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BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATERFIX	PART 2 SUR-REBUTTAL TESTIMONY AND SUMMARY OF TESTIMONY OF DR. RICHARD A. DENTON, PH.D., P.E., SUBMITTED ON BEHALF OF CONTRA COSTA COUNTY, CONTRA COSTA COUNTY WATER AGENCY, AND SOLANO COUNTY

1. Declaration of Qualifications

I, Dr. Richard Denton, declare that I am a Water Resources Consultant and sole-proprietor of Richard Denton and Associates. I have 46 years of experience in the areas of hydraulics and water quality. I received my Bachelor of Engineering (Civil) with First Class Honours in 1972 from the University of Canterbury, Christchurch, New Zealand. I received a Doctor of Philosophy (Ph.D.) in Civil Engineering in 1978 from the University of Canterbury. I am a registered Civil Engineer in the State of California (C47212).

From 1989 to 2006, I was an employee of the Contra Costa Water District ("CCWD"), Concord, California, and served for much of that time as Water Resources Manager. From 1982 to 1989, I was an Assistant Professor in Civil Engineering (Hydraulic and Coastal Engineering) on the faculty of the University of California at Berkeley. During the mid-80s, while at U.C. Berkeley, I prepared four detailed technical reports on the currents and water quality in San Francisco Bay under a contract from the State Water Resources Control Board ("SWRCB").

I have been involved in SWRCB Bay-Delta water right and water quality hearings since 1989. I have extensive experience analyzing Central Valley operations and flow and salinity regimes in the Sacramento-San Joaquin Delta ("Delta"). I provided key input to the environmental review and water rights permitting for CCWD's Los Vaqueros Project and development of the 1994 Bay-Delta Accord. Since 1996, I participated in development and permitting of the Grassland Bypass Project which regulated agricultural runoff and resulted in significant decreases in selenium and salinity loads from the west side of the San Joaquin Valley. I also served as chair of the CALFED Operations and Fish Forum from 2001 to 2006.

In 1995, I received the first annual Hugo B. Fischer Award from the California Water and Environmental Modeling Forum in recognition of my development and innovative application of a salinity-outflow model for the Delta. In 2010, I received a Career Achievement Award from the California Water and Environmental Modeling

Forum.

As a Water Resources Consultant, I assisted CCWD's completion of the environmental permitting of CCWD's Middle River Intake Project and Los Vaqueros Enlargement Project. I am currently assisting Contra Costa County, the Contra Costa County Water Agency, and Solano County on issues related to the California WaterFix Project and efforts to restore the Delta ecosystem and increase California's water supply reliability.

I am the author of 13 academic papers in peer-reviewed journals, 10 papers in conference proceedings and 6 research reports. A copy of my statement of qualifications has been accepted into the hearing record as Exhibit CCC-SC-2.

2. Summary of My Detailed Sur-rebuttal Testimony

My sur-rebuttal testimony is in response to testimony by Dr. Paul Hutton on behalf of the Petitioners regarding long-term trends in Delta outflow and Fall X2 (Exhibit DWR-1224-revised, page 4: DWR-1224-revised, page 12). Dr. Hutton opined that Delta outflow shows no statistically significant long-term annual trend with time and that a long-term increasing trend (i.e., higher salinity) in Fall X2 has not occurred.

Dr. Hutton's initial analysis focused on the time series of historical outflows without taking into account the effects of different water year patterns. My sur-rebuttal testimony presents historical Delta outflow and Fall X2 data as a function of the Sacramento 40-30-30 water year index. (SWRCB-21, page 188.) The data are categorized into four historical time periods: Pre-SWP (1955-1967); Pre-Bay-Delta Accord (1968-1994); Post-Bay-Delta Accord (1995-2008) and Post-Fall X2 limits and the 2008-2009 Biological Opinions (2009-2017.) This presentation of historical Delta outflow and Fall X2 data more clearly shows trends with respect to both time and water year type. After 1994, there was a reduction in Delta outflow in the fall and a corresponding increase in Fall X2.

3. Historical Trends in Delta Outflow

My sur-rebuttal testimony is in response to testimony by Dr. Paul Hutton on behalf of the Petitioners regarding long-term trends in Delta outflow and Fall X2[1].

In his written testimony (DWR-1224-revised, Page 4), Dr. Hutton stated:

> "The 2010 Flow Criteria Report and the Phase II Scientific Basis Report suggest that the magnitude and timing of outflow has changed significantly over time, as evidenced by the difference between calculated unimpaired outflows and actual outflows."

