIR/EIS – Alternatives 4A, 2D, and 5A

Comments were received regarding the modeling approach employed in the RDEIR/SDEIS. These comments were concerned with:

1. The use of water quality modeling results for Alternatives 4A, 2D, and 5A based on assumptions inconsistent with the definition of the alternatives, and
2. the concurrent use of sensitivity analyses results to interpret the modeling results and resulting water quality impacts.

The comments were focused primarily on the water quality impact assessments for salinity-related parameters bromide (Impact WQ-5), chloride (Impact WQ-7), and electrical conductivity (WQ-11).

The water quality assessment in the RDEIR/SDEIS found that Alternatives 4A, 2D, and 5A would result in less-than-significant impacts on water quality for all parameters assessed except for mercury and electrical conductivity (EC). Impacts on EC would be less than significant with implementation of the proposed mitigation. The impact conclusions are based on modeling results available at the time the RDEIR/SDEIS was prepared, which included the assumption of 25,000 acres of tidal habitat restoration and implementation of Yolo Bypass enhancements, neither of which are components of Alternatives 4A, 2D, and 5A. The modeling also assumed Threemile Slough as a compliance location, even though the alternatives descriptions had the compliance location at Emmaton. Further, the Montezuma Slough Salinity Control Gate was not operated (i.e., open for the entire simulation) whereas the alternatives' description has the gate operated, consistent with the No Action Alternative. Hence, sensitivity analyses were relied upon to interpret how the operation of the Salinity Control Gate, removal of restoration areas, and Emmaton as the compliance location would change water quality relative to that shown in the modeling results. Commenters noted that "full DSM2 runs" of the alternatives should have been done to fully evaluate the water quality impacts that would occur, and that water quality impacts based on this modeling coupled with sensitivity analyses are speculative. While additional modeling is provided for the Final EIR/EIS, as discussed below, the water quality impact determinations in the RDEIR/SDEIS were not speculative. Rather, the impact analyses were based on thorough review of the modeling available, as well as applicable sensitivity analyses, and were made based on the experience and professional judgment of water quality experts relying on the available data and modeling results. Where the modeling showed differences from the alternative definitions, explanations for expected differences in the water quality data evaluated were included to describe how professional judgment was used in the analysis.

Nevertheless, for the Final EIR/EIS, additional modeling for Alternatives 4A, 2D, and 5A is provided that removes the tidal habitat restoration and Yolo Bypass enhancements, includes Emmaton as the compliance location, and includes operation of the Montezuma Slough Salinity Control Gate. Final EIR/EIS appendices supporting Chapter 8, *Water Quality*, have been revised to show the updated modeling results, specifically Appendix 8D, *Source Water Fingerprinting Results,* Appendix 8E, *Bromide*, Appendix 8F, *Boron*, Appendix 8G, *Chloride*, Appendix 8H, *Electrical Conductivity*, Appendix 8I, *Mercury*, Appendix 8J, *Nitrate*, Appendix 8K, *Organic Carbon*, Appendix 8L, *Pesticides*, and Appendix 8M, *Selenium*. Based on the results of the updated modeling, the water quality impact conclusions presented in the RDEIR/SDEIS were confirmed, as presented in the Final EIR/EIS in Chapter 8, *Water Quality*. Alternatives 4A, 2D, and 5A would result in less-than-significant impacts on water quality for all parameters assessed except for mercury and EC. Mitigation for addressing periods of EC degradation at Emmaton was refined based on the updated modeling results. As explained in the following section, the revised analysis supports the determination that the impacts of Alternatives 4, 4A, 2D, and 5A on EC will be less than significant with mitigation.

Salinity Effects Analysis

A number of commenters asserted that there were deficiencies in the water quality assessment of the project alternatives effects on EC and chloride (i.e., salinity) in the Draft EIR/EIS. Commenters noted one or more of the following issues with the assessment:

- The frequency of exceedance of water quality objectives increased substantially under the project, relative to the baselines;
- The Draft EIR/EIS failed to include alternatives and modeling that met water quality objectives, or actions and commitments to avoid or mitigate significant adverse impacts for EC and chloride;
- Despite the Draft EIR/EIS acknowledging shortcomings in the modeling approach, modeling results are misinterpreted to provide predictions of actual future conditions and imply that whether or not BDCP (or California WaterFix) is implemented, the SWP and CVP will violate applicable salinity standards in the Delta;
- The acknowledgment of modeling shortcomings implies that some portion of the changes in chloride and EC identified for project alternatives are due to modeling artifacts or conservative modeling assumptions rather than actual project impacts, but the assessment does not attempt to differentiate between these; and
- Relocation of the Emmaton compliance location to Three Mile Slough near the Sacramento River would represent a serious degradation of Delta water quality, and this action is not assessed independent of the project.

Numerous additions and improvements to the water quality assessment of EC and chloride were made in the RDEIR/SDEIS and this Final EIR/EIS in response to these and other related comments.

In the Draft EIR/EIS, all project alternatives studied at that time (1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9) were found to have significant and unavoidable impacts on EC and chloride in the Delta. These impacts were due in part to apparent exceedances of Bay-Delta Water Quality Control Plan (WQCP) water quality objectives shown in the modeling results at several locations under Existing Conditions, the No Action Alternative, and BDCP alternatives. It was known that there are several factors related to the modeling approach that may result in modeling artifacts that show objective exceedance when, in reality, no such exceedance would occur. Appendix 8H, *Electrical Conductivity*, Section 8H.1, of the of the Draft EIR/EIS (now Section 8H.2 in the Final EIR/EIS) described some of these factors, but did not include an evaluation of how many of these exceedances were thought to be a result of these factors and how many were expected to be actual project impacts. Furthermore, in the Draft EIR/EIS, mitigation measures for EC and chloride called for additional modeling efforts to determine if impacts could be avoided or mitigated.

To address some of these issues, additional sensitivity analyses and other analyses were conducted to evaluate whether exceedances identified in the Draft EIR/EIS were modeling artifacts (and thus would not occur) or were potential project alternative-related impacts (which could occur). Based on the findings of these analyses, coupled with the original analyses in the Draft EIR/EIS, results of the EC and chloride assessments were qualified, and the impact determinations were revisited. Additionally, because these efforts shed light on why certain exceedances were occurring, it was possible to revise mitigation measures to better address the causes of the exceedances. All alternatives assessed in the Draft EIR/EIS (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9), remained significant and unavoidable for chloride and EC. Although the impacts remain significant and unavoidable, the magnitude of the impacts would be substantially less than was indicated in the Draft EIR/EIS.

Regarding exceedances of the Sacramento River at Emmaton EC objective for protection of agricultural beneficial uses (which is a maximum 14-day running average of mean daily EC and applies April 1 through August 15, but varies in the specific numeric threshold by water year type and season) identified in the Draft EIR/EIS, assuming the EC compliance location at Emmaton instead of Threemile Slough greatly decreased exceedances of this objective at Emmaton to levels similar to those occurring under the No Action Alternative. Based on this finding, the project description for Alternative 4 was modified to remove the change in compliance point for the Emmaton EC objective. Previously, the project descriptions for all action alternatives included a change in compliance point from Emmaton to Threemile Slough. The revised version of Alternative 4 maintains, and does not propose to change the existing compliance point at Emmaton, while all other action alternatives assessed in the Draft EIR/EIS (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8, and 9) still include the proposed change to Threemile Slough. With this change, Alternative 4 no longer results in a significant impact with respect to the Bay-Delta WQCP EC objective exceedance at Emmaton, while all other alternatives assessed in the Draft EIR/EIS result in significant impacts due to EC objective exceedance at Emmaton.

The three new alternatives—Alternatives 4A, 2D, and 5A— maintain the existing compliance point at Emmaton, and thus, for the reasons discussed above, would not result in significant impacts due to EC objective exceedance at Emmaton. Also, Alternatives 4A, 2D and 5A would have less water quality effects in the western Delta related to EC, and would have fewer exceedances of the fish and wildlife EC objective between Prisoners Point and Jersey Point, such that it was feasible to introduce mitigation that would prevent significant impacts related to EC increases. After introduction of these mitigation measures, Alternatives 4A, 2D, and 5A were determined to result in less than significant impacts for EC. Finally, Alternatives 4A, 2D, and 5A would not result in substantial degradation in the western Delta due to increased chloride concentrations, thus, the effects on chloride were determined to be less than significant.

Additional discussion of these EC and chloride analyses is included in Section 2.2.1 of the RDEIR/SDEIS, and Chapter 8, *Water Quality*, and Appendix 8H, *Electrical Conductivity*, of this Final EIR/EIS.

Contra Costa Water District and Antioch Intakes Water Quality Analysis

Some commenters asserted that there were deficiencies in the water quality assessment of the project alternatives on EC, chloride, and/or bromide (i.e., salinity), and organic carbon in the Draft EIR/EIS and/or RDEIR/SDEIS, specifically in regard to effects on drinking water intakes of Contra Costa Water District (CCWD) or City of Antioch. Commenters noted one or more of the following issues with the assessment:

- Effects at Antioch and CCWD intakes were underestimated because of coarse averaging periods (monthly, long-term, annual), and commenters assert that assessing impacts on a 15-minute or daily basis provides a more accurate representation of effects on the intake, and results in a greater level of effect than disclosed in the Draft EIR/EIS and RDEIR/SDEIS. Related, longer averaging periods are inappropriate because improvements during periods when water quality is high do not offset degradation of water quality during periods when the quality is low.
- The analysis only included two of CCWD’s four intakes, and thus impacts on CCWD cannot be completely understood from the analysis.
- Modeling simulated CCWD operations, including Los Vaqueros Reservoir storage, but this information was not used in the water quality assessment.
- The project reduces the periods of time when there is good water quality in the Delta (e.g., periods when chloride concentrations at CCWD’s intakes are less than 50 and 65 milligrams per liter [mg/L]), which causes a significant adverse impact on CCWD's delivered water quality and operation of the Los Vaqueros Reservoir. The Draft EIR/EIS fails to disclose impacts on CCWD's Los Vaqueros Reservoir.

Modeling Data Averaging Periods

Regarding use of 15-minute or daily data for assessment purposes, Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*, Section C under *Appropriate Use of Model Results* states:

> Due to the assumptions involved in the input data sets and model logic, care must be taken to select the most appropriate time-step for the reporting of model results. Sub-monthly (e.g. weekly or daily) reporting of model results is inappropriate for all models and the results should be presented on a monthly basis.

The models contain various assumptions and limitations that preclude use of daily or sub-daily modeling results for most assessments, particularly those that compare modeling results to specific thresholds. A detailed description of modeling limitations can be found in Appendix 5A as well as in Chapter 8, *Water Quality*, Sections 8.3.1.1 and 8.3.1.3. Given the models used and the associated limitations in interpreting the output, utilizing a shorter time step than monthly average for assessing water quality changes at the City of Antioch and CCWD’s intakes would not result in a more accurate assessment of effects of the project on salinity-related parameters (i.e., EC, chloride, bromide) or organic carbon. While there would be days within a month in which parameter concentrations/levels at a given location would be higher than the monthly average at that location (just as there would be days when it is lower), given the modeling limitations, comparing alternatives and baselines based on the monthly average at those locations is considered appropriate for the purposes of NEPA and CEQA.

Delta Assessment Locations

Regarding comments that the analysis only included two of CCWD's four intakes, and thus impacts on CCWD cannot be completely understood from the analysis, impacts on salinity were assessed at various locations throughout the Delta. Locations were chosen such that the assessment of changes under the alternatives relative to baselines would be representative of changes in various portions of the Delta as a whole. Some commenters have asserted that the chosen locations are not representative of other locations, in some cases by showing time-series plots of a water quality constituent concentration at the two locations and highlighting the differences. Water quality in the Delta does vary spatially and temporally. It is obvious that there are many locations in the Delta that would not have identical water quality to the chosen locations for assessment. However, assessment was done on a comparative basis (i.e., alternatives as compared to baselines). Given the purposes of the assessment, the effects of the project at the locations assessed are considered representative of the effects of the project in various portions of the Delta as a whole. Thus, although CCWD's four intakes vary in their instantaneous water quality, effects of the project on water quality at the two intakes assessed are considered representative of degree and direction of salinity changes at the other intakes.

Los Vaqueros Reservoir

Regarding use of modeling for Los Vaqueros Reservoir impacts, modeling conducted for the alternatives includes a representation of CCWD operations and Los Vaqueros Reservoir. However, the representation is a simplification and was not optimized for CCWD operations and intake options. The water quality assessment evaluated chloride levels relative to the Bay-Delta WQCP chloride objectives. Objectives that apply at Contra Costa Pumping Plant #1 ensure that the municipal and industrial beneficial use of surface water in the west Delta is protected, relative to salinity. Los Vaqueros Reservoir is not a named water body in the Basin Plan and does not contain surface water beneficial uses. Furthermore, the alternatives would not cause direct effects in Los Vaqueros Reservoir; rather, effects would be indirect and due to CCWD diversion of water from the Delta into the reservoir. Therefore, the assessment did not directly assess effects to Los Vaqueros Reservoir, but did assess effects of the project alternatives on surface water near CCWD intakes that divert water into the reservoir.

CCWD Chloride Goal

CCWD has a goal of 65 mg/L chloride in water delivered to customers. This goal is not a state or federal water quality objective. Arguments made in some comments imply that any increases in chloride represent an impact on the beneficial use of water in Los Vaqueros Reservoir, but small increases in chloride concentrations when chloride is < 100 mg/L typically do not adversely affect the municipal and industrial beneficial use of the surface water body. Adverse effects to the municipal and industrial beneficial use may occur when water quality objectives are exceeded (which was assessed via comparison of the modeling results to Bay-Delta WQCP objectives), or when substantial water quality degradation occurs, such that exceedance is more likely and beneficial uses may be impacted. The chloride analysis include an assessment of degradation on a monthly average basis for the entire period modeled and the drought period modeled. This analysis evaluated use of assimilative capacity relative to the Bay-Delta WQCP objective of 250 mg/L that applies year-round, which is the California Department of Public Health secondary maximum contaminant level applicable to drinking water at the tap. Adverse impacts were identified where degradation would result in substantially increased risk for adverse effects to municipal and industrial beneficial uses, including at Antioch and CCWD Pumping Plant #1. Thus, the Draft EIR/EIS, RDEIR/SDEIS, and this Final EIR/EIS disclose adverse effects associated with chloride degradation where they would occur.

