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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 WATER FIX	TESTIMONY OF PARVIZ NADER-TEHRANI

I, Parviz Nader-Tehrani, do hereby declare:

I. INTRODUCTION

I am a supervising Engineer. I am employed by the Department of Water Resources (DWR). I received a Bachelor of Science degree in Civil Engineering from California State University in Fresno (1981), a Master of Science degree (1985) and PhD (1989) in Civil Engineering from UC Davis. I am a registered Civil Engineer in the State of California. I have over 26 years of experience in numerical modeling in hydrodynamics, water quality, and particle tracking in the Sacramento San Joaquin Delta mostly using DSM2. My duties include directing staff to conduct computer modeling in support of various programs within the DWR and reviewing the computer modeling done by DWR engineers and the consultants in support of the California WaterFix (CWF). A copy of my statement of qualifications has been submitted as Exhibit DWR-26[1].

[1] Exhibit DWR-26 is a true and correct copy of the document.

In my testimony, I explain the water quality model and modeling results based on the analytical framework described in Ms. Pierre's testimony. The boundary analysis provides a range of operational criteria that are sufficiently broad so 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.

More specifically this testimony in conjunction with Mr. Munévar's separate testimony is provided to present the modeling results (CalSim II and DSM2) for the boundary analysis that show the effects on legal users of water with respect to expected changes in water supply, water quality, water levels, and end of September reservoir storage. I rely on testimony provided by Mr. Munévar, specifically the CalSim II output that feeds into the DSM2 model. The focus of my testimony is on possible changes to water quality and water levels. The modeling done in support of the information presented in this testimony was performed by the engineers from CH2M and DWR. The modeling done by CH2M was directed by DWR and I have reviewed the model results. The modeling conducted by DWR was done at my direction. It is my opinion that the modeling results are accurate and consistent with this testimony.

II. OVERVIEW OF TESTIMONY

This testimony provides an overview of the computer modeling performed to evaluate changes in the water quality and water levels associated with the CWF and any possible effects on legal users of water. This 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). Delta Simulation Model (DSM2) is the primary state of the art tool utilized in this analysis. The modeling results are shown in Exhibit DWR-513[2].

The model results comparing the operational scenarios to the No Action Alternative (NAA) show the following with respect to water quality changes:

[2] Exhibit DWR-513 is a true and correct copy of the document.

- The simulated water quality in the Delta is presented in terms of monthly average bar graphs for Electrical Conductivity (EC) and chloride concentration. The water quality is shown to meet the water quality objectives assigned to DWR and Reclamation under D-1641. The water quality results compared to the NAA are varied at locations and show seasonal variations. The water quality results at some locations are better and some are worse as compared to the NAA.
- Operations under D-1641 are modeled in CalSim II. Model results at times show modeling anomalies. A small fraction of these anomalies represent modeled exceedances at some locations.
- Changes in minimum water levels are shown for locations throughout the Delta. (See DWR-513, pp. 11-15, Figures W1-W5). The highest changes to water levels correspond to locations close to the proposed North Delta Diversion (NDD) intakes and can be up to 1.2 ft (during high flows) to 0.5 ft (during low flows). The modeled daily minimum water level for Boundary 1, which results in the most NDD diversions, drops below the lowest water level under the NAA only during 73 days out of the 16 years simulated, which represents less than 5 days in a year. Furthermore, the modeled minimum water levels occur only for a short period of time throughout the day. It is my opinion that there will not be negative effects to legal users of water due to water level changes.

III. DSM2

DSM2 is a one-dimensional hydrodynamic and water quality simulation model used to simulate hydrodynamics and water quality in the Sacramento-San Joaquin Delta. DSM2 represents the best available planning model for Delta tidal hydrodynamics and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental changes caused by future facilities and operations. The DSM2 HYDRO simulates velocities and water surface elevations and its output provides the flow input for QUAL, which is a module that simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO.

All DSM2 model runs (hydrodynamics and water quality) were based on 16 years of record (1976-1991). The years 1976-1991 contain a similar spectrum of year types as those reflected in the 82 years (1922-2003) included in the CalSim II simulations. The DSM2 16-year simulation period has an ample amount of data, provided in 15 minute increments, to look at the finer details of the physical system. The 16-year period contains the driest two-year drought on record and an extended drought period (1987–1991). There is adequate variation of year types and drought periods to evaluate the physical system and the effects of operational and structural changes to that system. (Exhibit DWR-511[3].)

