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Attorneys for **SAN JOAQUIN TRIBUTARIES AUTHORITY**

BEFORE THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

IN THE MATTER OF

CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLATION PETITION FOR WATER RIGHT CHANGE RE: CALIFORNIA WATERFIX.	**TESTIMONY OF SUSAN PAULSEN (San Joaquin Tributaries Authority (SJTA) Case in Chief, Part 2, EXHIBIT 304 Errata)**

QUALIFICATIONS

1. 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.

2. I currently am a Principal and Director of the Environmental and Earth Sciences practice of Exponent, Inc. ("Exponent"). Prior to that, I was employed by 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.

3. 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) using source water fingerprints. I also directed model studies to use chemical source fingerprinting to validate volumetric fingerprinting simulations using Delta models (including the Fischer Delta Model (FDM) and the Delta Simulation Model (DSM)). 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.

4. A copy of my curriculum *vitae* is included as Exhibit SJTA-307.

SUMMARY OF TESTIMONY

5. I was retained by the San Joaquin Tributaries Authority (SJTA) to assist with the evaluation of the California WaterFix Project (WaterFix). The SJTA requested that I evaluate the fate of San Joaquin River water that flows into the Delta for both existing conditions and for one of the WaterFix project scenarios, with a focus on critical, dry, and below normal water year (WY) types. My analysis and testimony can be summarized as follows.

6. Opinion 1: In below normal, dry and critical water years, very little of the San Joaquin River water that enters the Delta between February 1 and June 30 flows to San Francisco Bay as Delta outflow. Most San Joaquin River water that enters the Delta during this time period is either consumed within or diverted / exported from the Delta.

7. Opinion 2: The WaterFix operations show that in dry and critical water years, a large fraction of the water exported from the Delta continues to be exported by the CVP/SWP pumps in the south Delta.

METHODS

8. As described in Antioch-202 Errata Section 3.1, the DSM2 model can be used to perform “volumetric fingerprinting” to track inflows to the Delta throughout the model domain. Exponent used volumetric fingerprinting to “tag” San Joaquin River inflows to the Delta, to determine the

source of water within the Delta, and to determine the fraction of San Joaquin River inflows that exit the Delta as Delta outflow (i.e., that exit the model domain at the western boundary). Because the model input and output files provided to the public by the Department of Water Resources (DWR) did not include volumetric fingerprinting results to address the questions asked by the SJTA, Exponent used the DSM2 modules HYDRO and QUAL, together with the model input files provided by DWR, to perform fingerprinting analyses. Exponent simulated the fate of San Joaquin River inflows in the Delta for the existing condition scenario (EBC2) and for the H4 Project scenario.[1] These two scenarios were chosen to compare the fate of San Joaquin River water under present-day conditions to the future WaterFix scenario most similar to the preferred alternative as described in the Biological Opinions (BiOps) and WaterFix Final Environmental Impact Report/ Environmental Impact Statement.[2]

9. The San Joaquin River inflow at Vernalis between February 1 and June 30 of each year (“February-June San Joaquin River inflow”) was tagged to evaluate its fate in the Delta. (Modeled San Joaquin River flows into the Delta continued before and after this time period but were not tagged.) The volumetric fingerprinting results from the DSM2 model were used to track the tagged San Joaquin River inflow exported at Jones Pumping Plant (Central Valley Project, or CVP) and Clifton Court Forebay (State Water Project, or SWP); diverted at Rock Slough (CCWD); and exiting the Delta at Martinez (Delta outflow) by the end of each water year (September 30). San Joaquin River water that did not exit the Delta via these four pathways was assumed to remain in the Delta or to have been diverted to satisfy in-Delta consumptive use.

10. In addition, we tabulated the percentage of San Joaquin River water that entered the Delta throughout each WY (not just during the period of February 1 to June 30) that was exported by the CVP. This work was performed using existing DSM2 fingerprinting results generated by DWR during Part 1 of the WaterFix change petition proceedings (acquired May 2016).

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[1] The EBC2 model run was released by DWR with the March 2013 Revised Administrative Draft BDCP. In my opinion, EBC2 is the model run most representative of existing conditions in the Delta, as it includes Fall X2, which is a requirement under the 2008 USFWS biological opinion (BiOp). See Antioch-202 Errata section 6.1 for additional information.

[2] WaterFix scenario H4 was chosen over H3 because the preferred alternative (Alternative 4A) and H4 include additional spring outflow, whereas WaterFix scenario H3 does not.

TESTIMONY

Opinion 1

In below normal, dry and critical water years, very little of the San Joaquin River water that enters the Delta between February 1 and June 30 flows to San Francisco Bay as Delta outflow. Most San Joaquin River water that enters the Delta during this time period is either consumed within or diverted / exported from the Delta.

11. I was asked to evaluate the fate of San Joaquin River water during critical, dry, and below normal water year types. The results of the fingerprinting analysis are presented for each critical, dry, and below normal water year in the 16-year modeled period (WY 1976-1991) in SJTA-306. For reference, SJTA-306 also presents the total annual volume of water (all sources) exported or diverted during critical, dry, and below normal water years.