Finally, for chloride, project alternatives evaluated in the Draft EIR/EIS (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9) were considered to have significant and unavoidable impacts in the Delta due in part to water quality degradation occurring in the western Delta, and for some alternatives, exceedance of the 150 mg/L chloride objective. Various analyses and improvements to the assessment were added, as described in Section 2.2.1 of the RDEIR/SDEIS and as incorporated into this Final EIR/EIS. Alternatives 2D, 4A, and 5A did not show significant impacts for chloride from substantial degradation or objective exceedance in the western Delta, and thus impacts for chloride are considered less than significant for these alternatives.

Selenium Effects Analysis

A number of commenters asserted that there were deficiencies in the water quality assessment of the project alternatives effects on selenium. Commenters noted one or more of the following issues with the assessment:

- The Draft EIR/EIS failed to consider the effects of the project alternatives on selenium concentration and loading to San Francisco Bay.
- The Draft EIR/EIS underestimated the increases in selenium concentrations and loads in the Delta associated with the project alternatives.
- The Draft EIR/EIS relied on inappropriate regulatory standards.
- The Draft EIR/EIS did not provide sufficient context for the North San Francisco Bay selenium total maximum daily load (TMDL), and either inappropriately assumed future refinery effluent selenium concentrations, and/or relied on these decreases to offset increases in selenium concentrations from the Delta.
- The Draft EIR/EIS did not adequately address changes in residence time and the potential effects on selenium bioaccumulation.

The assessment of selenium was updated in the RDEIR/SEIS and this Final EIR/EIS to address these issues. As noted above, some commenters asserted that the Draft EIR/EIS failed to consider the effects of the project alternatives on San Francisco Bay. The western seaward boundary of the BDCP Plan Area has been delineated at Carquinez Strait. There are no actions in the BDCP or California WaterFix proposed to occur in the bays seaward of the Plan Area. Thus, the water quality analysis focused on assessing the alternatives' effects on water quality in the upstream of the Delta Region, within the Plan Area, and in the SWP/CVP Export Service Areas. However, public and agency comments raised questions regarding water quality effects of the alternatives in the bays seaward of Carquinez Strait. Because net flows move seaward from the Delta toward the bays, water quality constituents present in the Delta water column could potentially be transported seaward. New screening and assessment of water quality constituent effects in San Francisco Bay were conducted in response to these concerns. These new assessments, which are reflected in the RDEIR/SDEIS and this Final EIR/EIS analysis, did not identify any new adverse or significant impacts or any substantial increase in the severity of previously identified impacts, except in the case of selenium. For Alternatives 6A–9, projected increases in selenium loading and concentrations in North San Francisco Bay were considered adverse (under NEPA) and significant and unavoidable (under CEQA), while Alternatives 1A–5A, including Alternatives 4A and 2D, were considered not adverse and less than significant. This is consistent with findings for the assessment of selenium in the Delta, in which the same conclusions were reached for the same alternatives. The driving factor for the adverse impacts under Alternatives 6A–9 in both the western Delta and the North Bay is modeled increases in selenium concentrations and loading, leading to potentially higher body burdens of selenium in certain species.

As noted above, some commenters asserted that the Draft EIR/EIS underestimated the increases in selenium concentrations and loads in the Delta associated with the project alternatives. Section 2.2.2 of the RDEIR/SDEIS describes changes made relative to the Draft EIR/EIS, which have been carried forward into this Final EIR/EIS. The relevant portion of this section that addresses this issue reads:

> Modeling for selenium (water concentrations and bioaccumulation modeling) was updated on the basis of a review and update of Delta source water concentrations of selenium. Public comments on the Draft EIR/EIS indicated that the source water concentrations for both the Sacramento River and San Joaquin River were likely biased high (i.e., the modeling approach used concentrations for both rivers that indicated more selenium than is currently actually present in the rivers). This bias was due to inclusion of older monitoring data that used higher detection limits (on both rivers), as well as to the decrease of selenium concentrations on the San Joaquin River that has occurred over time. The source water concentrations for the Sacramento River, San Joaquin River, Yolo Bypass, and San Francisco Bay were reevaluated and re-derived using the most recent data available, and the water concentration and bioaccumulation modeling was updated based on these updated source water concentrations. Results showed that there was generally a greater increase from Existing Conditions and No Action concentrations to the concentrations under the alternatives than previously predicted (i.e., the relative effect of the project was greater). However, the absolute values of all of the estimated concentrations for Existing Conditions, the No Action Alternative, and all Project Alternatives were lower than modeled previously in the Draft EIR/EIS, and thus were lower relative to thresholds of concern and water quality criteria used in the assessment.

As noted above, some commenters asserted that the Draft EIR/EIS relied on inappropriate regulatory standards. Section 2.2.2 of the RDEIR/SDEIS describes changes made relative to the Draft EIR/EIS which have been carried forward into this Final EIR/EIS. The relevant portion of this section that addresses this issue reads:

> Numeric thresholds used in the selenium assessment were also updated. Current ambient water quality criteria are based on waterborne selenium concentrations, but EPA released draft water quality criteria for the protection of freshwater aquatic life from toxic effects of selenium in May 2014. The draft criteria include tissue-based concentrations, which are most closely associated with reproductive effects. The criteria also include water concentrations, which are to be used when fish tissue data is not available. The draft criteria have not been finalized, but they represent the most current science on numeric thresholds protective of beneficial uses. Accordingly, these draft criteria were used in the updated assessment. Specifically, the whole-body fish tissue threshold was lowered from 9 mg/kg to 8.1 mg/kg. Additionally, the criterion against which water concentration changes were compared was lowered from 2 μg/L to 1.3 μg/L, which is the EPA draft criterion for lentic (i.e., still or slow-moving) water bodies.

As noted above, some commenters asserted that the Draft EIR/EIS did not provide sufficient context for the North San Francisco Bay selenium TMDL, and either inappropriately assumed future refinery effluent selenium concentrations, and/or relied on these decreases to offset increases in selenium concentrations from the Delta. Chapter 8, *Water Quality,* Section 8.1.3.15, has been revised to state that the primary selenium loading to the North Bay and the Suisun Bay area is from the Delta and oil refineries in the vicinity of Carquinez Strait. Text was added regarding the methods of assessment of San Francisco Bay selenium, in Chapter 8, Section 8.3.1.8, that states:

> Selenium levels in the North Bay have declined gradually since the early 1990s before the North Bay was first 303(d) listed (Tetra Tech 2008). This was due in part to the fact that petroleum refineries, which were a major source of dissolved selenium to the North Bay at that time, implemented controls by 1999 that decreased selenium in their discharges by up to 66% (Tetra Tech 2008).

Text was also added in Section 8.3.1.8 and in the assessment of Conservation Measure (CM) 2–CM21 provided in Impact WQ-26 in Chapter 8, which states:

> The San Francisco Bay Water Board is conducting a TMDL project to address selenium toxicity in the North San Francisco Bay (North Bay), defined to include a portion of the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central Bay (State Water Resources Control Board 2011).The North Bay selenium TMDL will identify and characterize selenium sources to the North Bay and the processes that control the uptake of selenium by wildlife. The TMDL will quantify selenium loads, develop and assign waste load and load allocations among sources, and include an implementation plan designed to achieve the TMDL and protect beneficial uses.

Language regarding the expectation that point sources in North San Francisco Bay would be reduced under the TMDL was removed. The assessment did not rely on these decreases, but was stating the expectation based on a reasonably foreseeable change in water quality at the early and late-long-term time steps. However, because the language implied that these point sources were the primary source of selenium in the North Bay (which they are not—the Delta is the primary source), and because the TMDL is still under development, the language was removed.

As noted above, some commenters asserted that the Draft EIR/EIS did not adequately address changes in residence time and the potential effects on selenium bioaccumulation. Section 2.2.2 of the RDEIR/SDEIS describes changes made relative to the Draft EIR/EIS, which have been carried forward into this Final EIR/EIS. The relevant portion of this section that addresses this issue reads:

> An expanded discussion of residence time in the Delta and its effect on selenium bioaccumulation in the Delta was added in response to agency comments. Increased water residence times could increase the bioaccumulation of selenium in biota, thereby potentially increasing fish tissue and bird egg concentrations of selenium. However, if increases in fish tissue or bird egg selenium were to occur due to residence time changes alone, the increases would likely be of concern only where fish tissues or bird eggs are already elevated in selenium to near or above thresholds of concern. That is, where biota concentrations are currently low and not approaching thresholds of concern, changes in residence time alone would not be expected to cause them to then approach or exceed thresholds of concern. Based on the analysis, the most likely area in which biota tissues would be at levels high enough that additional bioaccumulation due to increased residence time from restoration areas would be a concern is the western Delta and Suisun Bay for sturgeon. Nevertheless, estimates of residence time increases in these areas are small enough that they are not expected to substantially affect selenium bioaccumulation in the western Delta.

As noted in Section 2.2.2 of the RDEIR/SDEIS:

> The changes discussed above did not result in any changes to the impact conclusions. Alternatives 6-9 remain adverse (under NEPA) and significant and unavoidable (under CEQA) due to modeled

> substantial increases in fish tissue concentrations for sturgeon in the western Delta, while Alternatives 1–5 remain less than significant.
>
> Refer to Chapter 8, *Water Quality*, Section 8.1.3.15 in Appendix A for updated existing selenium concentrations in the affected environment and a description of the EPA draft criteria. Refer to Section 8.3.1.7 in Appendix A for the updated source water concentrations used in the modeling and updated thresholds used in the assessment. Refer to Impact WQ-25 in Sections 8.3.3.1 through 8.3.3.16 in Appendix A for the selenium assessment updated based on the new modeling. Further details on the updates can be found in Appendix 8M, *Selenium*, in Appendix A.

Finally, some commenters asserted that the Draft EIR/EIS erred in making an assumption that selenium loading to, and concentrations in, the San Joaquin River would decrease over time as a result of the TMDL, Grassland Bypass Project, and Basin Plan objectives. Additionally, some commenters asserted that selenium loading would increase as a result of greater water deliveries to the San Joaquin River watershed, and thus greater agricultural irrigation drainage would occur. The analysis of Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 was conducted at the late long-term time step, and analysis of Alternatives 2D, 4A, and 5A at the early and late long-term time steps, both of which would be after implementation of the project. Just as climate change and sea level rise were assumed at this time step, other reasonably foreseeable changes in water quality were included in the assessment. The TMDL and Basin Plan limit the amount of selenium that can be discharged to the San Joaquin River, which in turn will require San Joaquin Valley agricultural dischargers to reduce selenium loading in their drainage. If selenium concentrations in discharges cannot come into compliance with the limits set forth in these regulations, the discharges will be prohibited. In either case, selenium loading to the San Joaquin River is expected to decrease at the early and late long-term time steps, relative to Existing Conditions. Thus, although there is uncertainty over whether treatment technologies will be cost effective, and therefore whether selenium concentrations in drainage water can be reduced, the current regulatory framework can be reasonably expected to result in decreasing loads of selenium to the San Joaquin River, relative to Existing Conditions. Furthermore, project alternatives are not expected to substantially increase the long term average amount of water exported from the Delta or delivered to the San Joaquin River watershed, relative to Existing Conditions or the No Action Alternative. Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*, Section C, provides these data for alternatives assessed in the Draft EIR/EIS and Alternatives 4A, 2D, and 5A. Therefore, it is not expected that the project would result in greater amounts of irrigation drainage water entering the San Joaquin River. Finally, selenium concentrations in the water exported to the San Joaquin Valley is expected to decrease as a result of the project alternatives, as described in Chapter 8, *Water Quality*, in the *SWP/CVP Export Service Areas* sections of the Impact WQ-25 discussions.

Mercury Effects Analysis

A number of commenters asserted that there were deficiencies in the water quality assessment of the project alternatives on mercury in the Draft EIR/EIS. Commenters noted one or more of the following issues with the assessment:

- The assessment did not introduce mitigation for potential effects on mercury of restoration activities;
- The assessment did not adequately characterize or quantify the potential effects on mercury of restoration activities;
- The assessment did not evaluate compliance with the Delta Methylmercury TMDL.

The assessment performed for CM2–CM22 for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 was qualitative, and indicated that increases in methylmercury could occur as a result of restoration activities. Restoration activities under these alternatives would include approximately 75,000 acres of restoration, including (generally) 65,000 acres of tidal restoration and 10,000 acres of floodplain restoration, including Yolo Bypass improvements. Specific mitigation measures to address the potential increases in methylmercury were not proposed, because *CM12 Methylmercury Management*, already included commitments to do everything practicable to minimize conditions that promote production of methylmercury in restored areas and subsequent introduction to the foodweb. Due to uncertainties as to the effectiveness of CM12, the conclusion was that CM2–CM22 could have a significant and unavoidable effect on mercury.

Alternatives 4A, 2D, and 5A differ from the other alternatives (1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9) in their evaluation of effects on mercury from other Environmental Commitments (Environmental Commitments 3, 4, 6, 7, 9–12, 15, and 16). These three alternatives contain substantially less tidal restoration acreage than the other alternatives. Thus, although the potential types of effects on mercury resulting from implementation of the Environmental Commitments under Alternatives 4A, 2D, and 5A would be generally similar to those described for the other alternatives, the magnitude of effects on mercury and methylmercury at locations in the Delta related to habitat restoration would be considerably lower.

It is not expected that the level of tidal restoration proposed under Alternatives 4A, 2D, and 5A would cause fish tissue concentrations to increase, at a measurable level, outside of the immediate localized area of the tidal restoration sites. However, habitat restoration has the potential to increase water residence times and increase accumulation of organic sediments that are known to enhance methylmercury bioaccumulation in biota in the vicinity of the restored habitat areas. Fish tissue concentrations in the Delta already frequently exceed the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins objective of 0.24 mg/kg for trophic level 4 fish in the Delta. The proposed tidal restoration may cause or contribute to increased fish tissue concentrations at a local level, though the magnitude of the increase is not quantifiable. The Basin Plan also includes methylmercury allocations for wetlands for various areas of the Delta. Because the proposed tidal restoration acreage is very small, it is possible that, relative to the allocations, the increased loading would be very small. However, it is still unknown how and if the allocations can be attained. The Basin Plan also requires that for many areas of the Delta (i.e., those needing reductions in methylmercury), proponents of wetland restoration projects shall (a) participate in Control Studies, or implement site-specific study plans, that evaluate practices to minimize methylmercury discharges, and (b) implement methylmercury controls as feasible. Design of restoration sites would be guided by Environmental Commitment 12, which requires development of site-specific mercury management plans as restoration actions are implemented to minimize methylmercury production. The effectiveness of minimization and mitigation actions implemented according to the mercury management plans is not known at this time, although the potential to reduce methylmercury concentrations exists based on current research.

