JOHN HERRICK, ESQ. – SBN 139125
LAW OFFICE OF JOHN HERRICK
4255 Pacific Avenue, Suite 2
Stockton, California 95207
Telephone: (209) 956-0150
Facsimile: (209) 956-0154

S. DEAN RUIZ, ESQ. – SBN 213515
HARRIS, PERISHO & RUIZ
3439 Brookside Rd. Ste. 210
Stockton, California 95219
Telephone: (209) 957-4254
Facsimile: (209) 957-5338

On behalf of South Delta Water Agency,
Central Delta Water Agency, Lafayette Ranch,
Heritage Lands, Mark Bachetti Farms
and Rudy Mussi Investments L.P.

STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

Hearing in the Matter of California Department of Water Resources and United States Department of the Interior, Bureau of Reclamation Request for a Change in Point of Diversion for California Water Fix

SUR REBUTTAL TESTIMONY OF THOMAS K. BURKE, P.E.

Sur Rebuttal: Protestants South Delta Water Agency, Central Delta Water Agency, Lafayette Ranch, Heritage Lands, Mark Bachetti Farms And Rudy Mussi Investments L.P.

I, Thomas K Burke do hereby declare:

I. INTRODUCTION

My name is Thomas Burke, and I have previously testified in this matter. A summary of my experience is included in [Exhibit SWDA-76] and a true copy of my statement of qualifications has been previously been submitted as [Exhibit SDWA-75]

This surrebuttal testimony has been provided to respond to issues that were raised by the Petitioners in their rebuttal testimony. The testimony has been organized into 9 topics, with each section responding to a separate issue that was presented in the Petitioners' rebuttal testimony.

II. Rebuttal Topics

1. The ability of the DSM2 model's to provide a comparative assessment between CFW scenarios on a short time step.

Dr. Tehrani, in DWR-79 testified that the output from the DSM2 model should only be used to compare CWF scenarios by using a long-term monthly average for the parameter being evaluated. I disagree with Dr. Tehrani's position that only long term averages are appropriate for evaluating the model output. It is my opinion that using long-term averages and monthly values actually mask the specific impacts being evaluated between different scenarios.

The DSM 2 model is a hydrodynamic and water quality model that was developed by the Department of Water Resources (DWR) to evaluate flow and salinity within the Delta. It was developed to a great extent to respond to the need for obtaining accurate estimates of flow and salinity in the Delta to assist in meeting RWQCB Orders as far back as Board Order 1485 in 1978.

The DSM2 model was developed and calibrated to provide a hydrodynamic and water quality analysis of the Delta on a 15 minute time step. The tidal nature of the Delta makes it imperative that a short time step be used to evaluate water movement through this complex estuary. The results may not be perfectly accurate when trying to compare model results to actual Delta conditions on a specific day and time period, but when used in a comparative analysis, to evaluate different scenarios, it is perfectly acceptable and standard modeling practice. It is in this comparative mode, and at a time step that is small enough to capture the hydrodynamics of the Delta, that the model has its greatest use in comparing the CWF scenarios.

DWR has been developing, using, and refining DSM2 for hydrodynamic and water quality studies in the Delta for over 20 years. The model is typically run in a 15-minute time step. During the development of DSM2, DWR understood the need to use a correctly sized small time step to accurately model the Delta hydrodynamics. During that development process, they investigated using shorter time steps, and found the shorter time steps did not provide any significant increase in model accuracy.

2. The relationship between short time step data when presented chronologically versus sorted high to low in an exceedance analysis.