12. An example of the fingerprinting results for scenario H4 is shown in Figure 1a, which presents mean daily San Joaquin River inflows between February 1 and June 30, 1977 (a critical WY), and the mean daily exports from the CVP and SWP, diversions by CCWD, and Delta outflow. The cumulative totals of these inflows, exports, and diversions are shown in Figure 1b, and the cumulative percentages are shown in Figure 1c. In this analysis, San Joaquin River water entering the Delta after June 30 was not tagged and tracked in the model, such that the "SJR Inflow" appears to drop to zero at the end of June in Figure 1a, and "SJR Inflow" and "SJR Export (Sum)" reach a horizontal asymptote in Figure 1b. [Note that the model included San Joaquin River inflows to the Delta before and after this period, but those flows were not tracked within the model. Model results after June 30 are shaded to indicate that the tracking of San Joaquin River inflows stopped after this date.]

13. Figures 2a, 2b, and 2c show results for Scenario H4 for 1985 (a dry year), and Figures 3a, 3b, and 3c show results for Scenario H4 for 1979 (a below normal year). Results for these three years are also summarized in Table 1. Similar figures were prepared for each critical, dry, and below normal year in the 16-year model period for both scenario H4 and the existing conditions scenario (EBC2), and are included in SJTA-306. Figures 1a, 1b, and 1c as well as similar figures in SJTA-306, show that San Joaquin River inflows begin to be exported by the CVP and/or the SWP

within days after they enter the Delta. In addition, these figures indicate that very little San Joaquin River water that enters the Delta between February 1 and June 30 leaves the Delta as Delta outflow during critical, dry, and below normal water years.

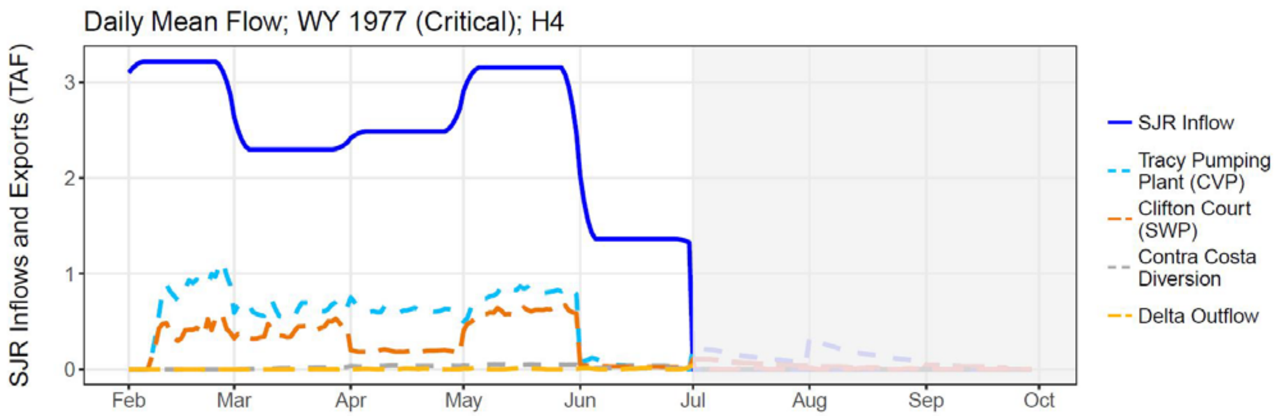

Figure 1a. Mean daily San Joaquin River inflow volume for February 1 to June 30, 1977 (critical WY), and the mean daily volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

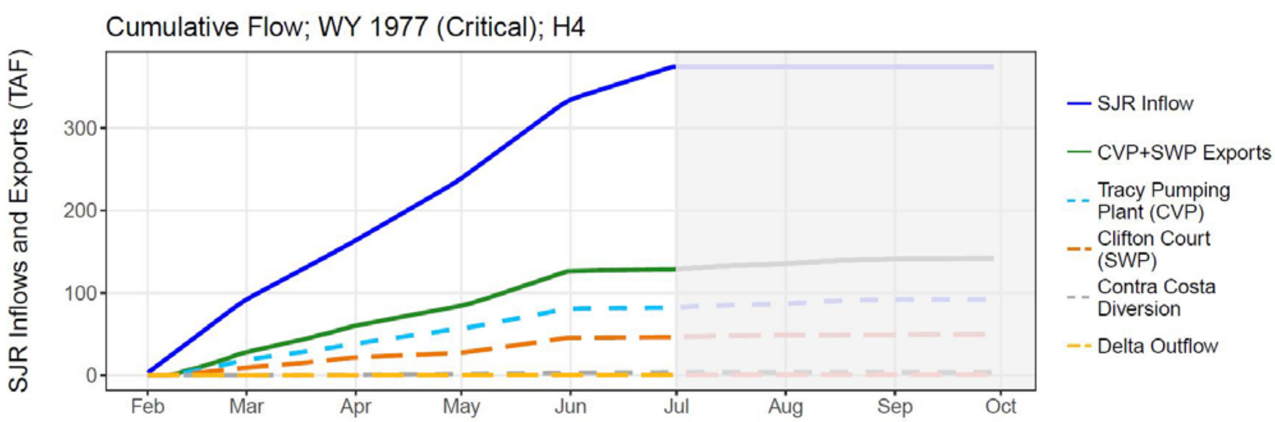

Figure 1b. Cumulative San Joaquin River inflow volume for February 1 to June 30, 1977 (critical WY), and the cumulative volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