Although this would constitute a potential environmental impact, these increases would not be expected to cause injury to downstream water rights holders or other downstream water users, because effects would be localized to the restoration sites. Nor would such localized impacts adversely affect any other downstream beneficial users.

Additionally, Alternatives 2D, 4A, and 5A do not include Yolo Bypass improvements. As with the other alternatives, specific mitigation measures were not proposed for mercury in the Draft EIR/EIS, RDEIR/SDEIS, or this Final EIR/EIS, because all practicable activities are included as part of the project in Environmental Commitment 12, which references CM12.

The discussion of CM12 in Chapter 3, *Description of Alternatives*, Section 3.6.2.2, contains a full description of activities, including commitment to produce and implement project-specific mercury management plans for each restoration project. This description also describes that these plans will be prepared in conjunction with the Central Valley Regional Water Quality Control Board Methylmercury TMDL program. The section also states the following:

> Because methylmercury is an area of active research in the Delta, each new project-specific methylmercury management plan would be updated based on the latest information about the role of mercury in Delta ecosystems or methods for its characterization or management. Results from monitoring of methylmercury in previous restoration projects would also be incorporated into subsequent project-specific methylmercury management plans. This program would be developed and implemented within the context of Methylmercury TMDL and Mercury Basin Plan Amendment requirements. In each of the BDCP project-specific methylmercury management plans developed under CM12, relevant findings and mercury control measures identified as part of TMDL Phase I Control Studies will be considered and integrated into restoration design and management plans. CM12 would also be implemented to meet any requirements of the U.S. Environmental Protection Agency (EPA) or the California Department of Toxic Substances Control actions.

Quantification of the effects or range of effects of restoration activities was not conducted both because of lack of site-specific information, and because research is ongoing regarding these activities and their effects on mercury. That is, quantification of effectiveness and performance is not possible generally, but can only be performed on a site-specific basis and with appropriate monitoring data to inform the site-specific evaluation. Although studies have been performed which provide useful information on the effects of restoration on methylmercury production, and also which provide insight into potential management strategies, application of the findings of these studies to the restoration areas proposed under the project is not possible without site-specific information on restoration areas. Further, as current and future research is conducted, it is expected that a more comprehensive understanding of how to design and manage restored areas, and thus further minimize the effects of restoration on mercury will be possible. Project-Specific Mercury Management Plans for each restoration project proposed under Environmental Commitment 12 or CM12 allow for the latest research and for site-specific information to be incorporated into the assessment and design.

Given the limitations regarding quantification of effects on mercury, a specific evaluation of achieving Delta methylmercury TMDL load allocations for various subareas was not feasible. As described above, the Basin Plan language implementing the TMDL states that in those areas of the Delta needing reductions in methylmercury, proponents of wetland restoration projects either "(a) participate in Control Studies, or implement site-specific study plans, that evaluate practices to minimize methylmercury discharges, and (b) implement methylmercury controls as feasible." Design of restoration sites will be guided by CM12 or Environmental Commitment 12, which requires development of site-specific mercury management plans as restoration actions are implemented to minimize methylmercury production. Actions proposed under the project are and will be in full compliance with the Delta Methylmercury TMDL and Basin Plan Amendments implementing it.

Pesticides Effects Analysis

Numerous comments were received regarding the characterization of existing pesticide conditions and method of assessment. Comments on the characterization of existing pesticide conditions focused on data that should have been or not been used to characterize existing conditions in Chapter 8, *Water Quality*, Section 8.1, *Environmental Setting/Affected Environment*. The comments on the pesticides assessment focused on whether the assessment should have been quantitative, instead of qualitative, and that discussion of concentrations and bioaccumulation were needed.

With regard to the characterization of existing pesticides conditions please see the discussion of data sources above. With regard to the pesticides assessment, the project condition with implementation of the alternatives at 2060 precludes the ability to perform a quantitative assessment for pesticides. As explained in the "Pesticides" sub-section of the Section 8.3.1.7, *Constituent-Specific Considerations Used in the Assessment*, while data availability was one consideration of the analysis, another primary consideration was the dynamic state of the pesticide market. It is unknown which pesticides and practices will be in use upon implementation of the proposed project, and data availability regarding current application rates will not resolve this unknown. Therefore, the assessment uses best available information and assesses conceptually the major mechanism of change that the project alternatives will affect and can be reasonably foreseen, which is changes in river flows and source water fractions in the Delta, and thus dilution. Hence, the pesticides assessment in Impacts WQ-21 and WQ-22 were performed qualitatively, based on quantitative changes in flow and source water fractions. Because the assessment was qualitative, the discussion addressed whether concentrations of pesticides, as a class of constituents, would increase or decrease, but could not provide specific concentration changes for specific pesticides. Also, because the assessment was qualitative, and due to the inability to predict future pesticide conditions at the project implementation timeframe, specific information regarding pesticide interactions (e.g., synergistic or additive effects) were not a component of the assessment.

Comments stated that the modeled increases in San Joaquin River fraction and increase in residence time, which is accounted for in the modeled source water fractions, at certain Delta locations would mix with local municipal, industrial, and agricultural inputs of pesticides. Discharges from these sources are not a component of the project alternatives or otherwise being conducted by the project proponents. These discharges come from individual entities that are regulated through the state's various NPDES regulatory programs and toxicity that may be caused by these discharges containing pesticides is addressed through that program.

In response to comments related to the combined effects of water conveyance facilities and the conservation measures or Environmental Commitments, these concurrent effects on pesticides are addressed in the RDEIR/SDEIS and this Final EIR/FEIS, in Section 8.3.3.21, *Concurrent Effects of the Action Alternatives*.

Temperature Effects on Drinking Water

A number of comments were received regarding the potential for the temperature changes identified in the Draft EIR/EIS and RDEIR/SDEIS for the American River and Sacramento River to affect municipal and domestic water supply uses.

As noted by the commenters, the effects of temperature changes in the Draft EIR/EIS and RDEIR/SDEIS focused on effects to aquatic life, because of all the beneficial uses of the waters in the affected environment, aquatic life uses were identified as the uses that would be most sensitive to the projected changes in temperature that would occur with the project alternatives. This was not to conclude that other uses (e.g., MUN, recreation, irrigation) are not affected by water temperature. Rather, it was concluded that aquatic life uses would be *most sensitive* to the changes due to the project alternatives, because these other uses are typically not precluded by small changes in seasonal water temperature that would occur due to the project alternatives.

Temperature can be a factor in disinfection byproduct (DBP) formation in drinking water supplies. There are other factors that can affect the degree to which DBPs are formed, including chlorine dose and contact time, and the duration of time the water spends in the distribution system. In its *Initial Distribution System Evaluation Guidance Manual for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule, Appendix A, Formation of Disinfection Byproducts* (2006), the U.S. Environmental Protection Agency (EPA) notes that because the formation rate of DBPs increases with increasing temperature, the highest levels may occur in the warm summer months. EPA also notes that water demands are often higher during summer months, resulting in lower water age within the distribution system, which helps to control DBP formation. Furthermore, high temperature conditions in the distribution system promote the accelerated depletion of residual chlorine, which can mitigate DBP formation and promote biodegradation of haloacetic acids (HAAs). Therefore, higher temperatures in diverted surface waters do not necessarily translate to higher DBPs in the delivered water supply.

Temperature changes relative to Existing Conditions, which reflects the combined effects of the project alternative, climate change, and increased water demands, and relative to the No Action Alternative, which reflects the effects of the project alternative, are provided in Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results Utilized in the Fish Analysis*, for the Sacramento River at Hamilton City and American River at Watt Avenue. Results relative to the No Action Alternative, which show the project alternative effects, show both increases and decreases in river temperature due to the project alternatives of relatively low magnitude, with most monthly average temperature changes being in the range of -0.5–+0.5°F, though a few alternatives in some months would result in increased monthly average temperatures of up to 1.4°F. Thus, while the modeling results may show large increases in monthly average temperatures in the Sacramento and American rivers in some months relative to Existing Conditions, those changes are primarily due to climate change and the warming ambient air temperatures. The project alternatives would cause relatively small increases and decreases in river temperatures.

The temperature increases relative to the No Action Alternative, and thus due to the project alternatives, in the American River would occur primarily in the months of July through September, though slight increases of 0.1°F would occur under some alternatives in April, November, and December. Similarly, for the Sacramento River, the temperature increases would occur primarily in the months of July through September, though slight increases of 0.1°F would occur under some alternatives in April, October, and December. The summer months, when the greatest temperature increases would occur, also correspond to the period of highest water use.

In the Journal AWWA (American Water Works Association), Westerhoff et al. (2000) published *Applying DBP models to full-scale plants*, in which an empirical model was developed relating raw temperature, along with dissolved organic carbon, bromide, pH, chlorine dose and contact time to total trihalomethane (TTHM) formation according to the equation:

$$\text{TTHM} = 0.0412\,[\text{TOC}]^{1.10}[\text{Cl}_2]^{0.152}[\text{Br}^-]^{0.068}\,[\text{Temp}]^{0.61}[\text{pH}]^{1.60}[\text{Time}]^{0.26}$$

TTHM (in micrograms per liter, μg/L) is a function of chlorine dose (Cl_2 in mg/L), bromide concentration (Br^- in μg/L), water temperature (degrees Celsius), pH, and contact time between the chlorine and water (hours). At temperatures between 68 and 82°F, a 0.5°F increase in temperature would result in a 0.6–0.8% increase in TTHM concentration. Conversely, a 2°F increase in temperature would result in a 2.5–3.4% increase in TTHM concentration, and a 4°F increase would result in a 5–7% increase in TTHM concentration. Based on this model, a substantially larger increase in temperature than what would occur due to the project alternatives would be necessary for there to be a noticeable increase in TTHM concentrations in delivered water supply, particularly considering the other variables involved.

Finally, one comment refers to information in the 2013 American River Sanitary Survey as evidence that higher river temperatures would contribute to higher DBP concentrations. While temperature is known to be a factor in DBP formation, the 2013 American River Sanitary Survey is not definitive evidence of a relationship between higher surface water temperature and DBP formation in the American River basin. The 2013 American River Sanitary Survey anecdotally indicates that San Juan Water District TTHM concentrations in recent years are related to higher Folsom Dam release temperatures, through time-series plots and a general comparison of average TTHM concentrations over a period and average temperature over the same period. However, there is no formal correlation analysis presented to confirm that there is indeed a significant relationship between TTHM concentration and dam release temperature, or the extent of the relationship relative to other factors. Information in the American River Sanitary Survey is insufficient to conclude that the small increases (or decreases) in temperature identified in the EIR/EIS relative to the No Action Alternative (and thus due to the project alternatives) would contribute to adverse (or beneficial) effects to drinking water.

Based on this discussion it is concluded that this Final EIR/EIS appropriately considered aquatic life uses to be the beneficial uses most sensitive to the temperature changes that would occur due to the project alternatives. No changes to the analysis related to this issue have been made.

Antidegradation Analysis

Several comments on the Draft EIR/EIS and RDEIR/SDEIS state that the discussion of potential water quality effects of BDCP and California WaterFix implementation is inadequate with respect to the federal and state antidegradation policies. Three common themes addressed in the comments include: 1) inadequate regulatory background setting provided; 2) inadequate analysis of degradation effects; 3) and/or incomplete analysis of project alternative-related effects relative to all provisions of the federal and state antidegradation policies. These issues are addressed sequentially in this response.

First, regarding the descriptions of the federal and state antidegradation policies, the descriptions of the federal antidegradation policy (Chapter 8, *Water Quality*, Section 8.2.1.3) and the state policy (Section 8.2.2.6) are sufficient for the purposes of the EIR/EIS analysis. Moreover, the descriptions summarize the key provisions of the policies verbatim, but admittedly do not include introductory or other information provided in the policy documents. The adequacy of the policy descriptions is directly related to the methods of assessment of degradation, which are described below in response to other aspects of the comments.

Regarding the second theme (adequacy) and third theme (completeness) of the comments regarding the assessment of degradation per se, the degradation assessment methods are described in Chapter

8, Section 8.3.2, *Effects Determinations*. As described, degradation was assessed via reduction of assimilative capacity with respect to regulatory objectives. The potential for each alternative to cause water quality degradation was addressed for each constituent of concern identified in Chapter 8, *Water Quality*. For those constituents with modeling results available, degradation was evaluated from the quantitative use of assimilative capacity relative to that occurring under existing conditions and the No Action Alternative. The comparison to the No Action Alternative allowed for identifying effects solely due to the alternative, separate from climate change. For constituents assessed qualitatively, the potential for degradation considered the degree to which that constituent could be increased by the alternative, and whether current conditions were degraded (i.e., Clean Water Act section 303(d) listings). Moreover, for constituents regulated by narrative regulatory water quality objectives, only a qualitative analysis of potential degradation is possible.

Thirdly, regarding completeness of the constituent degradation analyses, the comments generally suggest that impact determinations for constituents addressed in Chapter 8 should be based on consistency with the federal and state policies. However, the project proponents disagree with this assertion. In California, consistency with the federal and state antidegradation policies falls to the Regional and State Water Boards in considering point-source discharge and certain water rights permits. The State Water Board has interpreted the state antidegradation policy to incorporate the federal antidegradation policy in situations where the policy is applicable. (SWRCB Order WQ 86-17.) However, the application of federal antidegradation policy to nonpoint source discharges such as the California Water Fix is limited.[204] For the California Water Fix, application of antidegradation policy will be considered by the State Water Board with respect to DWR's and Reclamation's application to change the points of diversion in their water right permits. The water quality degradation analysis presented in the EIR/EIS is but one part in the subsequent application of the policy. As noted in many of the comment letters, antidegradation policy addresses both the amount of water quality lowering that would occur and determination of whether lowered water quality is necessary to accommodate economic or social development in the area and consistent with maximum benefit to the State. Water development and water conservation projects may be considered to be important social and economic developments that justify a lowering of water quality (see Water Code Section 13000). Similarly, environmental protection may constitute important social development, justifying a change in water quality, even if no other social or economic benefits to the community are demonstrated (see Letter from William R. Attwater to Regional Water Board Executive Officers, Federal Antidegradation Policy [Sept. 7, 1987]). Where there are two conflicting uses, the quality of water for one use may be reduced where the change improves water quality for the other, in appropriate circumstances (see 40 CFR Section 131.11(a)(1)). This latter analysis is outside the scope of CEQA and NEPA and necessarily requires evaluation of economic value and social issues associated with the existing beneficial uses, and the economic costs and changes in these conditions that may occur as a result of lowered water quality.