Dr. Tehrani, in DWR-79, testified that when comparing two CWF scenarios, the use of the hydrodynamic and water quality output from DSM2 on a 15-minute time step is not appropriate. He claims that the most appropriate way to look at the data is through exceedance graphs. I disagree. The difference between the 15-minute data DSM2 output data viewed chronologically, and an exceedance graph of the 15-minute output data, is how the data are sorted. I disagree with Dr. Tehrani's testimony that when the 15-minute data are sorted chronologically they are wrong, but when the same 15-minute data are sorted from high to low, as you would in an exceedance plot, they are correct. It is my opinion that the 15-minute data are correct and provide an invaluable insight into the response of the Delta to a CWF scenario, and can be used in a

comparative analysis, no matter what order you sort them in. The only real difference in comparing the CWF scenarios by exceedance graphs, is that you lose the ability to directly compare the response of the two scenarios over any specific time interval. The use of exceedance curves has some value, but obscures much of the detail in any direct comparison between the scenarios that you are trying to compare.

3. The inability to assess impacts when monthly averages are used in the assessment.

Dr. Tehrani, in DWR-79 testified that "Statistics based on long-term and water year type averages are an appropriate use of model results". I strongly disagree with this statement. Dr. Tehrani's use of long-term monthly averages of water quality, stage, and flow to evaluate the difference between the CWF scenarios masks impacts. It may be acceptable to use long-term monthly and annual averages in forecasting *water deliveries*, but using that same averaging approach to evaluate the *impacts* from the operation of new water project diversions in a tidal estuary is inappropriate. It would be similar to taking long term averages of climate to characterize rainfall. If you evaluated climate using long-term monthly averages, you would determine that California does not have any floods or droughts, each month would just consist of small changes around a common mean, and would look very much like the Petitioners' plots for the comparative analysis of the CWF scenarios for the Delta.

The averaging process removes all of the detail of the high and low values from the actual data set. That makes it impossible to determine the magnitude of any impact.

Most of the beneficial uses of water in the Delta are time sensitive, in that they respond to, and are impacted by, changes to depth, flow, or water quality at a specific time. By averaging out the high and low values of the parameter that you are evaluating, you are effectively erasing the potential impacts that may occur.

In the rebuttal testimony of Dr. Tehrani and Mr. Munevar, no reference has been made to any DSM2 manuals or documentation, which supports their position that the 15-minute data output from DSM2 cannot be used directly in an analysis. DSM2 was developed, refined and calibrated explicitly to provide hydrodynamic and water quality information throughout that Delta on a 15-minute time step. Based on my 35 years of modeling experience, and knowledge of DSM2, using the 15-minute data set to compare alternatives will provide the best and most accurate way of evaluating the changes to the Delta from the CWF scenarios.

4. The importance in understanding that each scenario is composed of many elements, not just NDD's.

Dr. Tehrani, in DWR-79, page 3, and Mr. Munevar in his rebuttal cross-examination testified that some of the differences between the CWF scenarios are due to the lack of meeting X2, or the implementation of a new HORB structure and barrier operations, or other components of each scenario other than the NDD's. It is inappropriate to ignore or discount the effect of the individual components from a scenario when you are evaluating each scenario. Each scenario is composed of many different components. All of these components act together a system and must be evaluated together within each scenario.

5. The difference between the probability of removal of X2 in the NAA and the removal from Scenario B1.

In his rebuttal cross-examination, Mr. Munevar stated that it is inappropriate to compare B1 to the NAA, because the X2 requirement has been removed from the B1 scenario and not from the NAA. Mr. Munevar insinuates that if X2 were allowed to be removed from B1 it would likely be removed independent of the CWF, and so, therefore, it should be removed from the NAA. I disagree with his assertion. With the NDD's in place, there is a significant benefit to the CVP and SWP if the X2 requirement were to be removed. Therefore, it is my opinion that if Petitioners are

allowed to operate at B1, there will be significant pressure – much more so than exists today -- put on the agencies to have the X2 requirement removed. Therefore, it is appropriate to evaluate the impacts to the Delta from Scenario B1 with X2 removed when compared to the NAA which contains the X2 requirement.

6. The ability for the proponents to be able to model extreme conditions with the available models.

In DWR-79, Dr. Tehrani testified that the CALSIM2 is unable to model extreme conditions because the model relies on generalized rules. I disagree with Dr. Tehrani's assertion.