On page 12 of his written testimony (DWR-1224-revised), Dr. Hutton further stated:

> "Both the 2010 Flow Criteria Report and the Phase II Scientific Basis Report propose a fall X2 requirement that is fully consistent with the USFWS 2008 Biological Opinion. To place the fall X2 trends presented in my testimony in proper context, it is important to recognize that these trends have not been influenced by the 2008 Biological Opinion's fall X2 actions."

In Part 2 Rebuttal, Dr. Hutton presented his opinions on long-term Delta outflow annual and seasonal trends and on the hydrology-based rationale for Fall X2 (September, October, and November).

Dr. Hutton opined that (DWR-1224-revised, page 4, line 8):

- "Delta outflow shows no statistically significant volumetric long-term annual time trend.
- Data outflow shows statistically significant increasing and decreasing volumetric long-term seasonal time trends.
- A long-term increasing trend (i.e., higher salinity) in fall X2 has not occurred.

[1] X2 is a measure of the distance of the 2 parts per thousand isohaline in the San Francisco Bay and Delta from the Golden Gate Bridge. This is currently determined by the location of the 2,640 µS/cm EC or from an equation for X2 as a function of antecedent Delta outflow. X2, also known as the estuarine habitat standard was adopted by the SWRCB in the May 1995 Bay-Delta WQCP (SWRCB-30.)

- Long-term trends in fall X2 can be attributed to multiple drivers.
- Under natural conditions, Delta salinity was more seasonally variable than under contemporary conditions, with more downstream X2 in winter and spring and more upstream X2 in summer and fall."

3.1 Accounting for Water Year Runoff

Dr. Hutton's initial analysis focused on the time series of historical outflows without taking into account the effects of different water year runoff patterns (Figures 2 and 3, DWR-1224-revised.)

However, the variation of Delta outflow and Fall X2 will depend heavily on the particular sequence of water year types. Figure 6 of Dr. Hutton's testimony (DWR-1224-revised, page 14) shows there was a cluster of critical and dry years prior to 1995 and a series of wet years from 1995 on. From 1987 through 1994, there were five critical years and two dry years. (Exhibit CCC-SC-72[2]; Exhibit DWR-552, CDEC Water Supply Index.) Starting with 1995, there were five wet years followed by an above normal year.

This particular pattern of drier years followed by a series of wetter years will result in reduced Delta outflows for a period (increased Fall X2) and then a prolonged period of higher Delta outflows (decreased Fall X2).

Plotting these historical data as a function of the Sacramento Valley water year type, also known as the 40-30-30 index, specifically addresses the effect of water year types on the historical trends in Delta outflow or Fall X2[3]. Dr. Hutton's treatment of the historical data by use of time series ignores the effect.

This approach utilizing the 40-30-30 index was used in my Part 2 direct testimony to demonstrate the degradation of water quality in the Delta in the fall after 1994. (Exhibit CCC-SC-7.) In that exhibit, Jersey Point monthly-averaged EC data for the months of October and November were plotted as a function of the 40-30-30 water year

[2] Exhibit CCC-SC-72 is a true and correct copy.

[3] The Eight River Index could also be used but the 40-30-30 index represents the majority of flow entering the Delta and is used in D-1641 to determine Delta operations.

index.

Dr. Hutton did use a similar approach with Figures 14, 15, and 16 in DWR-1224-revised, but the Fall X2 data were plotted as a function of April-July Unimpaired Runoff and not the full 40-30-30 index. The 40-30-30 index is calculated as 40% of the April-July runoff, 30% of the October-March runoff and 30% of the previous water year's 40-30-30 index. (SWRCB-21, page 188.) The latter 30% accounts for water carried over from the previous year in storage being available to the SWP and CVP operators. The Delta is operated based on water year types and carryover water in storage is important for meeting flow and water quality objectives in the next year. Using just the April-July runoff will not fully capture how flows and salinities will vary in a managed estuary.

Figure 1 in Exhibit CCC-SC-72 shows the relationship between reconstructed historical Sacramento Valley April-July runoff and the Sacramento 40-30-30 index for water years 1906-2016. These data were downloaded from DWR's CDEC website and are the same data shown in DWR-552, but extended through 2017. (Exhibit CCC-SC-72). The data are correlated as expected (linear regression r-squared = 0.76), but there is still a great deal of variation. For example, for a 40-30-30 index of 10.5, the April-July runoff ranges from 4 to 10 MAF.