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[204] 40 Code of Federal Regulations (CFR) 131.12(a)(2) requires that the "State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control." The EPA Handbook, Chapter 4, clarifies this as follows: "Section 131.12(a)(2) does not mandate that States establish controls on nonpoint sources. The Act leaves it to the States to determine what, if any, controls on nonpoint sources are needed to provide attainment of State water quality standards (See CWA Section 319). States may adopt enforceable requirements, or voluntary programs to address nonpoint source pollution. Section 40 CFR 131.12(a)(2) does not require that States adopt or implement best management practices for nonpoint sources prior to allowing point source degradation of a high quality water. However, States that have adopted nonpoint source controls must assure that such controls are properly implemented before authorization is granted to allow point source degradation of water quality."

Furthermore, such socio-economic evaluation is stipulated in the federal and state policies to consider these issues via “intergovernmental coordination”, “public participation”, and “the State's planning processes”. The evaluation of socio-economic changes is not the purview of the water quality analysis, which is rightfully focused on providing the numerical and qualitative assessment of only the potential for implementation of the project alternatives to degrade existing water quality with respect to regulatory water quality objectives and beneficial uses. The socio-economic evaluation must be conducted based on the results of the EIR/EIS and the later stages of regulatory agency review and permitting of changes to the CVP and SWP water rights orders, or other regulatory actions.

Microcystis Analysis

Commenters raised several concerns with the discussion and assessment of the effects of the project alternatives on *Microcystis* blooms and associated toxicity in the affected surface water bodies. Based on public comments received on the Draft EIR/S, new Impacts WQ-32 and WQ-33 were added to the assessments of Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 in Chapter 8, *Water Quality*, and included with the assessments of Alternatives 4A, 2D, and 5A in Section 4 of the RDEIR/SDEIS. Common themes in the comments on the *Microcystis* assessment included:

1. Adequacy of the assessment in the upstream of Delta region.
2. Adequacy of the assessment in the Delta region.
3. Potential for harmful microcystin levels in the San Francisco Bay.

Adequacy of the Assessment in the Upstream of Delta Region

Impact WQ-32, which addresses water quality impacts due to *Microcystis*, addresses the upstream of Delta region, as well as the Delta and SWP/CVP export service areas. As described in Impact WQ-32, *Microcystis* bloom development is limited upstream of the Delta due to high water velocity and low residence times. Further, *Microcystis* blooms upstream of the Delta have only been documented in eutrophic lakes such as Clear Lake. Large reservoirs upstream of the Delta are typically characterized by low nutrient concentrations, where other phytoplankton outcompete cyanobacteria, including *Microcystis*. Thus, bloom development is limited in watersheds of the eastern tributaries (Cosumnes, Mokelumne, and Calaveras Rivers), and the San Joaquin River upstream of the Delta. The Sacramento River and American River are also characterized by high water velocity and low residence times, providing inadequate conditions for the development of *Microcystis* blooms. High water velocity and low residence times are not expected to change under the No Action Alternative (early long-term [ELT] and late long-term [LLT]) or the project alternatives. Thus, any modified reservoir operations under the project alternatives are not expected to promote *Microcystis* production upstream of the Delta, relative to Existing Conditions and the No Action Alternative (ELT and LLT).

Adequacy of Assessment in the Delta Region

Commenters have suggested that the assessment of *Microcystis* does not properly link acknowledged alternative-related increases in residence times in the Delta to a worsening of the *Microcystis* problem. The assessment of *Microcystis* for all the project alternatives considers the degree to which the alternative would change in residence time as a factor in making a significant impact determination for the alternative. For Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9, modeled long-term average residence time data was available from which to determine the overall magnitude and direction of the change in residence time. Reductions in residence time contributed to the significant impact calls for these alternatives and the provision of Mitigation Measures WQ-32a and WQ32b.

Commenters are concerned that under Alternatives 4A, 2D and 5A there would be increases in residence time that would cause increased *Microcystis* production in the Delta, and with the adequacy of the assessment conducted to determine impacts in the Delta region. At the time of preparation of the RDEIR/SDEIS, Delta residence time modeling data was not available for Alternatives 4A, 2D, and 5A. Thus, a qualitative assessment was conducted to determine anticipated changes to residence times. This qualitative assessment considered how climate change, restoration activities, and changes in flows that may occur from the alternatives would affect water quality in the Delta. Residence time modeling completed for Alternative 4 was used as a basis for the qualitative assessment. Impact conclusions were then based on the qualitative assessment. Residence time modeling for Alternative 4A and the No Action Alternative has since been conducted for the Biological Assessment for the California WaterFix. The quantified changes in residence times within Delta sub-regions allows for more definitively determining the overall magnitude and direction of the change in residence time. However, modeling was not available for Alternatives 2D and 5A. Thus, there is some uncertainty regarding the degree to which operations and maintenance of Alternatives 2D and 5A would affect water residence times in the Delta.

In response to comments, and based on *Microcystis* life history strategy to outcompete other algal species and the inhibitory effect of flow and turbulence on its ability to do so, maximum daily channel velocities (which creates channel turbidity and turbulence) also were assessed using DSM2 velocity output for a number of locations throughout the Delta. The supplemental evaluation of residence time and flow velocities has been incorporated into the *Microcystis* assessment for Alternative 4A in Impact WQ-32 of the Final EIR/S. The evaluation of flow velocities shows little to no effects on peak daily velocities under Alternative 4A compared to the No Action Alternative at each location assessed. This indicates that areas of the Delta that are currently turbid will remain turbid and vertical mixing of the water column will be similar under Alternative 4A and the No Action Alternative. As described in Impact WQ-32 of the Final EIR/EIS, *Microcystis* cannot effectively retain its buoyancy or outcompete other faster growing phytoplankton in turbid, turbulent waters. Therefore, based on Alternative 4A maintaining similar to equivalent peak daily flow velocities in Delta channels (and turbidity and turbulence conditions), Alternative 4A would not be expected to substantially increase the frequency or geographic extent of *Microcystis* blooms in the Delta, relative to what would occur under the No Action Alternative.

To ensure project operations do not create increased *Microcystis* blooms in the Delta, water flow through Delta channels would be managed through real-time operations, particularly the balancing of the north and south Delta diversions. By operating the south Delta pumps more frequently during periods conducive to increased *Microcystis* blooms, residence times could be substantially reduced when necessary.

Commenters are concerned that under Alternatives 4A, 2D, and 5A there would be warmer temperatures that would cause increased *Microcystis* production in the Delta. As described in BDCP Appendix 5F, *Biological Stressors on Covered Fish*, climate warming, not water operations, will determine future water temperatures in the Delta. Thus, Alternatives 4A, 2A, or 5D are not expected to contribute to *Microcystis* bloom formation, relative to the No Action Alternative (ELT and LLT), because water residence time, peak daily flow velocities, and water temperatures are not projected to notably change throughout the Delta due to project operations.

Finally, commenters are concerned that under Alternatives 4A, 2D, and 5A there would be reduced turbidity that would cause increased *Microcystis* production in the Delta. As described in Chapter 8, *Water Quality*, Section 8.3.1.7 and in the discussion of Impact WQ-29: Effects on TSS and Turbidity Resulting from Facilities Operations and Maintenance, changes in TSS and turbidity levels within the Delta under the project alternatives could not be quantified, but are expected to be similar to Existing Conditions and the No Action Alternative (ELT and LLT). Thus, no substantial changes to water clarity that would substantially affect *Microcystis* levels are anticipated.

The potential effects of all the project alternatives on *Microcystis* bloom formation potential in the Delta, and impacts on human health, has been fully assessed in Final EIR/EIS Chapter 8, *Water Quality*, in Impacts WQ-32 and WQ-33 and in Chapter 25, *Public Health*, in Impacts PH-8 and PH-9. The assessments recognize the potential impacts on drinking water uses and human health. Hence, Mitigation Measure WQ-32 is provided to address the significant impacts identified for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9; Alternatives 4A, 2D, and 5A would not have significant impacts related to *Microcystis*.

Potential for Harmful Microcystin Levels in the San Francisco Bay

The assessment of *Microcystis* in San Francisco Bay in Impact WQ-34 in Chapter 8, *Water Quality*, acknowledges the presence of microcystin in the bay, and also acknowledges the potential for it to be transported in from the Delta inflow. The potential for increased *Microcystis* blooms and microcystin concentrations due to the project alternatives must be considered separate from the effects of climate change and associated temperature increases that would contribute to increased blooms. Potential increases in *Microcystis* blooms in the Delta are not expected to affect San Francisco Bay for three reasons: 1) the amount of dilution available in San Francisco Bay to dilute downstream transport of Delta-derived *Microcystis* and associated microcystins, 2) *Microcystis* is intolerant to San Francisco Bay salinity, and 3) high Delta outflows that could potentially transport *Microcystis* primarily occur during the winter and spring runoff season when the environment of San Pablo Bay (the only embayment of San Francisco Bay that would have low enough salinities to possibly support *Microcystis* blooms) is unsuitable for *Microcystis* growth. Nevertheless, Mitigation Measures WQ-32a and WQ-32b, which are provided for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 due to the potential impacts of CM2 and CM4 discussed in Impacts WQ-32 and WQ-33, would be available to lessen the effects in the Delta, which would further reduce any potential for effects in San Francisco Bay.

Table Cl-70. Period average change in chloride concentrations (mg/L) for Alternative 4A ELT relative to existing conditions and the No Action Alternative ELT. Calculation of chloride concentrations was based on EC-chloride relationship.