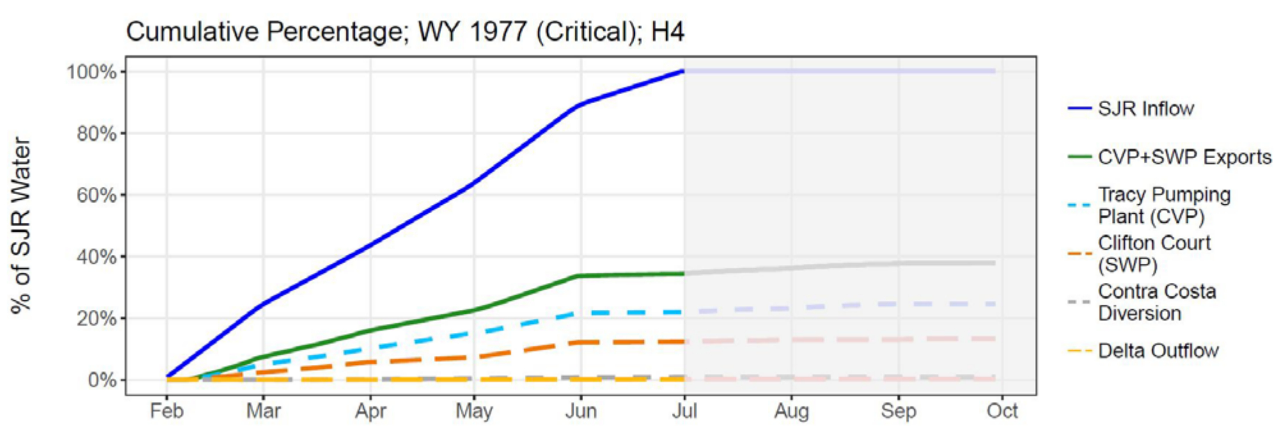

Figure 1c. Cumulative percentage of San Joaquin River inflow volume for February 1 to June 30, 1977 (critical WY), and the cumulative percentage of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

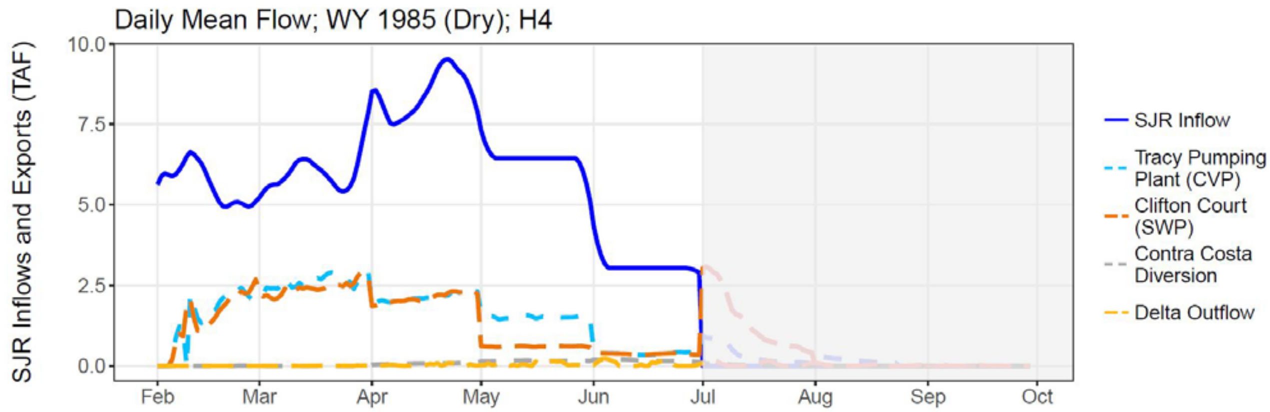

Figure 2a. Mean daily San Joaquin River inflow volume for February 1 to June 30, 1985 (dry WY), and the mean daily volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

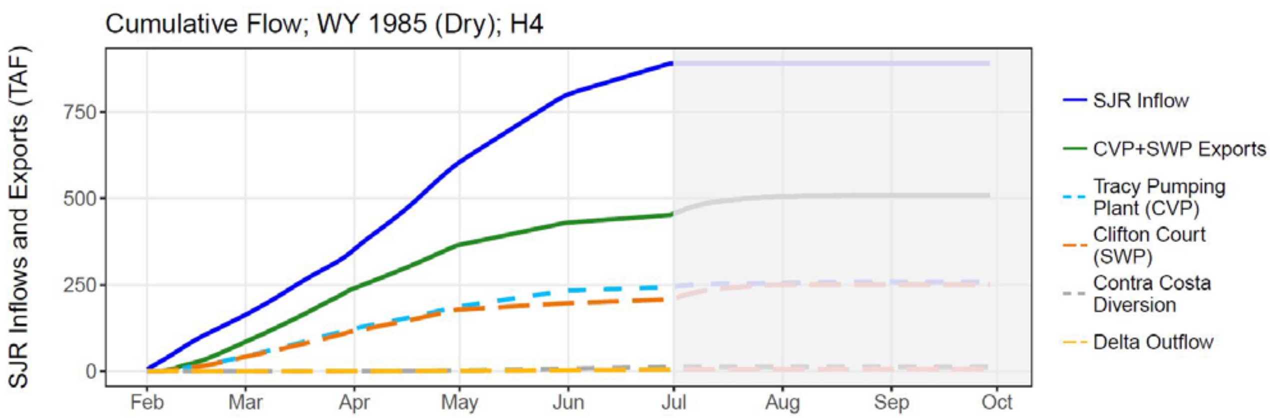

Figure 2b. Cumulative San Joaquin River inflow volume for February 1 to June 30, 1985 (dry WY), and the cumulative volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