One of the purpose of running an operations model such as CALSIM2 over a long period of record is to inform what measures need to be implemented in the operations of the project during average and the extreme conditions.

The evaluation of an operations model is typically done by simulating the operations through a variety of year types so that you can evaluate the response of the operations model, to the changes in the climate patterns. Based on the observed response of the operations model to those year types, one can then make changes to the operations model, and re-run the model, with those changes, to evaluate the new response. This cycle of run-evaluate-modify-rerun of the model over multiple years, is performed iteratively until the operational rules are adjusted to provide the best acceptable response. If, in some years, an acceptable response is not possible, the model would indicate where reduced deliveries or operational curtailments will be necessary. Such operational requirements in extreme years may not be optimal for petitioners, but knowing what those are, and when they will occur, should be the primary purpose of running the model through a robust range of year types.

The biggest hindrance to evaluating the model response over various climatic conditions, including climatic extremes, is the lack of available climate data to represent years when those conditions exist. In the case of evaluating the CALSIM II and DSM 2 models, we have an amazing 82 year period of record that covers extreme drought periods as well as extreme wet periods. This allows DWR and the USBR to disclose how the operations model will respond to very wet, normal, and very dry years.

The CALSIM II model has an integrated simulation language "Water Resources Simulation Model" (WRESL) that allows for the formulation of robust model control, allowing the model to dynamically respond to states and conditions that would occur during a model run. This allows for the model to be programmed to respond to extreme conditions in ways similar to how the project operators would respond during a drought or flood. Thus, DWR or the USBR can determine what measures would be required during those extreme conditions.

7. Mr. Munevar states that the diversion of flows through the NDD's will *not* make high flow years on the Sacramento River look like low flow years.

In his written rebuttal testimony (DWR-86, Page 37), Mr. Munevar states that the diversion of flows through the NDD's will not make high flow years on the Sacramento River look like low flow years. I disagree with this statement. The NDD's will remove a significant portion of the flow in the Sacramento River. An evaluation of DWR's DSM2 model output data shows that in late summer, up to 45% of the flow will be diverted. This magnitude of diversion will remove much of the excess water during wet years, to a point where, in late summer, most all years will look like dry and critically dry years.

In analyzing the data from the Petitioners' DSM2 model work, it is evident that during the late summer, when good quality water quality is critical, the NDD's result in the

Sacramento River having flow near to what the flow rate is during dry and critically dry years. This reduction in flow becomes more pronounced as you progress through the summer period.

As part of my surrebuttal testimony I analyzed the Sacramento River flow data from the Petitioners DSM2 models at the North Delta Diversions (NDD's). Below I include three plots (Figures D-1, D-2, and D-3 which show the difference between Scenario B1 and the NAA for the July, August, and September periods. Figure D-1 show the Sacramento River flow for the NAA and CWF Scenario B1 for the 16 year period that the Petitioners chose to model. On the figure, I have indicated the water year classification based on the Sacramento River Valley Water Year Index as developed by DWR. (See also SWRCB-104, p. 5.A-41: Figure 5.A-6 Example monthly-averaged and daily-averaged flow for Sacramento River at Freeport.) The blue line represents the flow rate for the NAA and the red line represents the flow rate for Scenario B1. As illustrated in figure D-1, after the diversions have been removed from the Sacramento River, nearly all years, except 1984 now fall between the flow rates that were previously experienced in dry to critically dry years. As the summer months progressed, this effect becomes more pronounced. Figure D-2 shows the same Sacramento River flow rates for the month of August. Figure D-3 shows the Sacramento River flow rates for September. In September, the flow rate after the diversions has nearly flat lined to what was previously primarily experienced only in critical year types.

Operation of the NDD's would basically remove much of the water that would otherwise flow through the Delta in a wet or above normal year out of the Sacramento River, leaving a river that is more frequently in a dry to critically dry state. It should be noted that this is most pronounced during the late summer and fall, when the need for flow and good water quality is most critical.