Estimates for all the Delta river inflows and Delta diversions (including SWP/CVP) from CalSim II are used to drive the DSM2-Hydro and QUAL for predicting tidally-based flows, stage, velocity, and salt transport within the estuary. The results from DSM2 are used to inform the understanding of the overall effects of the CWF including changes in water quality and water levels in the Delta.

IV. DELTA WATER QUALITY

The testimony that follows assesses the quantitative changes in water quality as measured by chloride concentration and Electrical Conductivity (EC) based upon a comparison of the DSM2 water quality results for all operational scenarios with the NAA. This allows for an isolation of direct project effects. These data are presented in terms of monthly average bar graphs for locations throughout the Delta. Later testimony will describe whether these data show a modeled exceedance of D-1641. (see Exhibit DWR-513, pp. 5-10, Figures C1-C6.)

In general, H3 and H4 operational scenarios result in very similar water quality results as measured in EC or chloride at most locations, and the EC values are typically (but not always) somewhere in between the results for Boundary 1 and Boundary 2 scenarios. Where these results do not fall within the boundary analysis, I explain why

[3] Exhibit DWR-511 is a true and correct copy of the document.

below. Because Boundary 2 has an operational scenario that results in higher outflow this generally results in lower EC and chloride. It should be noted that Boundary 1 does not include Fall X2 in its operational assumptions, and in general may reflect higher EC results, especially for the months of September through November, and mostly for areas in the Western and Central Delta.

Exhibit DWR-513, Figures EC1- EC4 show the monthly average EC concentrations at Sacramento River at Emmaton, San Joaquin River at Jersey Point, South Fork Mokelumne River at Terminous, and San Joaquin River at San Andreas Landing. D-1641 water quality objectives at these locations are specified April 1 to August 15, with actual EC thresholds varying depending on water year types. CalSim II prioritizes meeting the D-1641 water quality objectives for all scenarios, and therefore it is no surprise that the water quality results for all alternatives at these locations are similar during the period in which the SWP/CVP operate to meet their responsibilities for D-1641. For the months of April through June, the monthly average EC values for all scenarios are very similar to the NAA for all locations shown.

For all scenarios except Boundary 2, in the months of July and August there is an increase in EC at Emmaton of about 18-19 percent when compared to the NAA. (Exhibit DWR-513, p. 1, Figure EC1.) DWR-EC values for Boundary 2 are higher than those for NAA for the month of July by about 5 percent and are lower than those for NAA for the month of August by about 19 percent. (Exhibit DWR-513, p. 1, Figure EC1.)

At Jersey Point (see DWR-513, p. 1, Figure EC2), there is a reduction of EC for the months of July (19%-34%) and August (5%-41%) when compared to the NAA, with Boundary 2 scenario resulting in the lowest EC. At San Andreas Landing (see Exhibit DWR-513, p. 2, Figure EC3), there is a reduction of EC for the months of July (10%-15%) and August (7%-26%) when compared to the NAA, with Boundary 2 scenario resulting in the lowest EC. At Terminous, the EC results are very similar for all alternatives and are well below the D-1641 water quality objectives.

Figure EC5 shows the simulated EC results for Old River at Tracy Road. (Exhibit

DWR-513, p. 3.) The D-1641 South Delta agricultural water quality objective (based on 30-day running average) is 700 EC for the months April through August and 1000 EC for all other months. For all months except March through May, EC results are very similar to those for the NAA. For the months of March through May, Boundary 2 scenario results in higher EC than all alternatives, while all other scenarios result in similar EC compared to the NAA. (Exhibit DWR-513, p. 3.) It is my opinion that the increase in EC for Boundary 2 is most likely due to the assumption that there will be full closure of Head of Old River through the operable gate for the months of March through May.

Figure EC6 shows the simulated EC results for San Joaquin River at Brandt Bridge. At this location the EC results for all scenarios are very similar to the NAA. (Exhibit DWR-513, p. 3.)

V. Delta Water Quality (Chloride)

For chloride, this water quality assessment applies a relationship between EC and chloride that were developed based on historical water quality data to the DSM2 output for EC. This relationship was developed based on data at Mallard Island, Jersey Island, and Old River at Rock Slough. (Exhibit DWR-509.) The relationship was: Cl = max (0.15*EC-12 and 0.285*EC-50). In the equation above, Cl is the chloride concentration in mg/L, and EC is in µS/cm. The chloride regression method was developed using data for the west Delta and is thus valid for that area. (Exhibit DWR-509.) The chloride regression method has not been validated for other areas of the Delta.