3.2 Analysis Time Periods

Following the approach taken by Enright and Culberson (2009) (Exhibit DWR-1381), Dr. Hutton analyzed the historical data record according to two subintervals, a pre-WY 1968 subinterval and a post-WY 1968 subinterval. However, this does not capture other changes in SWRCB flow and water quality standards that may also affect CVP and SWP operations and Delta outflow and Fall X2 in particular.

After negotiation of the December 15, 1994 Bay-Delta Accord and the May 1995 Bay-Delta Water Quality Control Plan (WQCP) (SWRCB-30), DWR and Reclamation began operating to a new February-June estuarine habitat standard, also referred to as Spring X2. One might therefore expect a change in the location of X2 in the Spring after

1995. There may also be changes in subsequent months as the CVP and SWP tried to make up any export losses due to the 1995 WQCP.

In December 2008, the U.S. Fish and Wildlife Service issued a Biological Opinion for the Proposed Coordinated Operations of the CVP and SWP. (Exhibit SWRCB-87.) In June 2009, the National Marine Fisheries Service also issued a Biological Opinion on the Long-Term Operations of the CVP and SWP. (Exhibit SWRCB-84.) These biological opinions introduced new operating criteria, including Fall X2, that affected project operations.

I therefore subdivided the available historical outflow and Fall X2 data into the following periods of interest: 1955-1967, 1968-1994, 1995-2008, and 2008-2017. Note that because the data set was for October 1955 through September 2017, the October-December data start in 1955 and end in 2016 but January-September data start in 1956 and end in 2017.

The Fall X2 limit currently applies only in wet and above normal years. As noted by Dr. Hutton (DWR-1224-revised, page 12), there have only been two wet years since 2008 (2011 and 2017) and no above normal years. The Fall X2 action was partially adjusted in 2011 in response to a federal court order and modified criteria, although it was ultimately met without changing operations.

3.3 Findings regarding Delta Outflow Trends

Figures 1 and 2 in Exhibit CCC-SC-73[4] show the historical monthly-averaged Delta outflow for the months of March and April as a function of the Sacramento 40-30-30[5] water year index for the period 1956-2017. The data are categorized into four historical periods: Pre-SWP (1956-1967); Pre-Bay-Delta Accord (1968-1994); Post-Accord (1995-2008); and Post-2008-2009 Biological Opinions (2009-2017). The outflow

[4] Exhibit CCC-SC-73 is a true and correct copy.
[5] The water year controlling operations in these graphs is assumed to change on January 1.

data are from DWR's Dayflow[6] data set (SWRCB-67). The Dayflow data set includes X2 values calculated using the daily Kimmerer-Monismith equation (DWR-1261.)

As expected Delta outflows are higher in wetter years than in drier years, but there is no significant difference between the four time periods. This is surprising because the February-June estuarine habitat standard (Spring X2) developed in 1994 was intended to restore Delta outflows and salinity conditions in the western Delta to those occurring from 1968-1975. The March and April plots do not show any distinct improvement from pre-1995 to post-1995 conditions.

By way of comparison, Figure 6 in Exhibit CCC-SC-73 shows the historical monthly-averaged Delta outflow for the month of February as a percentage of estimated unimpaired Delta outflow. These outflow percentages are plotted as a function of time for the period 1955-2014. The data are again categorized into four periods: 1955-1967; 1968-1994, 1995-2008; 2009-2014. The unimpaired flow data are from DWR's March 2016 report: "Estimates of Natural and Unimpaired Flows for the Central Valley of California: Water Years 1922-2014" (Exhibit CCC-SC-75[7].)

The percentages of unimpaired outflow do appear to decrease with time after the SWP came on line (post-1968). There is an increase in February outflow as a percentage of unimpaired flow after the Bay-Delta Accord but that was also a prolonged wet period (i.e., 1995-1999 were all wet years.) Data plotted in this form is useful when considering the SWRCB's proposal to set new January-June Delta outflow requirements as a function of unimpaired flow. However, these plots can be confusing because percentages will be high during very wet periods because exports will be much less than the very high unimpaired Delta inflow, but the percentages can also be high during drier periods when unimpaired flow is low if Delta exports are very small. Figure 6 does not distinguish between these two very different cases.

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[6] https://water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data

[7] Exhibit CCC-SC-75 is a true and correct copy of extracted pages from the March 2016 draft report.

Figures 3, 4 and 5 in Exhibit CCC-SC-73 show the historical monthly-averaged Delta outflow for the months of September, October and November as a function of the Sacramento 40-30-30 water year index for the period 1955-2016. The outflows for the period after the Bay-Delta Accord (1995 on) during wetter years are very low and much lower than in previous wet and above normal years.