Chloride			OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		Annual Avg. Change	
Alt 4A ELT	Location	Period [a]	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT	Ex. Cond.	No Act. ELT
Delta Interior	Moke. R. (SF) at Staten Island	ALL	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
			(3%)	(3%)	(3%)	(2%)	(1%)	(1%)	(5%)	(4%)	(4%)	(4%)	(5%)	(4%)	(3%)	(3%)	(0%)	(1%)	(0%)	(1%)	(3%)	(3%)	(2%)	(1%)	(1%)	(1%)	(3%)	(2%)
		DROUGHT	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
			(2%)	(2%)	(1%)	(1%)	(-0%)	(1%)	(4%)	(3%)	(1%)	(3%)	(1%)	(3%)	(-0%)	(1%)	(0%)	(1%)	(0%)	(1%)	(5%)	(4%)	(2%)	(-1%)	(1%)	(0%)	(1%)	(2%)
	SJR at Buckley Cove	ALL	-8	0	-12	-1	-22	4	-21	3	-13	6	-10	5	-18	-6	-9	1	-6	4	-7	7	-11	6	-12	-1	-12	2
			(-8%)	(0%)	(-11%)	(-1%)	(-15%)	(4%)	(-13%)	(3%)	(-9%)	(5%)	(-7%)	(4%)	(-18%)	(-7%)	(-12%)	(2%)	(-6%)	(5%)	(-7%)	(7%)	(-10%)	(6%)	(-11%)	(-1%)	(-11%)	(2%)
		DROUGHT	-14	0	-18	-1	-33	2	-32	6	-14	12	-12	9	-32	-12	-14	3	-22	7	-11	15	-15	18	-17	0	-20	5
			(-11%)	(-0%)	(-13%)	(-1%)	(-20%)	(2%)	(-15%)	(4%)	(-6%)	(6%)	(-6%)	(5%)	(-19%)	(-8%)	(-12%)	(3%)	(-17%)	(7%)	(-9%)	(17%)	(-12%)	(20%)	(-12%)	(-0%)	(-13%)	(4%)
	Franks Tract	ALL	-60	-41	-125	-97	-67	-44	-32	-30	-10	-6	2	3	5	5	2	3	3	2	-49	-32	-44	-32	-29	-20	-34	-24
			(-32%)	(-24%)	(-54%)	(-48%)	(-32%)	(-24%)	(-24%)	(-23%)	(-16%)	(-10%)	(5%)	(8%)	(15%)	(16%)	(5%)	(9%)	(6%)	(5%)	(-38%)	(-28%)	(-29%)	(-23%)	(-15%)	(-11%)	(-28%)	(-22%)
		DROUGHT	-38	-52	-98	-112	-41	-40	-22	-35	-11	-15	2	1	5	6	7	5	9	0	-88	-61	-55	-24	31	18	-25	-26
			(-17%)	(-21%)	(-36%)	(-39%)	(-15%)	(-15%)	(-12%)	(-18%)	(-15%)	(-20%)	(6%)	(1%)	(18%)	(19%)	(22%)	(14%)	(22%)	(1%)	(-42%)	(-33%)	(-24%)	(-12%)	(13%)	(7%)	(-16%)	(-17%)
	Old R. at Rock Slough	ALL	-35	-22	-96	-76	-60	-40	-28	-29	-7	-2	4	7	2	4	-1	2	5	5	-36	-23	-39	-29	-22	-17	-26	-18
			(-23%)	(-16%)	(-51%)	(-45%)	(-33%)	(-25%)	(-21%)	(-21%)	(-10%)	(-4%)	(9%)	(15%)	(4%)	(9%)	(-2%)	(4%)	(12%)	(13%)	(-35%)	(-26%)	(-31%)	(-25%)	(-14%)	(-11%)	(-24%)	(-18%)
		DROUGHT	-15	-25	-75	-92	-37	-34	-16	-33	-12	-13	2	5	5	8	7	7	9	4	-69	-49	-54	-29	20	12	-19	-20
			(-8%)	(-13%)	(-35%)	(-40%)	(-16%)	(-15%)	(-9%)	(-18%)	(-13%)	(-14%)	(4%)	(8%)	(9%)	(16%)	(18%)	(17%)	(24%)	(8%)	(-43%)	(-35%)	(-28%)	(-17%)	(10%)	(6%)	(-14%)	(-15%)
Western Delta	Sac. R. at Emmaton	ALL	-145	-126	-144	-100	-9	-12	-36	-34	-12	-11	8	0	7	2	1	0	2	-10	110	88	140	85	58	82	-2	-3
			(-25%)	(-23%)	(-26%)	(-20%)	(-3%)	(-4%)	(-28%)	(-27%)	(-17%)	(-15%)	(21%)	(-1%)	(20%)	(4%)	(1%)	(0%)	(1%)	(-5%)	(49%)	(36%)	(42%)	(22%)	(10%)	(15%)	(-1%)	(-1%)
		DROUGHT	-146	-156	-134	-128	33	-14	-50	-74	-5	-18	16	0	13	5	27	-1	36	-6	211	171	204	76	215	84	35	-5
			(-19%)	(-20%)	(-17%)	(-17%)	(7%)	(-3%)	(-26%)	(-34%)	(-5%)	(-15%)	(36%)	(-1%)	(35%)	(11%)	(23%)	(-1%)	(15%)	(-2%)	(64%)	(46%)	(46%)	(13%)	(27%)	(9%)	(10%)	(-1%)
	SJR at Antioch	ALL	-547	-321	-524	-292	-142	-58	-140	-116	-63	-60	19	-7	22	3	1	-3	-7	-40	36	39	151	123	-111	55	-109	-56
			(-37%)	(-26%)	(-35%)	(-23%)	(-14%)	(-6%)	(-28%)	(-25%)	(-25%)	(-24%)	(16%)	(-5%)	(19%)	(2%)	(1%)	(-1%)	(-2%)	(-8%)	(4%)	(5%)	(14%)	(11%)	(-8%)	(4%)	(-14%)	(-8%)
		DROUGHT	-485	-390	-448	-272	-78	-56	-164	-191	-52	-94	47	-6	40	14	44	-10	37	-39	89	82	273	219	259	129	-36	-51
			(-26%)	(-22%)	(-23%)	(-16%)	(-5%)	(-4%)	(-23%)	(-26%)	(-13%)	(-21%)	(29%)	(-3%)	(28%)	(8%)	(12%)	(-2%)	(5%)	(-5%)	(7%)	(7%)	(21%)	(16%)	(14%)	(7%)	(-4%)	(-5%)
	Sac. R. at Mallard Island	ALL	-697	-273	-670	-276	-237	-75	-238	-196	-97	-104	78	2	73	14	28	-6	3	-100	136	116	294	226	-194	131	-127	-45
			(-23%)	(-10%)	(-23%)	(-11%)	(-11%)	(-4%)	(-19%)	(-16%)	(-12%)	(-13%)	(17%)	(0%)	(14%)	(2%)	(3%)	(-1%)	(0%)	(-6%)	(7%)	(6%)	(12%)	(9%)	(-7%)	(5%)	(-7%)	(-3%)
		DROUGHT	-640	-310	-666	-270	-194	-76	-343	-347	-86	-182	136	18	123	46	77	-15	46	-61	207	190	396	284	297	156	-54	-47
			(-17%)	(-9%)	(-18%)	(-8%)	(-6%)	(-3%)	(-18%)	(-18%)	(-6%)	(-12%)	(21%)	(2%)	(17%)	(6%)	(5%)	(-1%)	(2%)	(-3%)	(8%)	(7%)	(14%)	(9%)	(8%)	(4%)	(-2%)	(-2%)
Major Diversions (Pumping Stations)	NBA at Barker Slough PP	ALL	-1	0	0	0	0	0	0	0	1	0	0	0	-1	0	0	0	-1	0	-1	0	0	0	0	0	0	0
			(-3%)	(1%)	(-1%)	(1%)	(1%)	(1%)	(1%)	(1%)	(4%)	(-0%)	(1%)	(1%)	(-3%)	(1%)	(-0%)	(1%)	(-3%)	(0%)	(-3%)	(0%)	(-0%)	(1%)	(-1%)	(1%)	(-1%)	(1%)
		DROUGHT	-1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	-1	0	0	0	0	0	0	0	0	0
			(-4%)	(1%)	(-1%)	(0%)	(3%)	(2%)	(1%)	(-0%)	(2%)	(0%)	(4%)	(1%)	(5%)	(2%)	(3%)	(1%)	(-3%)	(-0%)	(-2%)	(0%)	(1%)	(1%)	(0%)	(1%)	(1%)	(1%)
	Contra Costa PP #1	ALL	-28	-5	-59	-45	-78	-59	-43	-26	4	-17	-9	1	0	8	-6	-4	4	6	-21	-17	-52	-33	-27	-26	-26	-18
			(-17%)	(-4%)	(-37%)	(-31%)	(-43%)	(-36%)	(-24%)	(-16%)	(4%)	(-13%)	(-10%)	(2%)	(0%)	(12%)	(-9%)	(-7%)	(8%)	(14%)	(-24%)	(-20%)	(-37%)	(-27%)	(-19%)	(-19%)	(-22%)	(-16%)
		DROUGHT	-5	12	-49	-68	-71	-76	-15	-27	-4	-28	-2	-10	5	9	5	0	8	5	-44	-38	-86	-46	-6	2	-22	-22
			(-3%)	(7%)	(-26%)	(-33%)	(-31%)	(-32%)	(-7%)	(-12%)	(-4%)	(-21%)	(-3%)	(-12%)	(6%)	(13%)	(8%)	(0%)	(17%)	(10%)	(-35%)	(-31%)	(-39%)	(-25%)	(-4%)	(1%)	(-16%)	(-15%)
	Banks PP	ALL	-42	-33	-63	-51	-59	-42	-56	-52	-31	-29	-34	-30	-15	-10	-3	2	-9	-7	-33	-27	-47	-35	-38	-35	-36	-29
			(-38%)	(-32%)	(-48%)	(-43%)	(-41%)	(-33%)	(-41%)	(-39%)	(-30%)	(-29%)	(-39%)	(-36%)	(-18%)	(-13%)	(-4%)	(3%)	(-14%)	(-11%)	(-45%)	(-40%)	(-46%)	(-39%)	(-35%)	(-33%)	(-35%)	(-31%)
		DROUGHT	-27	-26	-52	-64	-50	-40	-37	-49	-31	-36	-70	-59	-26	-16	0	6	6	7	-46	-37	-74	-50	-21	-18	-36	-32
			(-20%)	(-19%)	(-35%)	(-39%)	(-28%)	(-24%)	(-22%)	(-27%)	(-22%)	(-25%)	(-52%)	(-48%)	(-20%)	(-14%)	(0%)	(6%)	(8%)	(11%)	(-45%)	(-40%)	(-48%)	(-38%)	(-15%)	(-14%)	(-27%)	(-25%)
	Jones PP	ALL	-38	-32	-59	-51	-41	-26	-60	-48	-57	-46	-62	-56	-21	-17	-21	-17	-26	-30	-28	-24	-34	-25	-24	-21	-39	-33
			(-35%)	(-31%)	(-46%)	(-42%)	(-27%)	(-19%)	(-40%)	(-35%)	(-44%)	(-39%)	(-52%)	(-50%)	(-24%)	(-20%)	(-28%)	(-24%)	(-41%)	(-44%)	(-34%)	(-31%)	(-33%)	(-27%)	(-23%)	(-20%)	(-36%)	(-32%)
		DROUGHT	-32	-36	-45	-58	-41	-32	-81	-72	-68	-51	-101	-91	-21	-17	-30	-26	-22	-23	-50	-42	-45	-26	-7	-5	-45	-40
			(-24%)	(-26%)	(-30%)	(-36%)	(-23%)	(-19%)	(-42%)	(-39%)	(-36%)	(-29%)	(-52%)	(-50%)	(-16%)	(-13%)	(-26%)	(-24%)	(-35%)	(-36%)	(-47%)	(-42%)	(-30%)	(-20%)	(-5%)	(-4%)	(-31%)	(-29%)

[a] ALL: Water years 1976-1991 represent the 16-year period modeled using DSM2. DROUGHT: Represents a 5 consecutive year (water years 1987-1991) drought period consisting of dry and critical water year types (as defined by the Sacramento Valley 40-30-30 water year hydrologic classification index).

evaluation of the project's impacts in the meantime does not 'giv[e] due consideration to both the short-term and long-term effects' of the project … and does not serve CEQA's informational purpose well" (*Ibid*., quoting State CEQA Guidelines Section 15126.2, subd. (a)). Although the Supreme Court did not adopt a strict prohibition against the exclusive use of a future baseline consisting of anticipated conditions at the commencement or mid-point of project implementation, any sole reliance on such a future baseline is only permissible where a CEQA lead agency can show, based on substantial evidence, that an existing conditions analysis would be "misleading or without informational value" (*Ibid*., 457).

Existing Conditions

Although originally formulated prior to the issuance of the *Neighbors for Smart Rail* decision, the CEQA baseline employed in this EIR/EIS is consistent with the principles outlined above. Following CEQA Guidelines Section 15125(a), the CEQA baseline was developed to assess the significance of impacts of the BDCP alternatives in relation to the Existing Conditions at the time of the NOP. The Existing Conditions assumptions for the EIR/EIS include facilities and ongoing programs that existed as of February 13, 2009 (publication date of the most recent NOP and Notice of Intent [NOI] to prepare this EIS/EIR), that could affect or could be affected by implementation of the action alternatives (refer to Appendix 1D, *Final Scoping Report*, for copies of the NOP and NOI).

In some instances, though, certain assumptions were updated within the CEQA lead agency's reasonable discretion. For example, the June 2009 Biological Opinion (BiOp) for salmonid species from National Marine Fisheries Service (NMFS) was included within the CEQA baseline even though it had not been issued in its final form as of February 2009. Because the December 2008 BiOp for the delta smelt from the United States Fish and Wildlife Service (USFWS) was in place as of February 2009, it made sense to also include the NMFS BiOp, which had been released in draft form prior to February 2009. The California Department of Water Resources (DWR) decided that it would have been anomalous to rely on the most current USFWS BiOp with respect to delta smelt issues, but to ignore the soon-to-be-adopted NFMS BiOp with respect to salmonid issues.

Even so, because of the importance of focusing on Existing Conditions, DWR as CEQA lead agency did not assume implementation of *all* aspects of either BiOp. In particular, DWR did not assume full implementation of a particular requirement of the delta smelt BiOp, known as the "Fall X2" salinity standard, which in certain water-year types can require large upstream reservoir releases in fall months of wet and above normal years to maintain the location of "X2" at approximately 74 or 81 river kilometers inland from the Golden Gate Bridge. 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. This uncertainty, together with CEQA's focus on Existing Conditions, led DWR to the decision to use a CEQA baseline without the implementation of the Fall X2 action. However, for the purposes of the NEPA comparison, which uses a different method for assessing environmental effects of the action alternatives, the Fall X2 action is included in the NEPA point of comparison as discussed below in the *No Action Alternatives* section.

- Changes in monitoring to support project operations.
- Re-initiation of consultation (ESA Section 7) and 2081(b) permit amendment (CESA) to address changes outside of existing authorizations.

Memorandum of Agreement

Commitments to adaptive management and collaborative science will be secured through a MOA between DWR, Reclamation, the public water agencies, CDFW, NMFS, and USFWS. Details of the collaborative science and adaptive management process, including adaptive management decision-making, an organizational structure for adaptive management decisions, and funding for collaborative science will be developed and incorporated through the MOA, as needed.

Possible Operational Scenarios

Under the real time operational decision-making process, as well as the adaptive management and monitoring program, both of which are described above, the RTO team will have flexibility for operations. The RTO team, in making operational decisions, will take into account operational constraints, such as coldwater pool management, instream flow, and temperature requirements. The extent to which real time adjustments that may be made to each parameter (e.g., OMR flow target) shall be limited by the criteria and/or ranges set out in the section describing Scenario H (Alternative 4A). Operations are flexible, so long as they are in compliance with existing and applicable permitting requirements and standards, as may be amended, and any other regulatory and contractual obligations. In addition, following the initial operations, the adaptive management and monitoring program could be used to make long-term changes in initial operations criteria, if appropriate, to address uncertainties about spring outflow for longfin smelt and fall outflow for delta smelt, among others.

For that reason, Appendix 5E, *Supplemental Modeling Requested by the State Water Resources Control Board Related to Increased Delta Outflows,* also presents a broader operational boundary analysis, as well as an additional operational scenario requested by the State Water Board that results in increased Delta outflow and decreased SWP/CVP exports (Modified Alternative 8). As shown in Appendix 5E, the operation of the future conveyance facility under a possible adaptive management range represented by Boundary 1 and Boundary 2 will be consistent with the impacts discussed for the range of alternatives considered in this document (see Appendix 5E, Section 5E.2, for additional information on these boundaries). Boundary 1 and Boundary 2 also encompass the full range of impacts found in the analysis prepared for H1 and H2(as well as H3 and H4). For modeling information on H1 and H2, please see Appendix 11G, *Supplemental Modeling Results at ELT for Alternative 4 at H1 and H2*.

3.7 Environmental Commitments

As part of the project planning and environmental assessment process, DWR will incorporate certain environmental commitments and BMPs into the proposed action alternatives to avoid or minimize potential impacts. These *environmental commitments* refer to design features, construction methods, and other BMPs that have been incorporated as part of the project description to preclude the occurrence of environmental effects that could arise without such commitments in place. These environmental commitments tend to be relatively standardized and are often already compulsory;

Appendix 5E
Supplemental Modeling Related to the State Water Resources Control Board

5E.1 Introduction and Purpose of the Supplemental Modeling

The State Water Resources Control Board (State Water Board) is expected to issue discretionary approvals considered a "project" under California Environmental Quality Act (CEQA), and therefore, the State Water Board is identified as a Responsible Agency for purposes of California Department of Water Resources (DWR's) CEQA document. DWR prepared the Bay Delta Conservation Plan (BDCP) Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) in consideration of the State Water Board and other Responsible Agency approvals and specifically included Alternative 8 in the BDCP Draft EIR/EIS at the request of State Water Board staff. The 2015 Partially Recirculated Draft EIR/Supplemental Draft EIS (RDEIR/SDEIS) included, at the request of State Water Board staff, supplemental modeling at year 2025 (Early Long Term [ELT]), conducted to evaluate an operational scenario that provides higher Delta outflows than the Preferred Alternative (Alternative 4A), while including model assumptions that avoid impacts to fish and aquatic resources attributable to reductions in cold water pool storage and flow modifications under Alternative 8 and other higher outflow scenarios analyzed in the BDCP Draft EIR/EIS.