Exhibit DWR-513, Figures CL1 to 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.

At Contra Costa Canal the results are mixed. (Exhibit DWR-513, p. 4, Figure CL1.) For Boundary 1, chloride concentrations are higher than those for the NAA for the months of October through March, while for other months the chloride concentrations are similar or lower than the NAA. In fact, for the months of April through May, Boundary 1 results in the lowest chloride concentration among all alternatives. It is my opinion that this is most likely due to the higher negative Old and Middle River (OMR) flows assumed under this scenario. Chloride concentration for alternatives H3 and H4 are similar or lower than the NAA for all months except June. (Exhibit DWR-513, p. 4, Figure CL1.) Chloride concentration for Boundary 2 is similar or lower than the NAA for all months except February through April and June. (Exhibit DWR-513, p. 4, Figure CL1.) Boundary 2 results in the lowest chloride concentration among all scenarios for the months of August through January. (Exhibit DWR-513, p. 4, Figure CL1.) Surprisingly, Boundary 2 results in the highest chloride concentration among all scenarios for the months of March and April. It is my opinion that this is most likely to due to the lower South Delta diversions assumed under this scenario.

There is a relationship between bromides and chlorides and there is a formula that calculates bromides based on chloride concentration. The chloride to bromide relationship is approximately the same in many areas in the Delta, (Contra Costa Water District 1997). (Exhibit DWR-509[4].) The relationship used is Br=0.0035*Cl.

There are three municipal diversion locations where bromides may be of concern. Two of which DWR has contracts that address SWP operations. (Exhibits DWR-303, DWR-310, DWR-304.) The third point is the North Bay Aqueduct at Barker Slough. Based on the chloride results shown in Figure CL-3 which show little to no change in chloride, it is my opinion there will be no change in bromide. (Exhibit DWR-513, p. 5.)

Also I have had my staff review the CCWD agreement for potential water quality changes in the Delta and based on this analysis it is my opinion there would be minimal changes in water quality. (Exhibit- DWR-512[5].)

[4] Exhibit DWR-509 is a true and correct copy of the document.

[5] Exhibit DWR-513 is a true and correct copy of the document.

VI. D-1641 Compliance

As mentioned earlier, D-1641 objectives are implemented in CalSim II, but due to many factors, including the difference in time-step size between the models, DSM2 may show exceedances that are more related to the differences in the assumptions within each model. In addition, the models do not reflect the ability of the SWP/CVP operators to meet those water quality objectives.

Exhibit DWR-513, Figures C1 through C5 show the modeled probability of meeting D-1641 water quality objectives at Emmaton, Jersey Point, San Andreas Landing, Terminous, and Contra Costa Canal. (Exhibit DWR-513, pp. 5-9.) The information shown is based on DSM2 water quality analysis. Based on the model results, in general all scenarios including the NAA meet D-1641 water quality objectives most of the time. The data shows a similar or an increased ability for all operational scenarios (compared to the NAA) to meet D-1641 water quality objectives at all locations except Emmaton. At Emmaton there is only a slightly lower ability to meet D-1641 water quality objectives. At San Andreas Landing (see Exhibit DWR-513, p. 7, Figure C3) all scenarios (except the NAA) meet the D-1641 water quality objectives at all times. At Terminous (see Exhibit DWR-513, p. 8, Figure C4) all scenarios meet the D-1641 water quality objectives at all times.

Exhibit DWR-513, p.10, Figure C6 shows the number of days in a year meeting the 150 mg/l mean daily chloride concentration at the Contra Costa Canal Intake. DSM2 Results indicate that Boundary 2 meets D-1641 water quality objectives for all water years. All other scenarios (including the NAA) meet D-1641 for all years except 1977. It should be noted that in general, all scenarios except Boundary 1 meet the 150 mg/l mean daily chloride concentration for a greater number of days, beyond what is required, compared to the NAA.

Exhibit DWR-513, p. 10, Figure C6 does not reflect actual chloride experienced in 1977 drought. Due to severe drought conditions, barriers were installed at six different locations in the Delta in 1977, in order to help reduce ocean salinity intrusion and to raise water levels. These barriers are not reflected in the modeled results. (Exhibit DWR-510[6].)

VII. Water Levels

Exhibit DWR-513, pp. 11-15, Figures W1 through W5 show the probability of exceedance for daily minimum water levels for locations throughout the Delta. For example, the 10% exceedance represents the top 10% minimum daily water levels, which most likely occur during high flow periods. Similarly, the 90% exceedance represents the bottom 10% minimum water levels, which most likely occur during low flow periods. Results show in general that all scenarios (except the NAA) result in a similar frequency distribution for water levels.