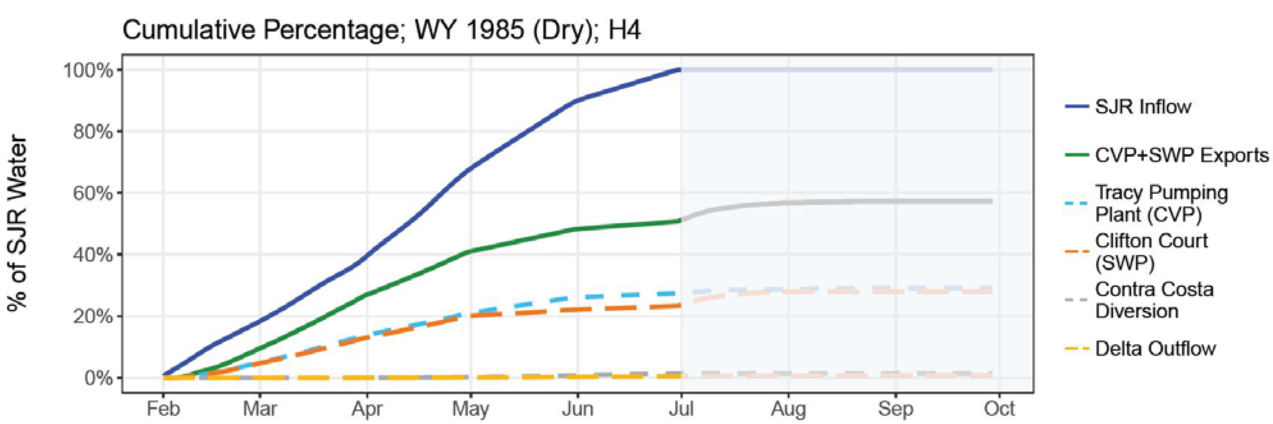

Figure 2c. Cumulative percentage of San Joaquin River inflow volume for February 1 to June 30, 1985 (dry WY), and the cumulative percentage of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

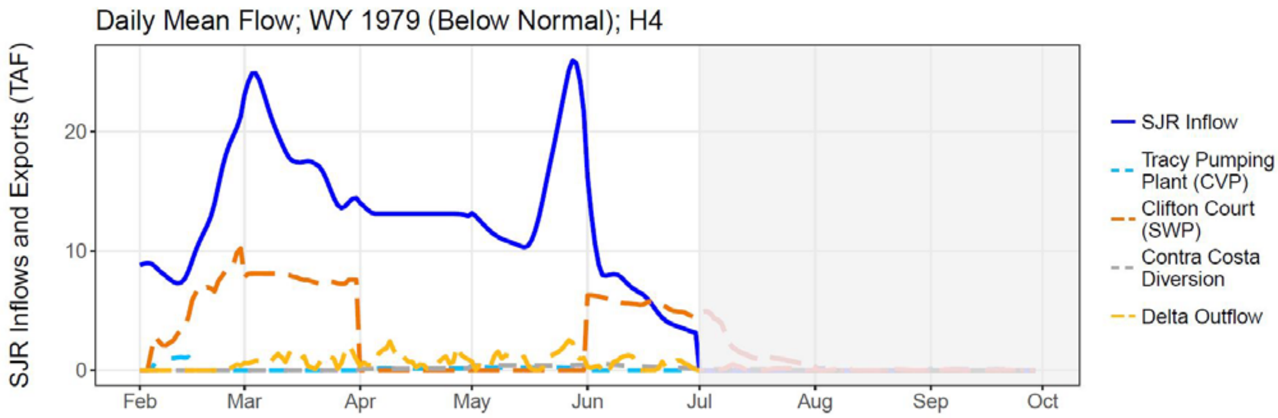

Figure 3a. Mean daily San Joaquin River inflow volume for February 1 to June 30, 1979 (below normal WY), and the mean daily volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

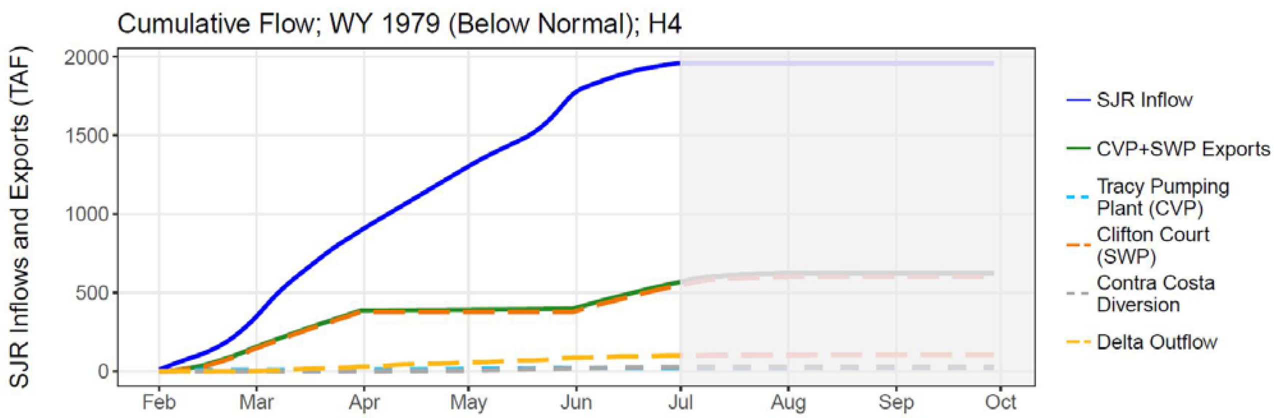

Figure 3b. Cumulative San Joaquin River inflow volume for February 1 to June 30, 1979 (below normal WY), and the cumulative volume of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