The same primarily applies to water quality. In DWR-79, page 7 of Dr. Tehrani's rebuttal testimony, he presents a plot of chloride for the period 1984 through 1987. This period contains two wet years and two dry years. The plot is provided below (identified as Figure 2). As illustrated in the plot, the chloride level in the wet years of 1984 and 1986 goes from a very low level in the NAA and increases nearly 200% for Scenario B1. It raises to a level that is almost identical to the levels observed for the dry years of 1985 and 1987.

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

//

Figure D1 - Sacramento River Downstream of NDD's - Mean July Flow Rate

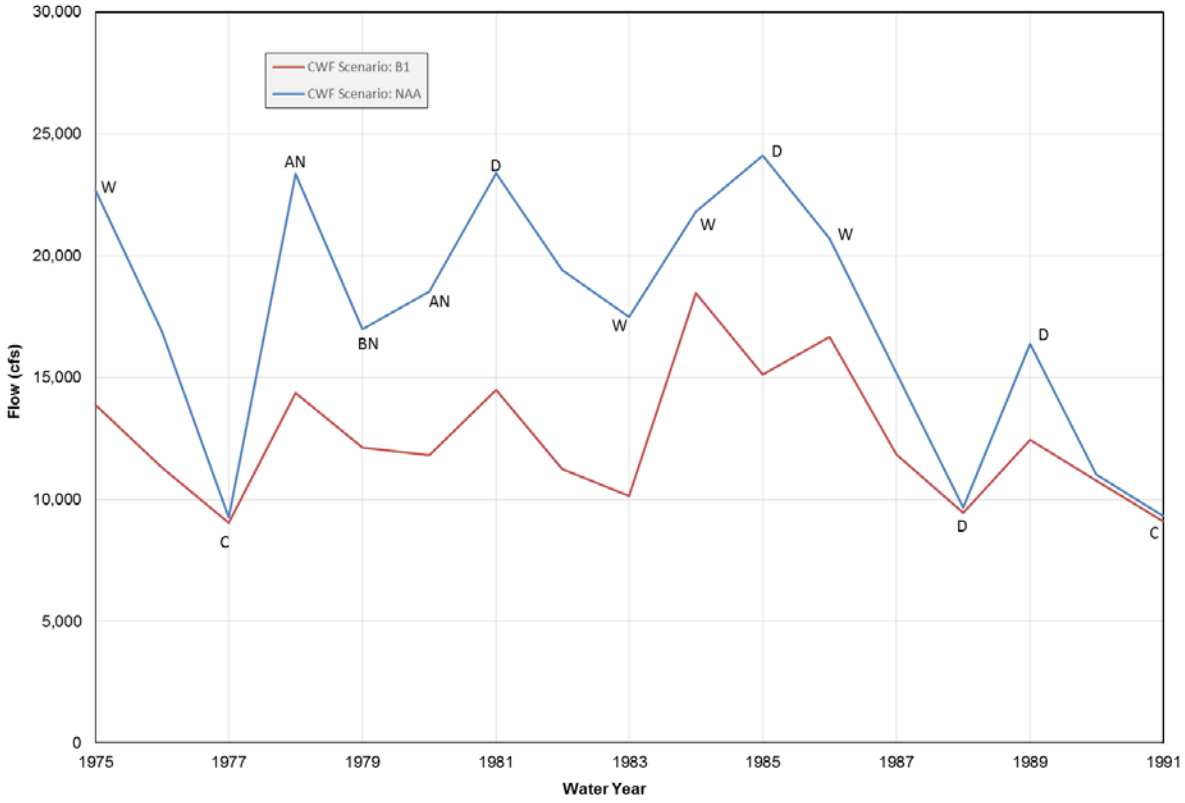
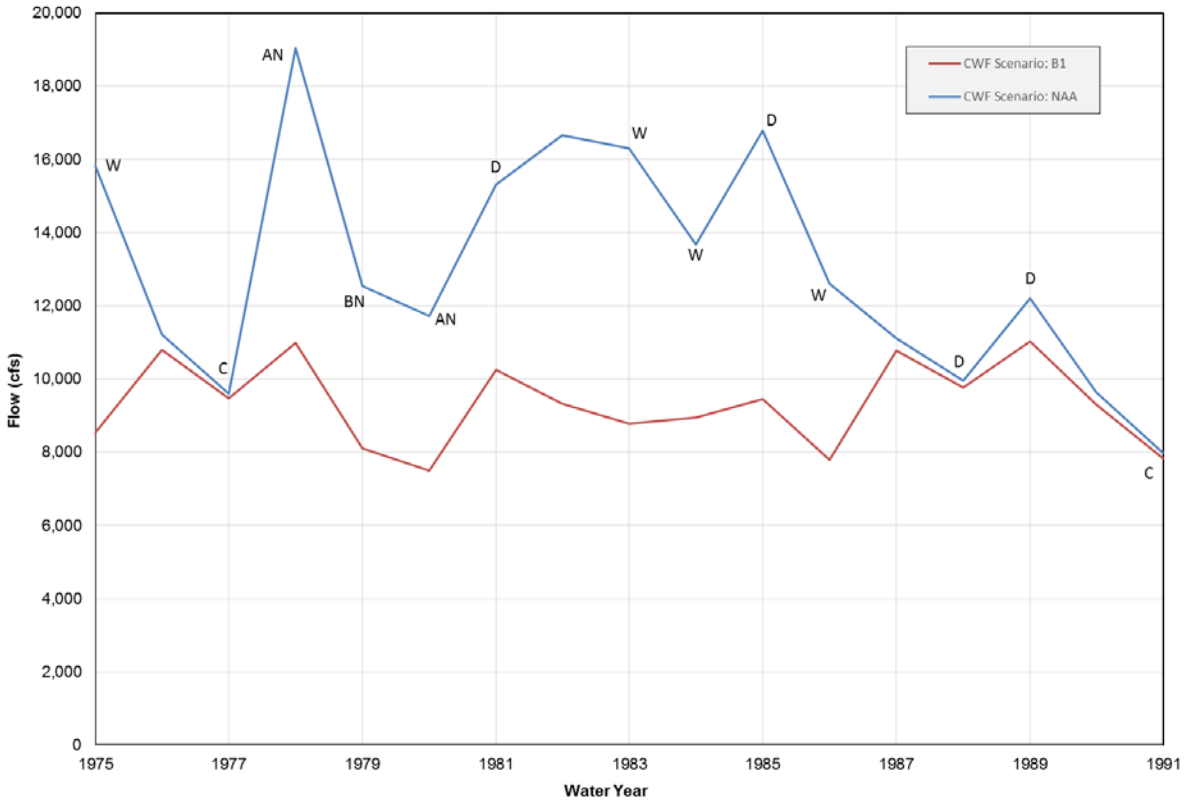
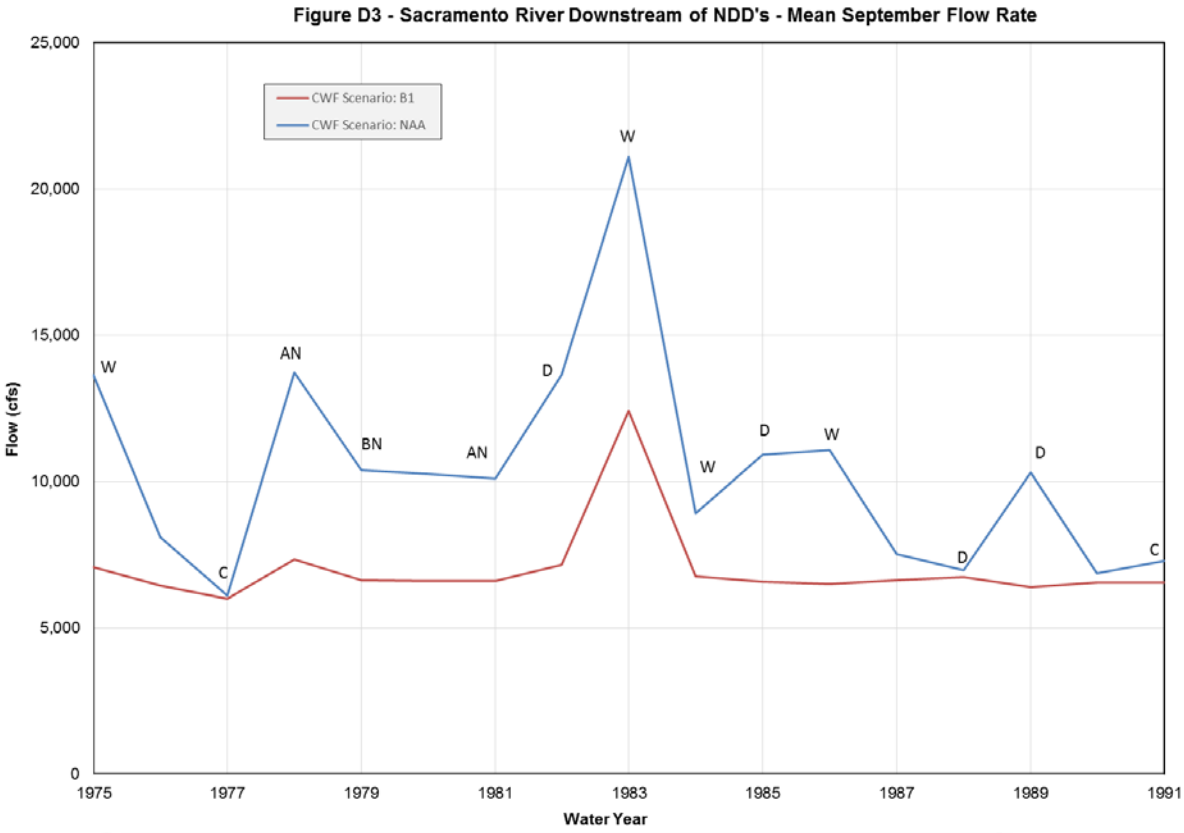