This appendix includes a revised and updated version of the State Water Board staff requested scenario that was presented in the RDEIR/SDEIS (referred to as Scenario 2 in this appendix) and also provides supplemental modeling and analysis of 2 additional scenarios, each at year 2025 (Early Long Term [ELT]) that were presented in the State Water Board water rights petition process (Boundary 1 and Boundary 2). Boundaries 1 and 2 were presented to the State Water Board during the water rights petition process as a means to represent a potential range of operations that could occur as a result of the proposed Adaptive Management Program, and the conditions of any approvals obtained as a result of the ongoing regulatory review of U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Wildlife, and State Water Board. The description and analysis included in this appendix for Boundaries 1 and 2 incorporates by reference the testimony presented to the State Water Board July 29 through September 27, 2016, for the California WaterFix change in point of diversion petition. The testimony exhibits on which this analysis relied are posted at:

> http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/CWF_ChangePetition_TOC_V212.pdf

The transcripts on which this analysis relied are posted at:

> http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/CWF_ChangePetitionHearingTranscript.pdf

Chapter 8 – Water Quality	Alternative																			
	Existing Condition	No Action	1A	1B	1C	2A	2B	2C	3	4	5	6A	6B	6C	7	8	9	4A	2D	5A
WQ-5: Bromide (CM1) - Percent increase in long-term average concentration at Barker Slough	-	-2%	38/43%	38/43%	38/43%	22/26%	22/ 26%	22/ 26%	34/38%	40/44%	23/27%	19/22%	19/22%	19/22%	-2/1%	4/8%	19/23%	-2/2%	-2/2%	-4/0%
		LTS	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A[a]	S/A[a]	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-7: Chloride - Percent of years when 150 mg/L water quality objective exceeded at CCPP#1[b]	7%	0	13%	13%	13%	13%	13%	13%	7%	7%	13%	13%	13%	13%	20%	13%	13%	0%	0%	0%
		S	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-11: EC- Percent of days Emmaton objective would be exceeded	6%	14	31%	31%	31%	26%	26%	26%	30%	27-29%[c]	25%	32%	32%	32%	19%	22%	18%	16%[c]	7%[c]	10%[c]
		S	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-13: Mercury (CM1) - Maximum percent increase in fish tissue concentrations at Delta locations	6%	6%	8/10%	8/10%	8/10%	13/11%	13/11%	13/11%	6/8%	15/12%	8/7%	64/58%	64/58%	64/58%	45/39%	46/41%	66/59%	8/7%	10/9%	5/3%
		LTS	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA

Notes

[a] While the long-term average increases in bromide would be low, the drought period increases would be 34% for Alternative 7 and 50% for Alternative 8, relative to Existing Conditions and the No Action Alternative. These increases in the drought period were considered significant/adverse.

[b] Water quality degradation as measured by use of available assimilative capacity also played a significant role in determining effects by alternative, and degradation varied by alternative.

[c] Alternative 4 does not include a change in compliance location from Emmaton to Threemile Slough, but the modeling used to evaluate the alternative did include the change. Thus, although the percent of days the Emmaton objective was exceeded is high, it is expected that under the alternative it would be similar to the No Action.

Key

Level of significance or effect **before** mitigation
(Quantity of impact: number of sites, structures, acres, etc. affected)

Increasing level of significance →

Bromide - Percent increase (%)	<0	1 - 20	21 - 40	>40
Chloride - % of years objective exceeded (%)	0	1-12	13-19	>20
EC - percent of days objective exceeded (%)	<10	11 - 20	20 - 30	>30
Mercury (CM1) - Percent increase (%)	<10	10 - 20	21 - 50	>50
Mercury (CM2-CM22) - restoration acres	0	1 - 100	25,000	65,000
Organic Carbon (CM1) - mg/L	<0.1	0.1 - 0.5	0.6 - 1.0	>1.0
Organic Carbon (CM2-CM21) - restoration acres	0	1 - 100	25,000	65,000
Selenium - Exceedance Quotient	0.87	0.88 - 0.93	0.94 - 0.99	>1.0
Microcystis - relative rank	1	2	3	4

Level of significance or effect **after** mitigation
(CEQA Finding / NEPA Finding)

CEQA Finding		**NEPA Finding**	
NI	No Impact	B	Beneficial
LTS	Less than significant	NE	No Effect
S	Significant	NA	Not Adverse
SU	Significant and unavoidable	A	Adverse

n/a not applicable
\> greater than
< less than
≈ about equal to

Continued on Figure 8-0b

Figure 8-0a
Comparison of Impacts on Water Quality

Chapter 8 – Water Quality (continued)	Alternative																			
	Existing Condition	No Action	1A	1B	1C	2A	2B	2C	3	4	5	6A	6B	6C	7	8	9	4A	2D	5A
WQ-14: Mercury(CM2-CM21) - Amount (acres) of new tidal habitat restoration that could contribute additional methylmercury	0	0	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	25,000	65,000	65,000	65,000	65,000	65,000	65,000	59	65	55
		-- [d]	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A
WQ-17: Organic Carbon (CM1) - Maximum increase in long-term average DOC (mg/L) at interior Delta locations	--	<0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.2	0.4	0.2	1.2	1.2	1.2	0.8	0.8	0.7	0.2	0.2	0.1
		LTS	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-18: Organic Carbon (CM2-CM21) - Amount (acres) of new tidal habitat restoration that could contribute additional DOC	0	0	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	25,000	65,000	65,000	65,000	65,000	65,000	65,000	59	65	55
		-- [d]	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-25: Selenium (CM1) - High threshold exceedance quotient for whole body sturgeon (concentration divided by threshold) during drought period	.87	0.87	0.89	0.89	0.89	0.92	0.92	0.92	0.89	0.93	0.89	1.1	1.1	1.1	1.1	1.1	1.2	0.91	0.89	0.90
		LTS	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	LTS/NA	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA
WQ-32 and 33: Microcystis (CM1-CM21) - potential for increased production in Delta [e]	--	2	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	2	2	2
		5	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	S/A	LTS/NA	LTS/NA	LTS/NA

Notes

[d] CM2-CM21 are not a component of Existing Conditions or the No Action Alternative, thus, no impact call was made for this effect in the EIR/EIS.

[e] The Microcystis was qualitative. Thus, the severity of the impact was established as a rank from 1 to 4, with the rankings based on the alternative-specific factors that would contribute to increased Microcystis production, including restoration area, diversions of Sacramento River water at the north intakes, and net Delta outflow.

Key

Level of significance or effect **before** mitigation
(Quantity of impact: number of sites, structures, acres, etc. affected)

Increasing level of significance →

Bromide - Percent increase (%)	<0	1 - 20	21 - 40	>40
Chloride - % of years objective exceeded (%)	0	1-12	13-19	>20
EC - percent of days objective exceeded (%)	<10	11 - 20	20 - 30	>30
Mercury (CM1) - Percent increase (%)	<10	10 - 20	21 - 50	>50
Mercury (CM2-CM22) - restoration acres	0	1 - 100	25,000	65,000
Organic Carbon (CM1) - mg/L	<0.1	0.1 - 0.5	0.6 - 1.0	>1.0
Organic Carbon (CM2-CM21) - restoration acres	0	1 - 100	25,000	65,000
Selenium - Exceedance Quotient	0.87	0.88 - 0.93	0.94 - 0.99	>1.0
Microcystis - relative rank	1	2	3	4

Level of significance or effect **after** mitigation
(CEQA Finding / NEPA Finding)

CEQA Finding		**NEPA Finding**	
NI	No Impact	B	Beneficial
LTS	Less than significant	NE	No Effect
S	Significant	NA	Not Adverse
SU	Significant and unavoidable	A	Adverse

n/a	not applicable
>	greater than
<	less than
≈	about equal to

00139.14 EIR-EIS Ex Summ 7-25-2016 (tm)

Figure 8-0b
Comparison of Impacts on Water Quality (continued)

STKN-026

Potential Impact	Alternatives	Impact Conclusions Before Mitigation	Proposed Mitigation (CEQA and NEPA)	Impact Conclusion After Mitigation	
		CEQA		CEQA	NEPA
WQ-4: Effects on boron concentrations resulting from implementation of CM2–CM21	NAA (LLT), NAA (ELT), 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 2D, 4A 5A	LTS		LTS	NA
WQ-5: Effects on bromide concentrations resulting from facilities operations and maintenance (CM1)	NAA (LLT), NAA (ELT), 2D, 4A, 5A	LTS		LTS	NA
	1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9	S	WQ-5: Avoid, minimize, or offset, as feasible, adverse water quality conditions; site and design restoration sites to reduce bromide increases in Barker Slough	SU	A
WQ-6: Effects on bromide concentrations resulting from implementation of CM2–CM21	NAA (LLT), NAA (ELT), 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 2D, 4A, 5A	LTS		LTS	NA
WQ-7: Effects on chloride concentrations resulting from facilities operations and maintenance (CM1)	NAA (LLT), NAA (ELT)	S		S	NA
	1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9	S	WQ-7: Conduct additional evaluation and modeling of increased chloride levels and develop and implement phased mitigation actions WQ-7a: Conduct additional evaluation of operational ability to reduce or eliminate water quality degradation in western Delta incorporating site-specific restoration areas and updated climate change/sea level rise projections, if available WQ-7b: Site and design restoration sites to reduce or eliminate water quality degradation in the western Delta WQ-7c: Consult with Delta water purveyors to identify means to avoid, minimize, or offset for reduced seasonal availability of water that meets applicable water quality objectives WQ-7d: Site and design restoration sites and consult with CDFW/USFWS, and Suisun Marsh stakeholders to identify potential actions to avoid or reduce chloride concentration increases in the Marsh	SU	A
	4A	LTS	WQ-7e: Implement Terms of the Contra Costa Water District Settlement Agreement	LTS	NA
	2D, 5A	LTS		LTS	NA
WQ-8: Effects on chloride concentrations resulting from implementation of CM2–CM21	NAA (LLT), NAA (ELT), 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 2D, 4A, 5A	LTS		LTS	NA
WQ-9: Effects on dissolved oxygen resulting from facilities operations and maintenance (CM1)	NAA (LLT), NAA (ELT), 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 2D, 4A, 5A	LTS		LTS	NA
WQ-10: Effects on dissolved oxygen resulting from implementation of CM2–CM21	NAA (LLT), NAA (ELT), 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, 9, 2D, 4A, 5A	LTS		LTS	NA

Level of Significance/Determination of Effects:

CEQA

SU = significant and unavoidable (any mitigation not sufficient to render impact less than significant).
S = significant.
LTS = less than significant.
NI = no impact.
B = beneficial.
ND = no determination.

NEPA

A = adverse.
NA = not adverse.
NE = no effect.
B = beneficial.
ND = no determination.

variations can also be attributed to phytoplankton, zooplankton and other biological material in the water.

The TSS and turbidity assessments were conducted in a qualitative manner based on anticipated changes in these factors.

Microcystis

Microcystis has an annual life cycle characterized by two phases. The first is a benthic phase, during which cysts overwinter in the sediment. In the second planktonic phase, during summer and fall, *Microcystis* enters the water column and begins to grow. When environmental conditions, such as sufficiently warm water temperatures, trigger *Microcystis* recruitment from the sediment, the organism is resuspended into the water column through a combination of active and passive processes (Verspagen et al. 2004; Mission and Latour 2012). In the Delta, there are five primary environmental factors that trigger the emergence and subsequent growth of *Microcystis*.

1. Warm water temperatures (>19°C) (Lehman et al. 2013).
2. Nutrient availability (e.g., nitrogen and phosphorus) (Smith 1986; Paerl 2008 as cited in Davis et al. 2009).
3. Water column irradiance and clarity (surface irradiance >100 Watts per square meter per second and total suspended solid concentration <50mg/L (Lehman et al. 2013).
4. Flows and long residence times (Lehman et al. 2013).

Microcystis blooms typically develop over a period of several weeks after cells emerge from the benthic state (Marmen et al. 2016). Because environmental conditions and benthic recruitment drive *Microcystis* formation within the water column, it is common for many *Microcystis* cells to enter the water column at the same time. Once in the water column, and when environmental conditions are favorable, *Microcystis* rapidly multiplies. One study found the doubling time of *Microcystis aeruginosa* strains ranged from 1.5 to 5.2 days, with an average doubling time of 2.8 days (Wilson et al. 2006). This fast growth rate allows cells to form colonies which come together to form a “scum” layer at the water surface. In the Delta, scums are primarily composed of the colonial form of *Microcystis*, but single cells are also present (Baxa et al. 2010).

Like many cyanobacteria species, *Microcystis* possess specialized intracellular gas vesicles that enable the organism to regulate its buoyancy (Reynolds 1981 as cited in Paerl et al. 2014). This buoyancy allows *Microcystis* to take advantage of near surface areas with optimal growth conditions (e.g., light). The collection of cells at the surface, primarily in calm waters, allows *Microcystis* to sustain a competitive advantage over other phytoplankton species by optimizing their photosynthetic needs while shading out other algal species, which they compete with for nutrients and light (Huisman et al. 2004).

Wind and tides can enhance the aggregation of *Microcystis* cells in slow moving waters (Baxa et al. 2010), but in faster moving, turbulent waters, the ability of *Microcystis* to maintain its positive buoyancy is reduced (Visser et al. 1996). Therefore, high flow rates make it difficult for *Microcystis* to collect and form dense colonies at the water surface. Turbulence effects metabolic processes and cell division (Koch 1993; Thomas et al. 1995 as cited in Li et al. 2013) and thus can be a negative growth factor (Paerl et al. 2001 and articles cited within). Turbulent water mixes all algae throughout the photic zone of the water column and reduces light through turbidity which allows faster growing chlorophytes (green algae) and diatoms to outcompete the slower growing cyanobacteria, including *Microcystis* (Wetzel et al. 2001; Huisman et al. 2004; Li et al. 2013). Although the amount of flow required to disrupt a *Microcystis* bloom varies by system, in the Zhongxin Lake system China, flow velocities of 0.5–1.0 feet/second shifted the dominant phytoplankton species from cyanobacteria to green algae and diatoms (Li et al. 2013).