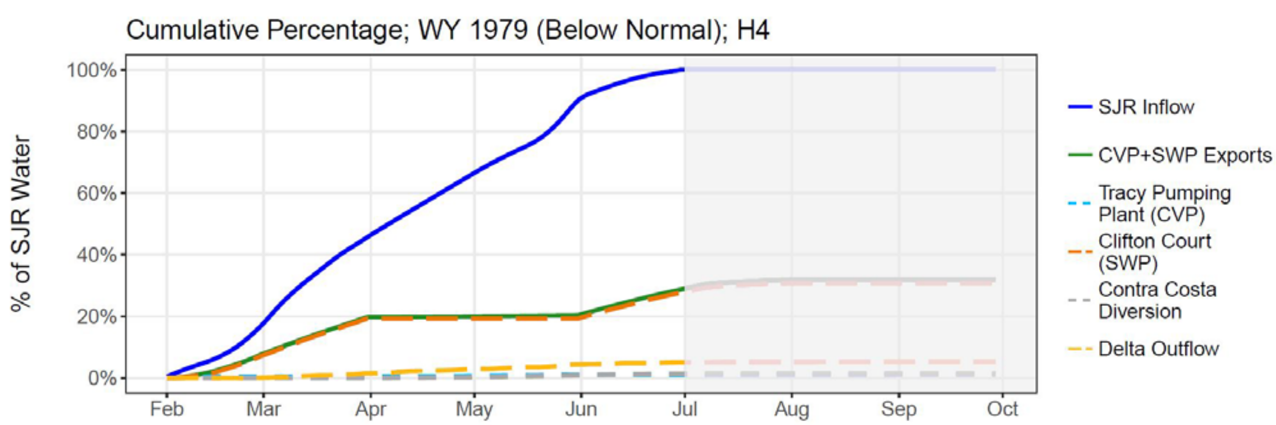

Figure 3c. Cumulative percentage of San Joaquin River inflow volume for February 1 to June 30, 1979 (below normal WY), and the cumulative percentage of February-June San Joaquin River water exported, diverted, and exiting the Delta as outflow for scenario H4.

14. I chose WY 1977 (critical WY), WY 1985 (dry WY), and WY 1979 (the sole below normal WY in the 16-year modeled period) for a detailed evaluation of the fate of San Joaquin River inflows. During dry and critical water years for both existing conditions and H4 scenarios, less than 1% of the February-June San Joaquin River inflows exit the Delta as Delta outflow. During 1979, the only below normal water year in the 16-year simulation period, 3.1% of San Joaquin River February-June inflows leave the Delta as Delta outflow under existing conditions, and 5.3% of this flow leaves the Delta as outflow under WaterFix Scenario H4 operations.

15. Under existing conditions (EBC2), the CVP and SWP together export 60 percent (in 1979, a below normal WY), 54 percent (in 1977, a critical year), and 77 percent (in 1985, a dry WY) of February-June San Joaquin River inflows. For the WaterFix H4 scenario, the CVP and SWP together export 32 percent (in 1979, a below normal WY), 38 percent (in 1977, a critical year), and 57 percent (1985, a dry WY) of February-June San Joaquin River inflows. The differences in the fraction of February-June San Joaquin River inflows that are exported from the Delta is due to the shift in pumping from the South Delta pumps to the NDD export locations, which export Sacramento River water. For example, for existing conditions in WY 1985, the CVP and SWP pumps together export about 5.3 million acre feet (MAF) of water.[3] Under H4 operations for WY 1985, the CVP and SWP pumps together export just under 2.7 MAF, and the NDD exports just less than 1.5 MAF.[4] (See also Opinion 2.)

Table 1. Fate of San Joaquin River water for WY 1979, WY 1985, and WY 1977.[5]

Water Year	Existing Conditions (EBC2): Percent of San Joaquin River water			H4 Scenario: Percent of San Joaquin River water		
	CVP	SWP	Delta Outflow	CVP	SWP	Delta Outflow
1977 (Critical)	39	15	0.1	25	13	0.3
1985 (Dry)	39	38	0.4	29	28	1
1979 (Below normal)	28	32	3.1	1	31	5.3

[3] SJTA-306, p. 40.
[4] SJTA-306, p. 85.
[5] The data presented in Table 1 were summarized from SJTA-306, pp. 37, 38, 40, 82, 83, and 85.

16. The model results also show that under existing conditions, almost 40 percent[6] of CVP exports are from San Joaquin River inflows during dry and critical water years. Figures 4 and 5 show the annual volume of water exported by the CVP as well as the volume of San Joaquin River water exported by the CVP under existing conditions (EBC2) and WaterFix scenario H4.