Figure D2 - Sacramento River Downstream of NDD's - Mean August Flow Rate





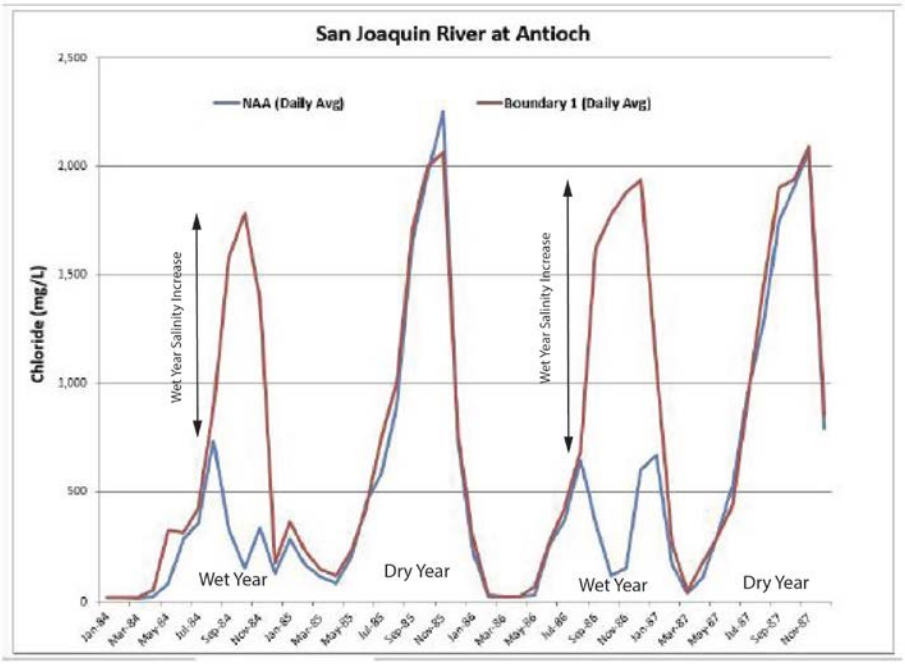


Figure 2. Monthly Average Chloride Concentration at Antioch (1984-1987)