As described under Impact WQ-29 (Effects on TSS and Turbidity), changes in TSS and turbidity levels within the Delta under the project alternatives could not be quantified, but are expected to be similar under the project alternatives to Existing Conditions and the No Action Alternative. Minimal changes in water clarity would result in minimal changes in light availability for *Microcystis* under the project alternatives. As such, the project alternatives' influence on *Microcystis* production in the Delta, as influenced by the project alternatives' effects on Delta water clarity, is considered to be negligible.

Regarding nutrients the maintenance of *Microcystis* blooms in the Delta requires the availability of the nitrogen and phosphorus. However, the body of science produced by scientists studying *Microcystis* blooms in the Delta and elsewhere does not indicate that the specific levels of these nutrients, or their ratio, currently control the seasonal or inter-annual variation in the bloom. A large fraction of ammonia in the Sacramento River will be removed due to planned upgrades to the Sacramento Regional County Sanitation District's SRWTP, which will result in >95% removal of ammonia from the effluent discharge from this facility. Following the SRWTP upgrades, levels of ammonia in Sacramento River are expected to be similar to background ammonia concentrations in the San Joaquin River and San Francisco Bay (see Section 8.3.3.1, Impact WQ-1). The response of *Microcystis* production in the Delta to the substantial reduction in river ammonia levels (from removing ammonia from the SRWTP discharge) is unknown because nitrate and phosphorus levels in the Delta will remain well above thresholds that would limit *Microcystis* blooms.

Nutrient ratios in excess of the Redfield N:P ratio of 16 have also been hypothesized to favor *Microcystis* growth in the Delta (Glibert et al. 2011). However, considerable doubt has been cast on this hypothesis because median N:P molar ratios in the Delta during peak bloom periods are usually near or a little lower than the Redfield ratio of 16 needed for optimum phytoplankton growth, and when ammonia is considered the sole N source, the N:P ratio drops substantially to a median of 1.31:1 (Lehman et al. 2013). Based on this information, there is no evidence as to what type of effect small changes in nutrient concentrations and ratios would have on *Microcystis* blooms, given that such blooms are largely influenced by a host of other physical factors, including water temperature and water residence time within channels.

Based on the above, water clarity and nutrient effects on *Microcystis* were determined to not have substantial effects on *Microcystis* abundance under the project alternatives, relative to Existing Conditions and the No Action Alternative. A qualitative evaluation was performed to determine if the action alternatives would result in an increase in frequency, magnitude, and geographic extent of *Microcystis* blooms in the Delta based on the following two additional abiotic factors that may affect *Microcystis*: 1) changes to water operations and creation of tidal and floodplain restoration areas that change water residence times within Delta channels, and 2) increases in Delta water temperatures.

The methodology used to determine residence time for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 is described in BDCP Appendix 5.C, Section 5C.4.4.7, *Residence Time*. Briefly, residence time in different subregions of the Plan Area was assessed using the results of the DSM2 Particle Tracking Model for multiple neutrally buoyant particle release locations. Residence time was defined as the time at which 50% of particles from a given release location exited the Plan Area (either by movement downstream past Martinez or through entrainment at the south Delta export facilities, north Delta diversion, North Bay Aqueduct, or agricultural diversions in the Delta). The data were reduced into mean residence time by subregion and season. The data do not represent the length of time that water in the various subregions spends in the Delta in total, but do provide a useful parameter with which to compare generally how long algae would have to grow in the various subregions of the Delta. Table 8-60a shows the residence time results that are used in the *Microcystis* assessments. Results for summer and fall are most relevant for the *Microcystis* assessment, but all seasons are presented for completeness.

Table 8-60a. Average Residence Time for Subregions of the Plan Area by Season and Alternative

		Average Residence Time (days)										
Subregion	Season	Ex Cond.	No Act.	Alt 1	Alt 2	Alt 3	Alt 4 Scn H3	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
North Delta	Summer	33	38	43	38	41	39	41	43	40	46	40
	Fall	49	50	61	56	60	57	55	55	57	58	55
	Winter	36	37	40	40	40	39	41	37	37	37	40
	Spring	30	33	37	35	36	35	36	34	34	29	35
	Overall	35	38	43	41	43	41	41	40	40	40	41
Cache Slough	Summer	18	21	46	40	45	39	39	49	46	59	46
	Fall	46	46	44	39	43	40	39	39	45	56	39
	Winter	29	31	33	32	33	32	33	28	29	27	31
	Spring	22	24	33	33	33	33	33	31	30	33	31
	Overall	27	29	38	36	38	35	36	36	36	42	36
West Delta	Summer	22	24	32	28	30	28	29	40	27	33	28
	Fall	25	27	34	30	33	30	30	30	31	32	27
	Winter	18	20	21	21	21	21	21	19	19	19	19
	Spring	18	20	24	22	24	22	23	20	20	17	20
	Overall	20	22	27	25	26	25	25	27	23	24	23
East Delta	Summer	22	26	40	34	35	34	31	76	32	48	21
	Fall	15	35	33	47	32	48	48	58	55	55	21
	Winter	28	32	40	42	40	42	40	50	51	50	26
	Spring	42	47	57	54	59	54	56	61	57	54	35
	Overall	29	36	45	45	44	45	44	61	49	52	27
South Delta	Summer	8	10	16	17	14	16	11	70	23	33	35
	Fall	5	11	8	42	8	43	34	79	53	52	33
	Winter	10	11	19	19	14	16	15	59	57	56	28
	Spring	25	26	24	29	20	28	27	65	60	58	31
	Overall	13	16	18	26	15	25	21	67	49	50	32
Suisun Marsh	Summer	51	58	38	35	37	35	36	37	36	39	42
	Fall	17	19	39	34	38	34	33	32	34	34	38
	Winter	9	9	28	28	29	27	29	24	24	24	32
	Spring	45	51	32	31	31	30	30	29	28	25	33
	Overall	33	37	33	32	33	31	32	30	30	30	36

was defined as the time at which 50% of particles from a given release location exited the Plan Area (either by movement downstream past Martinez or through entrainment at the south Delta export facilities, north Delta diversion, North Bay Aqueduct, or agricultural diversions in the Delta). The data were reduced into mean residence time by subregion and season. The data do not represent the length of time that water in the various subregions spends in the Delta in total, but do provide a useful parameter with which to compare generally how long algae would have to grow in the various subregions of the Delta. Table 8-60a shows the residence time results that are used in the *Microcystis* assessments. Results for summer and fall are most relevant for the *Microcystis* assessment, but all seasons are presented for completeness.

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Subregion	Season	Ex Cond.	No Act.	Alt 1	Alt 2	Alt 3	Alt 4 Scn H3	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
North Delta	Summer	33	38	43	38	41	39	41	43	40	46	40
	Fall	49	50	61	56	60	57	55	55	57	58	55
	Winter	36	37	40	40	40	39	41	37	37	37	40
	Spring	30	33	37	35	36	35	36	34	34	29	35
	Overall	35	38	43	41	43	41	41	40	40	40	41
Cache Slough	Summer	18	21	46	40	45	39	39	49	46	59	46
	Fall	46	46	44	39	43	40	39	39	45	56	39
	Winter	29	31	33	32	33	32	33	28	29	27	31
	Spring	22	24	33	33	33	33	33	31	30	33	31
	Overall	27	29	38	36	38	35	36	36	36	42	36
West Delta	Summer	22	24	32	28	30	28	29	40	27	33	28
	Fall	25	27	34	30	33	30	30	30	31	32	27
	Winter	18	20	21	21	21	21	21	19	19	19	19
	Spring	18	20	24	22	24	22	23	20	20	17	20
	Overall	20	22	27	25	26	25	25	27	23	24	23
East Delta	Summer	22	26	40	34	35	34	31	76	32	48	21
	Fall	15	35	33	47	32	48	48	58	55	55	21
	Winter	28	32	40	42	40	42	40	50	51	50	26
	Spring	42	47	57	54	59	54	56	61	57	54	35
	Overall	29	36	45	45	44	45	44	61	49	52	27
South Delta	Summer	8	10	16	17	14	16	11	70	23	33	35
	Fall	5	11	8	42	8	43	34	79	53	52	33
	Winter	10	11	19	19	14	16	15	59	57	56	28
	Spring	25	26	24	29	20	28	27	65	60	58	31
	Overall	13	16	18	26	15	25	21	67	49	50	32
Suisun Marsh	Summer	51	58	38	35	37	35	36	37	36	39	42
	Fall	17	19	39	34	38	34	33	32	34	34	38
	Winter	9	9	28	28	29	27	29	24	24	24	32
	Spring	45	51	32	31	31	30	30	29	28	25	33
	Overall	33	37	33	32	33	31	32	30	30	30	36

current conditions will continue and that *Microcystis* blooms will not increase here (ICF International 2016).

Based on *Microcystis* life history strategy to outcompete other algal species and the inhibitory effect of flow and turbulence on its ability to do so, maximum daily channel velocities (which creates channel turbidity and turbulence) also were assessed using DSM2 velocity output for a number of locations throughout the Delta (Appendix 8P). The evaluation of flow velocities shows little to no effects on peak daily velocities under Alternative 4A compared to the No Action Alternative at each location assessed. This indicates that areas of the Delta that are currently turbid will remain turbid and vertical mixing of the water column will be similar under Alternative 4A and the No Action Alternative. As stated in Section 8.3.1.7, *Microcystis* cannot effectively retain its buoyancy or outcompete other faster growing phytoplankton in turbid, turbulent waters. Therefore, based on Alternative 4A maintaining similar to equivalent peak daily flow velocities in Delta channels (and turbidity and turbulence conditions), Alternative 4A would not be expected to substantially increase the frequency or geographic extent of Microcystis blooms in the Delta, relative to what would occur under the No Action Alternative.

Changes in flow paths of water through the Delta and change in operation of the south Delta pumps that would occur due to facilities operations and maintenance of Alternative 4A could result in localized increases in residence time in various Delta sub-regions and decreases in residence time in other areas. In addition to the effects of operations and maintenance of Alternative 4A, increases in water residence times are expected occur due to separate factors and actions concurrent with the alternative, including habitat restoration (8,000 acres of tidal habitat and enhancements in the Yolo Bypass) and sea level rise due to climate change.

Residence times in 19 Delta sub-regions during the *Microcystis* bloom season of July through October was modeled for the Biological Assessment for the California WaterFix (ICF International 2016). The Proposed Action modeled in the Biological Assessment is Alternative 4A. Modeling results show varying levels of change in residence time, depending on sub-region, month and water year type (Tables 6.6-5 through 6.6-25, ICF International 2016). DSM2 PTM output indicates residence times may increase in parts of the southern and central Delta. Because there is no published analysis of the relationship between *Microcystis* occurrence and residence time, there is uncertainty on how increased residence times may affect *Microcystis* occurrences (ICF International 2016). In some areas of the Delta currently affected by *Microcystis* blooms, decreasing median residence times in some months (decreases from 0.1 – 3.8 days) has potential to lower the magnitude and duration of *Microcystis* blooms. However, in other areas of the Delta that experience *Microcystis* blooms, longer median residence times in some months (0.1 - 16.5 days) has potential to increase the magnitude and duration of *Microcystis* blooms.

The changes in residence time are driven by a number of factors accounted for in the modeling, including diversion of Sacramento River water at the proposed north Delta intake facilities, which does not account for the flexibility of operations of the north and south Delta intakes or real-time management of reservoir releases. To ensure project operations do not create increased *Microcystis* blooms in the Delta, water flow through Delta channels would be managed through real-time operations, particularly the balancing of the north and south Delta diversions. By operating the south Delta pumps more frequently during periods conducive to increased *Microcystis* blooms, residence times would be substantially reduced from those modeled for Alternative 4A. Reducing residence times would decrease the potential for blooms to develop, and thus decrease potential microcystin increases due to project operations. As such, effects of Alternative 4A on *Microcystis*

RECIRC Ltr#	Cmt#	Comment	Response
		which is critical for RD 551. The BDCP proponents must address this issue in the RDEIR/SDEIS and then recirculate the document for public review.	storage. DWR will consult directly with landowners to refine the storage area footprint to further minimize impacts to surrounding land uses, including agricultural operations. • Where feasible, dredged material will be stored on higher elevation land that is set back from surface water bodies a minimum of 150 feet. Upland disposal will help ensure that the material will not be in direct contact with surface water prior to its draining, characterization, and potential treatment. Based upon these factors in the project description, it was determined that the RTM would not be placed within a floodway or flood channel unless the material was specifically being used for levee or habitat restoration maintenance which would require subsequent engineering and environmental analyses. For additional information regarding RTM, please see Master Response 12.
2496	1	The City of Stockton is greatly concerned that the Project will have significant impacts that would adversely affect the City of Stockton and its residents. The City expressed its concerns with the BDCP in its July 29, 2014 comments on the Draft EIR/EIS. Those comments identified numerous problems with the BDCP and DEIR/DEIS, which failed to adequately assess or mitigate the BDCP's impacts to the City's water supply and operations or the Delta ecosystem, among other concerns. Chief among these problems was the failure to recognize the City as a major diverter of water for municipal and industrial uses whose supply could be at risk by the BDCP. To the City's surprise and dismay, none of the problems identified in our July 29, 2014 comments were addressed by the changes to the Project or the revised environmental documents. By altering flows and water quality in the Delta, the California Water Fix Project, like the BDCP, threatens to have significant impacts that would adversely affect the City and its residents. The DEIR/DEIS contained no analysis of potential changes to water quality at the location of the City's drinking water intake on the San Joaquin River. Despite the City's comments, the RDEIR/SDEIS failed to incorporate, or address any of our concerns regarding potential water quality impacts at our intake. As a result, the City remains unable to understand the California Water Fix Project impacts on the issues of greatest concern to our residents.	Public comments submitted during the official public comment period and the previous comment period for the 2013 Public Draft will be made available to the public upon the release of the Final EIR/EIS. The Final EIR/EIS will include all comments received during the official comment period and responses to substantive comments. For more information about water quality analysis, please see Master Response 14. For more details about the adequacy of operational criteria, please also see Master Response 28.
2496	2	The RDEIR/SDEIS fails to address the City's prior comments on the effects of the proposed north Delta diversions & conveyance. The City of Stockton provided extensive comments on the DEIR/DEIS. None of the concerns raised in these comments was addressed in the supplemental or revised analyses included in the RDEIR/SDEIS, including the new evaluation of Alternative 4A and Alternatives 2D and 5A. As noted, among the City's chief concerns with the BDCP was the potential for the North Delta diversion to adversely affect water quality and the City's water supply. In particular the City objected to the DEIR/DEIS's failure to evaluate water quality and flow changes at the location of the City's drinking water intake. The City also raised concerns about impacts to agricultural resources, groundwater, air quality, roadways and traffic, as well as socioeconomic impacts. These issues remain unaddressed in the RDEIR/SDEIS. Because no changes were made to the Project or RDEIR/SDEIS that would address the City's comments and concerns, to the extent new alternatives, including Alternative 4A, are similar to the previously proposed BDCP CM1 , the City's prior comments apply to the California Water Fix Project and RDEIR/SDEIS, and the City reasserts its prior comments here and incorporates them by reference as comments on the RDEIR/SDEIS and California Water Fix Project alternatives.	Public comments submitted during the official public comment period and the previous comment period for the 2013 Public Draft will be made available to the public upon the release of the Final EIR/EIS. The Final EIR/EIS will include all comments received during the official comment period and responses to substantive comments. For more information about water quality analysis, please see Master Response 14. For more details about the adequacy of operational criteria, please also see Master Response 28.
2496	3	The RDEIR/SDEIS repeats and compounds the problems of the DEIR/DEIS. The water quality impact analysis provided for Alternative 4A fails to answer or address any of the questions	The assessment locations for the water quality Impacts analysis in Chapter 8, Water Quality, were selected within key portions of the Delta, including the eastern Delta where the City's intake is located. Given the