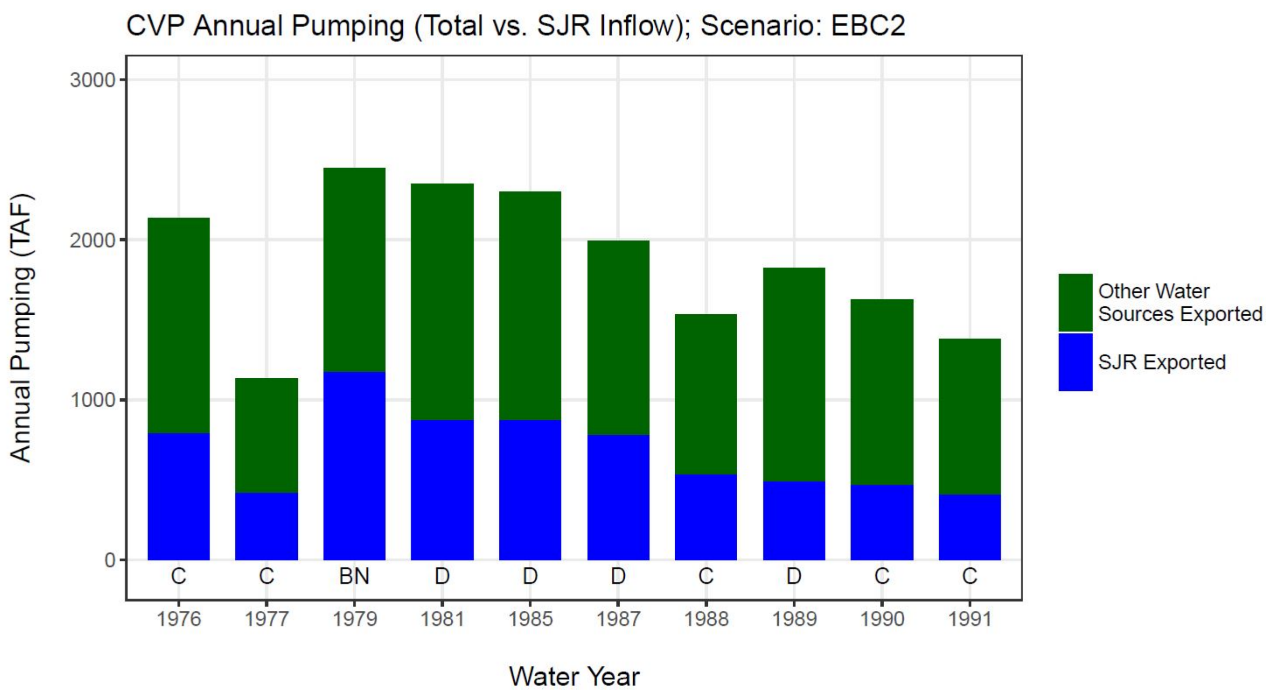

Figure 4. Annual volume of water exported by the CVP (Tracy Pumping Plant) and the volume of San Joaquin River that is exported by the CVP for existing conditions. The water year type is indicated in text below each bar.

[6] The average percent of San Joaquin River water exported by the CVP was calculated as an average of all dry water years (1981, 1985, 1987 and 1989) and critical water years (1976, 1977, 1988, 1990, and 1991).