From DWR-79, page 7

8. The monthly CALSIM II boundary conditions for DSM2 prohibit accurate sub monthly analysis of DSM2 results.

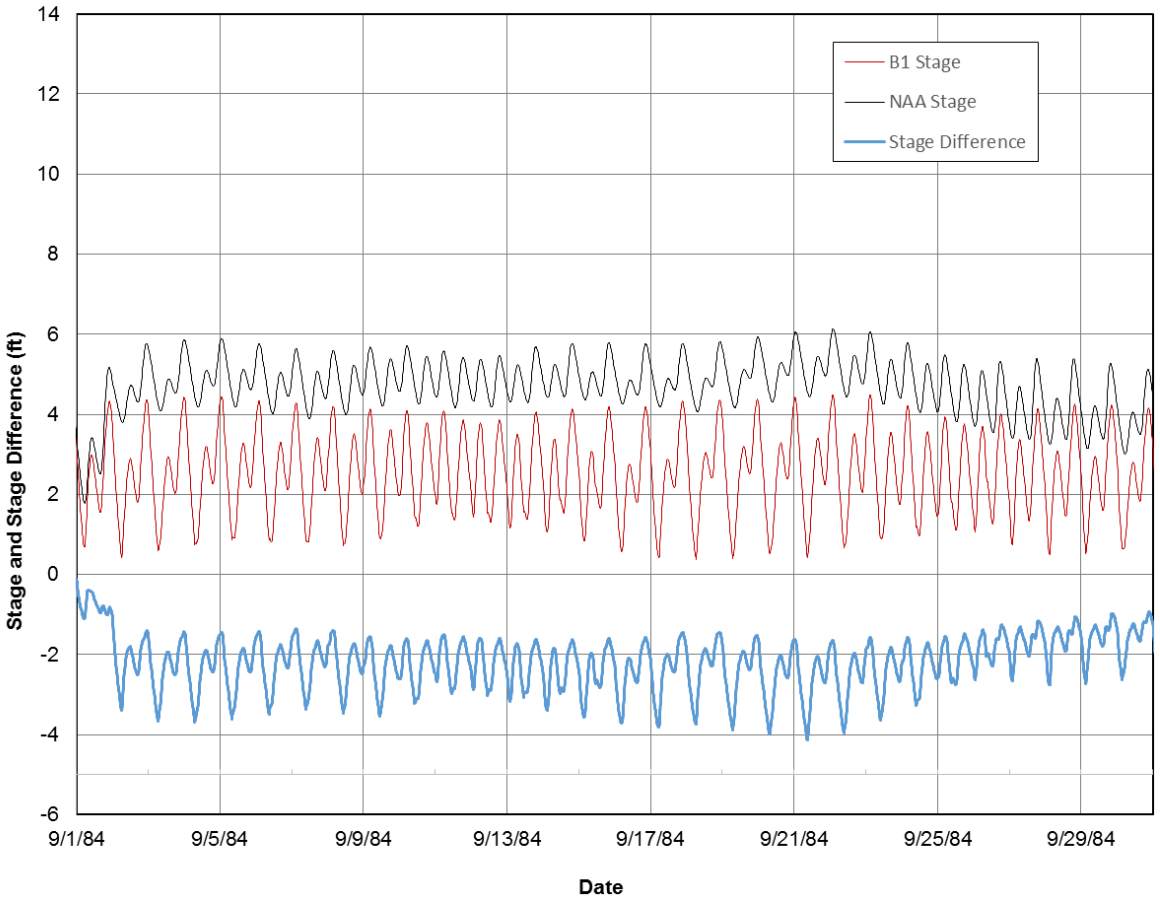
In DWR-79, that the data from CALSIM II is based on a monthly time step, and, therefore, precludes accurate sub monthly analysis when this data is transferred to DSM2. This monthly CALSIM II output becomes the boundary condition for the DSM2 model, which runs on a 15-minute time step. The conversion from Monthly to 15-minute at the DSM2 boundary, is based on a predetermined disaggregation process. The disaggregation was developed from historic flow records. This disaggregation does not necessarily match the flow pattern on any specific day but, since the disaggregation process is applied *identically* to all the scenarios, the DSM2 15-minute time step data can be used for comparison purposes to evaluate the hydrodynamic and water quality changes between the different CWF scenarios on shorter than a monthly time step.