RECIRC Ltr#	Cmt#	Comment	Response
		or concerns the City of Stockton raised in its comments on the original project proposal. There is no discussion of water quality effects at the City's intake. Moreover, the analysis of impacts at the locations that were included is hopelessly vague, convoluted and, ultimately, uninformative. The analysis is made even more unintelligible and factually suspect by the RDEIR/SDEIS's reliance on the flawed modeling methodology of the DEIR/DEIS. Rather than conduct a comprehensive analysis of the fundamental project changes in the California Water Fix Project, the RDEIR/SDEIS attempts to bootstrap an analysis of California Water Fix impacts on to modeling that was unique to the abandoned BDCP. The authors thus spend considerable time explaining why the model results are not necessarily accurate, or predictive of actual Project impacts, with the result that the public is asked to take on faith the RDEIR/SDEIS's conclusion of no significant impacts.	purposes of the assessment, the effects of alternatives at the locations assessed are considered representative of the effects of the alternatives in various portions of the Delta as a whole. Thus, although different locations can vary in their instantaneous water quality, effects of the project on water quality at locations assessed are considered representative of the degree and direction of water quality changes at other locations. Four interior Delta locations were assessed, including one in the eastern Delta at Buckley Cove, which provides information regarding the direction of water quality changes in this portion of the Delta. Also, please refer to Master Response 30regarding the assumptions used in the modeling to support the water quality assessment.
2496	4	An example is the discussion of electrical conductivity (EC) impacts for Alternative 4A on pages 4.3-24 through 4.3-26. (footnote 1: The problems with the RDEIR/SDEIS EC analysis are representative of the analysis in other water quality areas of key concern to the City, including bromide, chloride, organic carbon, nitrate and pesticides.) The section starts by attempting to explain the methodology used to estimate electrical conductivity impacts and justify the lead agencies' decision not to model the effects of the Alternative 4A changes, which eliminate habitat restoration actions that affect Delta hydrodynamics, a fundamental factor in the analysis. The result of these shortcuts and omissions is that "the quantitative modeling results presented in this assessment is not entirely predictive of actual effects under Alternative 4A, and the results should be interpreted with caution .... In this assessment the modeling results are described and then in most cases are qualified in light of findings from sensitivity analyses." (p 4.3.4-23.)	Please see Master Response 30 regarding the modeling approach used for the RDEIR/SDEIS and updated for the Final EIR/EIS.
2496	5	Of concern to the City of Stockton regarding adverse effects to the water quality is the failure of the RDEIR/SDEIS to adequately consider the effects of modified in-Delta flow regimes and increased residence time changes associated with the proposed project. For example, it is commonly accepted that flow is a prime driver of the undesirable proliferation of cyanobacteria (e.g. Microcystis) in the Delta. The occurrence and magnitude of this undesirable species is associated with low velocities and increased residence times in the system. While the RDEIR/SDEIS includes new information regarding Microcystis and other harmful aquatic species, the document does not properly link the acknowledged project-related increases in residence times in the Delta to a worsening of the Microcystis problem. The RDEIR/SDEIS should be modified to acknowledge these impacts in the vicinity of the City's drinking water intake. The RDEIRISDEIS then states that model results show the Project will result in an increase in the number and frequency of exceedances of electrical conductivity (EC) water quality objectives. However, the RDEIR/SDEIS downplays the significance of these exceedances, offering vague and noncommittal assurances that "modeling results without restoration areas would be expected to show a lesser effect and are expected to be able to be addressed [in] real time operations, including real time management of the north Delta and south Delta intakes, as well as Head of Old River Barrier management." (pp. 4.3-25 through 4.3-26.) Not only does this statement fail to quantify the actual exceedances, or the degree of any "lesser effect," but the assurance that effects could be "addressed" is not tied to any definable or enforceable mitigation commitment. The RDEIR/SDEIS provides no information about how "real time management" will occur, what type and extent of water quality sampling will occur to verify project effects on EC, the specific actions that Project operators will take, including the time lapse between identification of an exceedance and changes to operations, and the corresponding time lapse between any change in operations resulting from "real time management" and	Regarding the Microcystis assessment and consideration of residence time changes, please see Master Response 14. Also see section 8.1.3.18, Microcystis, in Ch. 8 of the Final EIR/EIS. Also see Master Response 22, for more details about the standards governing the adequacy of mitigation measures. Please see Master Response 30 regarding the modeling approach used for the RDEIR/SDEIS and updated for the Final EIR/S. Please see Master Response 32, Adaptive Management and Monitoring.

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Adaptive management process requires defined management objectives and clearly identified sources of ecological uncertainty that respectively become the basis for, and barriers to, a desired resource management regime (Williams, 2010). Based on those objectives and the identification of uncertainty, resource managers develop hypotheses about the potential resource responses to management actions, and then manage the resource in a way that incorporates explicit assumptions about those expected outcomes for comparison with actual outcomes (Williams *et al.* 2009).

Adaptive management incrementally reduces uncertainty and management risks by improving understanding. The challenge then becomes how to use the flexibility provided by an adaptive management approach in a way that balances gaining knowledge to improve management in the future and achieving the best near-term outcome (Stankey and Allan 2009).

Time Scale of Adaptive Management Program/Implementation and Relationship of Adaptive Management to Real-Time Operations

Adaptive management of the SWP/CVP will consider the multiple different time-scales applicable to CVP/SWP actions. Adaptive management changes to SWP/CVP operations are expected to be implemented on an annual or longer (multi-year) basis.

Under the current BiOps and future operations under California WaterFix, a “real-time operations” (RTO) mechanism will allow for adjustment of water operations, within established conditions, to respond in real time to changing conditions for the purpose of maximizing opportunities to benefit covered fish species. The adaptive management and decision-making processes described here do not apply to these real-time operations because individual decisions have to be made too quickly. However, changing operational criteria in existing BiOps and California WaterFix authorizations through the adaptive management process may affect how real-time operations are implemented.

Evaluation of Effects of Adaptive Management

The outcome of adaptive management will vary based on the information developed as part of the research and implementation aspects of the adaptive management program. The full potential of adjustments made under the adaptive management program cannot be anticipated, and is speculative at this time. However, any adjustments made would require compliance with CEQA, NEPA, ESA, and/or CESA and would be evaluated as proposed for the need for any additional environmental compliance or permitting requirements beyond what is done for the California WaterFix at this time.

Collaborative Science

The program will provide guidance and recommendations on relevant science related to the operations of the CVP and SWP within the Delta to inform implementation of the existing BiOps for the coordinated operations of the SWP and CVP and the 2081b permit for the SWP facilities and operations, as well as for the new biological opinion and 2081b for this proposed project. The collaborative science effort will build on the progress being made by the existing Collaborative Science and Adaptive Management Program (CSAMP) that was established to make recommendations on the science needed to inform implementation of or potential changes to the existing BiOps for the SWP and CVP operations, and proposed alternative management actions. The CSAMP process and its Collaborative Adaptive Management Team (CAMT) rely on the Delta Science Program to coordinate independent peer review of both science proposals and products.

CEQA Conclusion: Demands for supplemental water supplies to offset declines in SWP and CVP allocations will increase, and demand for cross-Delta water transfers will increase, due to reductions in SWP and CVP water deliveries. The reductions in SWP and CVP water deliveries under the No Action Alternative as compared to Existing Conditions would be mainly due to a combination of effects of sea level rise and climate change, increased future upstream and in-Delta water demand or in-basin consumptive use (having priority over SWP and CVP rights) and implementation of Fall X2.

5.3.4.2 Alternative 4A—Dual Conveyance with Modified Pipeline/Tunnel and Intakes 2, 3, and 5 (9,000 cfs; Operational Scenario H)

Facilities construction under Alternative 4A would be identical to that described under Alternative 4. Alternative 4A water conveyance operations would be similar to the range of possible operations for the spring Delta outflow requirements that would occur under Alternative 4 H3 and Alternative 4 H4.

Model simulation results for Alternative 4A ELT are summarized in Tables 5-10 through 5-12. The effects of Alternative 4A at LLT were assessed qualitatively based on the results at ELT. As the LLT model simulations of the Alternative 4A and the No Action Alternative would only differ by climate change and sea level rise effects from their ELT counterparts and given that the climate change and sea level rise assumptions are consistent between the Alternative 4A and the No Action Alternative at both ELT and LLT, the incremental changes between the No Action Alternative and Alternative 4A at LLT are expected to be similar to the ELT.

Modeling for Alternative 4A was conducted for Operational Scenario H3+, a point that generally falls between Scenario H3 and H4 operations, as the initial conveyance facilities operational scenario. As specified in Chapter 3, *Description of Alternatives*, Section 3.6.4 the Delta outflow criteria under Scenario H for Alternative 4A would be determined by the Endangered Species Act and California Endangered Species Act Section 2081 permits, and operations to obtain such outflow would likely be between Scenarios H3 and H4. Modeling results for Scenarios H3 and H4 using the 2015 CALSIM II model are shown in Appendix 5E, *Supplemental Modeling Requested by the State Water Resources Control Board Related to Increased Delta Outflows*, Attachment 1. In addition, following the initial operations, the adaptive management and monitoring program could be used to make long-term changes in initial operations criteria to address uncertainties about spring outflow for longfin smelt and fall outflow for delta smelt, among other species.

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 (see Section 5E.2 of Appendix 5E for additional information on Boundary 1 and Boundary 2). Impacts as a result of operations within this range would be consistent with the impacts discussed for the alternatives considered in this EIR/EIS. As shown in Appendix 5F, water supply modeling results for H3+ are within the range of results for Scenarios H3 and H4, and are consistent with the impacts discussed in the Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement. The following analysis of Alternative 4A impacts reflects modeling results of Operational Scenario H3+.

In the following impact analysis No Action Alternative and Alternative 4A refer to both at ELT and LLT, unless specified.

Bromide

Bromide concentrations at a particular location and time in the Delta are determined primarily by the sources of water to that location, at a given time. Hence, long-term average concentrations at a particular Delta location are determined primarily by the long-term average sources of water to that location, and the long-term average concentration of bromide in each of the major source waters to the location. The major source waters to any given Delta location are: (1) Sacramento River, (2) San Joaquin River, (3) Bay water, (4) eastside tributaries, and (5) agricultural return water.

Bromide is not routinely monitored in surface water samples collected north of the Delta, primarily due to the low concentration of bromide in this region. Data available for the American River suggests that bromide concentrations are <10 μg/L. Table 8-43 provides a summary of bromide concentrations in the primary source waters of the Delta, as well as information on the source of the data and summary statistics. Due to the quality and quantity of data available, as well as the conservative nature of the constituent, a quantitative assessment utilizing a mass-balance approach was employed in the assessment of alternatives. Additionally, results of a second modeling approach utilizing EC to chloride and chloride to bromide relationships were used to supplement the results of the mass-balance approach (see Section 8.3.1.3, *Plan Area*). Because bromide is a precursor to the formation of DBPs which represent a long-term risk to human health, and because the existing source water quality goal is based on a running annual average, the quantitative assessment focuses on the degree to which an alternative may result in change in long-term average bromide concentrations at various locations throughout the affected environment. For municipal intakes located in the Delta interior, assessment locations at Contra Costa Pumping Plant No.1 and Rock Slough are taken as representative of Contra Costa's intakes at Rock Slough, Old River and Victoria Canal, and the assessment location at Buckley Cove is taken as representative of the City of Stockton's intake on the San Joaquin River. Municipal intakes at Mallard Slough, City of Antioch, and the North Bay Aqueduct are represented by their respective assessment locations. For the purposes of this assessment, bromide concentrations for water transported into the SWP/CVP Export Service Areas are assessed based on concentrations at the primary SWP and CVP Delta export locations (i.e., Banks and Jones pumping plants).

As demonstrated in Table 8-43, achieving the CALFED goal of 50 μg/L bromide at drinking water intakes is challenged by the bromide concentrations in two main source waters to the Delta, the San Joaquin River and San Francisco Bay (seawater), where long-term average concentrations exceed this goal many fold. In establishing its source water goal for bromide, CALFED assumed more stringent DBP criteria for treated drinking water than are currently in place. Source water with bromide between 100 μg/L and 300 μg/L is believed sufficient to meet currently established drinking water criteria for DBPs, depending on the amount of *Giardia* inactivation required (California Urban Water Agencies 1998, ES2). This assessment of alternatives evaluates how each alternative would affect the frequency with which predicted future bromide concentrations would exceed 50 μg/L (based directly on the CALFED goal) and 100 μg/L (based on the lower limit of the range considered sufficient for meeting currently established drinking water criteria) on a long-term average basis at the assessment locations. Because, in many cases, existing bromide concentrations in Delta water bodies already exceed 50 μg/L, the focus of the assessment is on the frequency with which bromide would exceed 100 μg/L, as well as the change in long-term average bromide concentration.