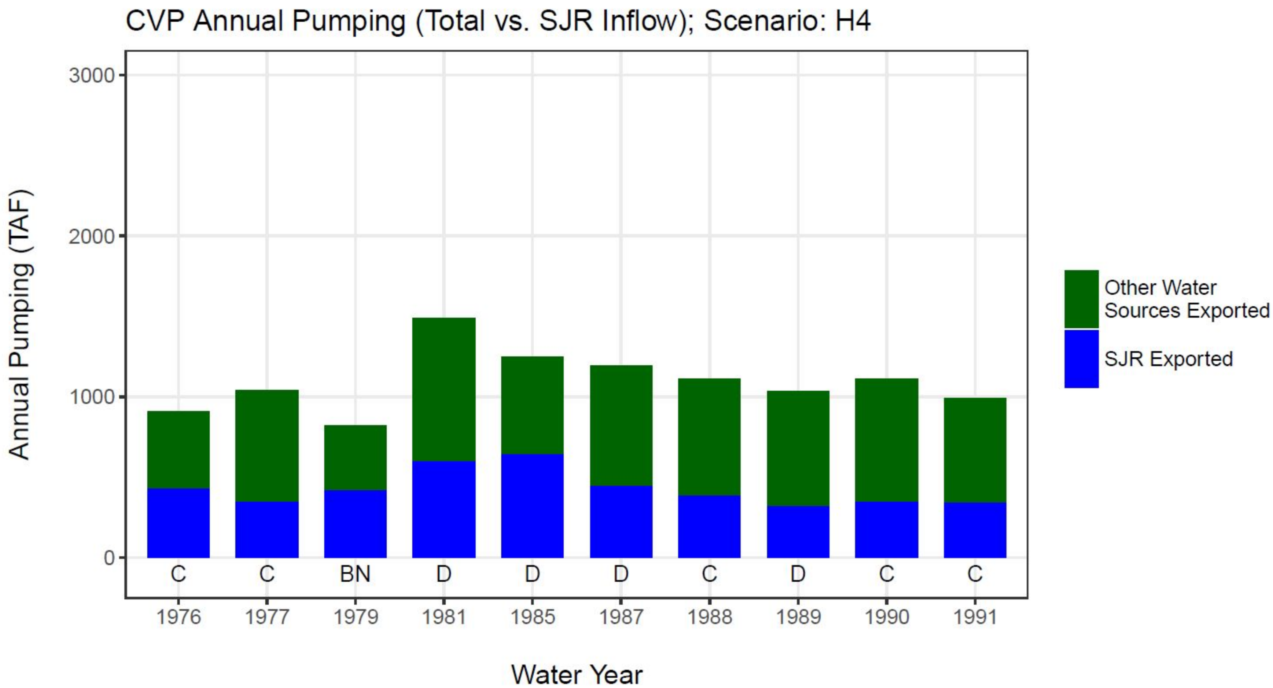

Figure 5. Annual volume of water exported by the CVP (Tracy Pumping Plant) and the volume of San Joaquin River that is exported by the CVP for the H4 scenario. The water year type is indicated in text below each bar.

OPINION 2

The WaterFix operations show that in dry and critical water years, a large fraction of the water exported from the Delta continues to be exported by the CVP/SWP pumps in the south Delta.

17. As shown in Opinion 1, in critical, dry, and below normal years, nearly all February-June San Joaquin River inflows to the Delta are either exported by the CVP and SWP or diverted for consumptive use within the Delta. This conclusion holds for both existing conditions (EBC2) and WaterFix operations scenarios (as illustrated by H4). Note that critical, dry, and below normal water year types comprise 54 % of the historic record (1906-2016), but 62.5 % of the simulation period of 1976-1991 (10 of 16 years).

18. In WaterFix Scenario H4 and the other WaterFix project scenarios, water is exported from the Sacramento River channel at the three north Delta diversion (NDD) locations, in addition to continuing to be exported from the existing CVP and SWP pumping locations in the south Delta as well. Because the San Joaquin River enters the Delta near the CVP and SWP export locations, a

large fraction of San Joaquin River water flows directly down Old River toward the export pumps. In addition, a portion of the San Joaquin River flow that travels past the head of Old River mixes with other flows in the central Delta and travels via other channels (e.g., Middle River, Victoria Canal) to the CVP and SWP export pumps in the south Delta.

19. Despite the export of Sacramento River water from the north Delta diversion (NDD) locations under the H4 scenario (most similar to the preferred alternative), significant quantities of water continue to be exported from the CVP and SWP pumps in the south Delta. Figures 6a, 6b, and 6c were prepared from DWR's DSM2 model results and show the average rate of water pumped monthly from the south Delta (CVP and SWP) and from the NDD for Scenarios EBC2 and H4 during critical, dry, and below normal water years.

20. Figures 6a, 6b, and 6c show total exports from the CVP and SWP for the existing condition (EBC2) as a green bar.[7] For Scenario H4, the bar is divided into two parts; the yellow part of the bar indicates the rate of water exported from the south Delta pumps (CVP and SWP), while the red part of the bar indicates the rate exported from the NDD. Figures 6a and 6b demonstrate that during dry and critical water years, the CVP/SWP exports typically comprise a majority of the water exported, and CVP/SWP exports are significantly greater than NDD exports in most months. The bars on the right hand side of each figure present the annual average values of the diversion rate during each water year type, and show that on an annual basis, more water is diverted from the CVP and SWP pumping locations in the south Delta than from the NDD during critical and dry water year types. During the sole below normal water year (Figure 6c), the annual average CVP/SWP exports are nearly identical to the NDD exports.

21. In summary, scenario H4, the proposed starting point for WaterFix operations, continues to result in the export of a significant volume of San Joaquin River water during dry and critical water years. Under both existing conditions and WaterFix scenario H4, the south Delta pumps will continue to export a substantial percentage of San Joaquin River water.

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[7] Figures 6a and 6b in Opinion 2 of SJTA-304 presented maximum monthly exports and diversions from the south Delta pumps and the proposed north Delta diversion locations, not average monthly exports and diversions. Figures 6a and 6b were replaced with average monthly values. This is the only change made in this errata document.