9. The Effect of Water Fix Scenarios on Water level

In DWR-79, page 10, Dr. Tehrani testifies that the largest water level difference in the Sacramento River downstream of the NDD's was found for a single 15-minute time step in September of 1984. This representation is incorrect. It is true that the maximum, by definition, represents the worst single point but the water level change varied between 2 and 4 feet throughout September. Figure D-4 is a plot of the water level difference for September 1984. It was developed from the DSM2 model output data that was submitted by DWR. The worst decreases in water level were during the month of September for Scenario B1. Dr. Tehrani further testifies that the stage change was due to X2 removal from Scenario B1. That is partially true, but removal of X2 is a component of the scenario, and is intricately tied into the many other components of that scenario. This water level comparison was based on an evaluation of 15-minute data that in my professional opinion is not only appropriate, but necessary in order to evaluate the full impact. (See topic No's. 1, 3 and 8 above). If you were to take long-

term monthly averages of this data which is the approach taken by Petitioners, nearly, all the negative impacts disappear.

Figure D-4 Stage Difference Between CWF Scenario B1 and The NAA, Downstream of NDD No. 5



Conclusions:

As discussed above, the conclusions of my surrebuttal testimony are as follows:

1. The DSM2 model output can be used on a 15-minute time step for the comparison of the effects that each of the CWF scenarios have on the Delta. The model was developed and calibrated to run at this time step and has been continually developed and modified over the past 20 years to improve its accuracy. It is an excellent way to

evaluate impacts from different CWF scenarios, as compared to the NAA, especially in a comparative rather than a predictive mode.

2. Each of the proposed operation scenarios consist of many different components. These components act, and interact, together as a system that defines the scenario. It is inappropriate to discount any one component because it results in a negative impact.
3. The boundary conditions to DSM2 are the monthly output from the CALSIM II model. This monthly data is converted into 15-minute data for use in DSM2 exactly the same way for each scenario. Since the conversion to 15-minute data is performed identically for each scenario, the different scenarios can be directly compared on the 15-minute time step used by the model.
4. Evaluation of the impacts from the different CWF scenarios on a monthly or mean monthly basis, masks the actual impacts on the Delta from each scenario. The averaging process eliminates the high and low values from the data being evaluated. It is these high and low values that have the greatest potential for generating impacts.
5. The CALSIM II model has the ability to evaluate the operational scenarios for the extreme wet and dry periods which have occurred over 82 year climate data set that is available. The simulation language that is incorporated into the model can be used to develop operational criteria that responds to the extreme climate conditions.
6. Operation of the NDD's will result in the Sacramento River experiencing drought like conditions in late summer and early fall for all water years.
7. Based on the model results that were submitted by DWR, the water level change in the Sacramento River downstream of the NDD's can be significant. In some instances, it was determined to vary between 2 and 4 feet for a month or more.

I declare under penalty of perjury under the laws of the State of California that the foregoing statements are true and correct.

Executed on the 8th day of June 2017, at Placerville, California.

Thomas K. Burke

Thomas K. Burke, P.E.