As expected, the largest changes in water levels occur in the vicinity of the proposed intakes along Sacramento River. Figure W1 shows the probability of exceedance for daily minimum water levels at Sacramento River downstream of the proposed intakes. (Exhibit DWR-513, p. 11.) The results show the maximum reduction of about 1.0-1.2 ft, occurring at the 0-10% exceedance levels (highest changes expected during high flow periods periods). This is consistent with the highest changes occurring at times when the three proposed NDD are utilized at or near maximum capacity (9,000 cfs), typically occurring at high flow periods. At highest probability levels (i.e., lowest range in water levels), the results show the reduction in water levels is about 0.5 ft. This is consistent with the lowest changes in water levels occurring during low flow periods when the total flow diverted through the three proposed NDD is at its lowest range. On average, the minimum water levels in the vicinity of the proposed NDD drop below the lowest minimum water level under the NAA only during less than 5 days in a year.

Furthermore, the minimum water levels occur only for a short period of time throughout the day. DSM2 results show that under the lowest minimum water levels the tidal range at Sacramento River downstream of the proposed intakes is between 2 to 4 ft.

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[6] Exhibit DWR-510 is a true and correct copy of the document.

Which means for most of the day, the water level would be well above the minimum value. During low flow periods, the total amount of water diverted from the proposed NDD is much lower than the 9,000 cfs capacity. Modeled results were not refined on an hourly basis for meeting specific water elevations. For this reason, the modeled results are showing a more conservative outcome.

Similarly, Figure W2 shows the probability of exceedance for daily minimum water levels at Sacramento River downstream of Georgiana Slough. (Exhibit DWR-513, p. 12.) The results show the highest changes of about 0.9 ft, occurring at the 0-10% exceedance levels, and the lowest changes of about 0.3 ft occurring at 90-100% exceedance levels.

As expected, the results show smaller changes in water levels at locations that are farther from the three proposed NDD. In fact, according to Figures W3 to W5, there is very little change in water levels at Sacramento River at Rio Vista, Mokelumne River at Terminous, and Old River at Tracy Road. (Exhibit DWR-513, pp. 13-15.)

It is my opinion that for all of these reasons there will not be negative effects to legal users of water due to these water level changes.

VIII. SUMMARY

Delta Water quality (based on EC and chloride) results are mixed. During the period which Agricultural D-1641 water quality objectives for Western and Interior Delta applies (April through August), water quality at most locations in the Delta are somewhat similar amongst all operational scenarios**.** (Exhibit DWR-513, pp. 1- 5.) In general, the EC values overall are expected to be higher at Emmaton for all alternatives except for Boundary 2, and lower or similar for most other locations. (Exhibit DWR-513, pp. 1-5.) This is as expected since Boundary 2 operational scenario has the highest Delta outflow among all alternatives which results in lower EC.

Results for all operational scenarios including the NAA show modeled exceedances in D-1641 water quality objective (agricultural, municipal, and industrial). (Exhibit DWR-513, 5-10.) However, as explained earlier, the exceedances are mostly a result of differences in model assumptions, such as the time-step issue described previously. In reality, and as testified to by Mr. Leahigh, SWP/CVP project operators have been able to meet their regulatory obligations to prevent most exceedances. (Exhibit DWR-61.)

The largest reduction in water levels is expected to occur in the vicinity of the NDD and mostly during high flow periods. (Exhibit DWR-513, p. 11.) However, during low flow periods, the expected reduction in daily minimum water levels is about 0.5 ft near the three intakes and are much smaller at other areas farther from the three intakes. On average, the minimum water levels in the vicinity of the proposed NDD drop below the lowest minimum water level under the NAA only during less than 5 days in a year, and only for a short period of time during the day. Furthermore, the modeled results are showing a more conservative outcome. It is my opinion that for all of these reasons there will not be negative effects to legal users of water due to water level changes.

The modeling shows the expected changes to water quality and water levels within the Delta for the operational scenarios as compared to the NAA. Any changes that occur, either structurally or operationally, within the Delta affects areas throughout the Delta. Through careful planning and analysis, many areas of the Delta benefit and any negative water quality and water level changes have been minimized. It is my opinion that the modeling cannot completely mimic operational decisions but it does show that D-1641 water quality objectives can be met.

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Executed on 27 day of May, 2016 in Sacramento, California.

Parviz Nader-Tehrani