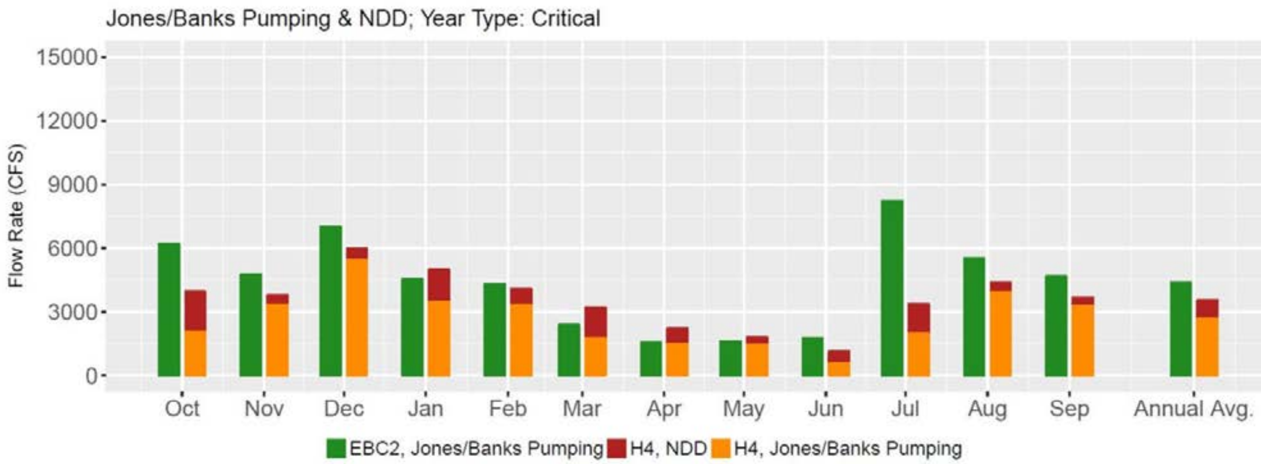

Figure 6a. Simulated monthly pumping totals (in cfs) during critical water years under the existing condition scenario (EBC2) and scenario H4.

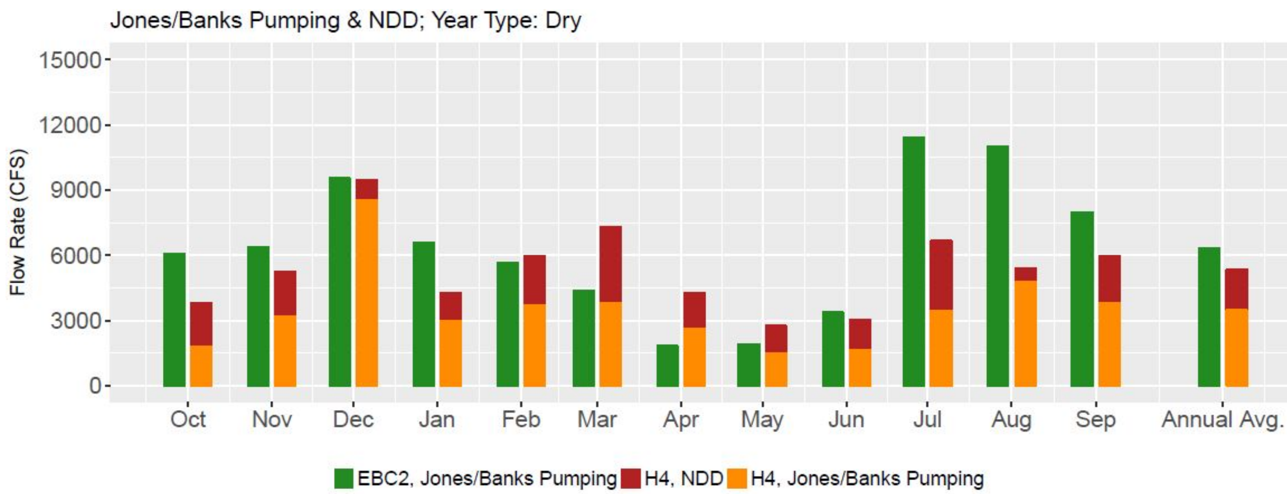

Figure 6b. Simulated monthly pumping totals (in cfs) during dry water years under the existing condition scenario (EBC2) and scenario H4.

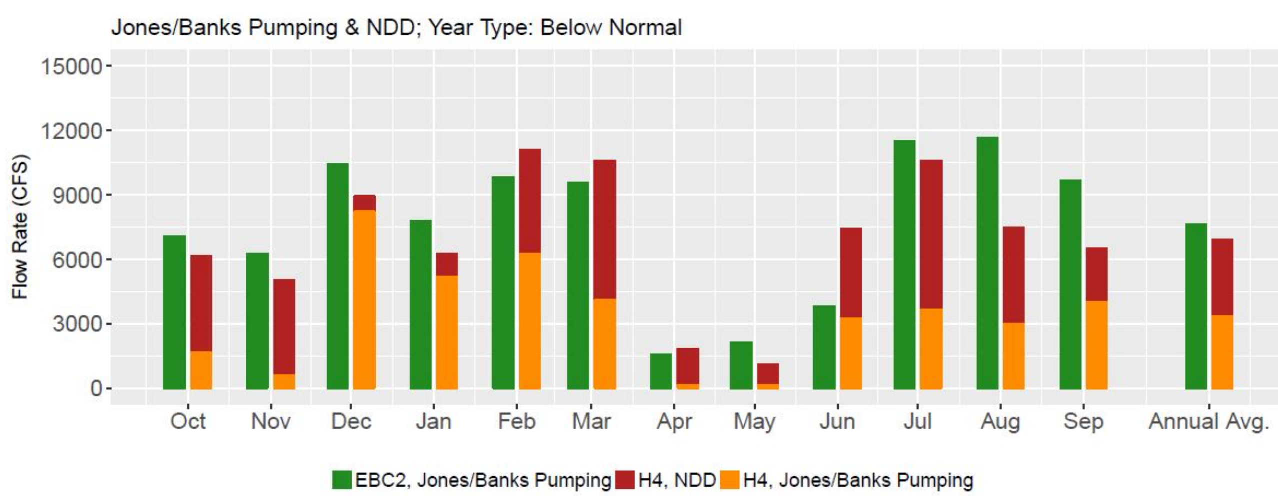

Figure 6c. Simulated monthly pumping totals (in cfs) during below normal (1979) water years under the existing condition scenario (EBC2) and scenario H4.

Executed on March 15, 2018 in Pasadena, CA.

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