These low Delta outflows are consistent with those simulated for the WaterFix Boundary 1 scenario. The Boundary 1 scenario did not include Fall X2. As was shown in Figure 2 of CCC-SC-56-errata, the simulated outflows in September for Boundary 1 were typically only the bare D-1641 minimum of 3,000 cfs.

The substantial reduction in outflows in the fall since 1995 is not readily apparent by just plotting outflow data as a function of time.

4. <u>Historical Trends in Fall X2</u>

Figures 1, 2 and 4 in Exhibit CCC-SC-74[8] show the historical monthly-averaged X2 data for the months of September, October and November, respectively, as a function of the Sacramento 40-30-30 water year index for the period 1955-2016. The data are categorized into four historical periods: Pre-SWP (1956-1967); Pre-Bay-Delta Accord (1968-1994), Post Accord (1995-2008); Post 2008-2009 Biological Opinions (2009-2017).

The period after 1994 is again significantly different than the early trend in X2 as a function of water year index. X2 values after 1994 during above normal and wet years are much higher and are more consistent with Fall X2 values in drier historical years.

The plot of October X2 in Figure 2 does suggest that X2 for 1955-1967 in below normal years were lower than in later years but this may not be a significant trend.

Figure 3 (Exhibit CCC-SC-74) again shows the October X2 data but compares these data with the current Fall X2 limits of 74 km in wet years and 81 km in above normal years. The Fall X2 limits from the USFWS 2008 Biological Opinion (SWRCB-87)

[8] Exhibit CCC-SC-74 is a true and correct copy

and SWRCB Delta Flow Criteria Report (SWRCB-25) are consistent with historical trends prior to 1994 and will help to restore fall salinities back to pre-1994 conditions.

Figure 6 (Exhibit CCC-SC-74) shows the October X2 data plotted as a function of Sacramento April-July unimpaired runoff. This was how Dr. Hutton plotted fall X2 data in Figures 12-14 of DWR-1224-revised. There is some redistribution of the data but the general finding of higher X2 since 1995 still holds.

5. Trends in Delta Outflow from CWF Modeling

The WaterFix modeling studies show similar trends when the simulation data are plotted as a function of the Sacramento 40-30-30 water year index. WaterFix modeling studies without the Fall X2 limits suggest that the project would operate to very low Delta outflows in the fall in wet and above normal years if there are no Fall X2 limits. This would result in correspondingly high values of Fall X2 in the fall months.

Figure 1 in Exhibit CCC-SC-76[9] shows simulated monthly Delta outflows for the month of October as a function of the Sacramento 40-30-30 water year index for the period 1921-2002. The Delta outflows for the Boundary 1 scenario, which has no Fall X2 limits, are typically only 4,000 cfs (the D-1641 minimum outflow) in wet and above normal years. These October outflow data are similar to the historical Post-1995 outflow data in Figure 4 of Exhibit CCC-SC-73.

The corresponding October outflows for the adopted WaterFix project (CWF H3+) and the Boundary 2 scenario are much higher in wet and above normal years in order to comply with minimum Fall X2 objectives of 74 and 81 km, respectively.

6. Conclusions

Contrary to Dr. Hutton's findings, plots of Delta outflow as a function of water year index for different historical time periods do exhibit certain trends over time, particularly in the fall. Delta outflows in September, October and November did reduce

[9] Exhibit CCC-SC-76 is a true and correct copy.

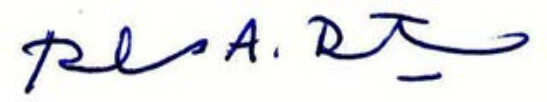
substantially after development of the February-June estuarine habitat objective (Spring X2). This appears to be an unintended consequence of trying to restore and sustain the Delta ecosystem in the Spring while not providing corresponding protections for the summer and fall.

Curiously, the outflows in the period the Spring X2 objective was designed to address did not improve significantly after 1995.

The reductions in outflow in the fall after 1995 resulted in corresponding increases in Fall X2. The X2 values in September, October and November were much larger than the prior historical trend and much higher than the Fall X2 limits for wet and above normal years that were introduced in 2008.

The plots of X2 as a function of water year index do show that an increasing trend (i.e. higher salinity) in fall X2 did occur during the 14-year period (1995-2008.) Since that time there have only been two wet years and no above normal years so the effect of the Fall X2 limits on this trend has not been tested.

Executed on this 20th day of September, 2018, in Oakland, California.



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Richard A. Denton, Ph.D., P.E.