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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 JOHN LEAHIGH

I, John Leahigh, do hereby declare:

I. INTRODUCTION

My name is John Leahigh. I am employed by the Department of Water Resources (DWR) as Chief of the State Water Project (SWP) Water Operations Office within the Division of Operations and Maintenance. I received a bachelor's degree in civil engineering from the University of New Mexico in 1989 and a master's degree in civil engineering with emphasis on water resources engineering from California State University at Sacramento in 1999. I am a registered Civil Engineer in the State of California.

I have over twenty years of experience in the SWP Operations Control Office and nearly ten of those years in my current role as lead manager for the SWP water operations planning and coordinating activities. My current duties include directing SWP water management activities including scheduling of real-time water operations and formulating annual water delivery allocations to the SWP water contractors.

My responsibilities also include working with the United States Bureau of Reclamation (Reclamation) to coordinate SWP operations with Central Valley Project (CVP) operations. This coordination includes scheduling SWP exports at Clifton Court Forebay and upstream releases from Lake Oroville in coordination with the CVP's scheduling of pumping at Jones Pumping Plant and releases from Lake Shasta and Folsom Lake in accordance with the Coordinated Operations Agreement.

Another significant responsibility is to coordinate the implementation of the 2008 United States Fish and Wildlife Service and 2009 National Marine Fisheries Service biological opinions on the coordinated operation of the SWP and the CVP (BiOps) and state California Endangered Species Act (CESA) permits as they relate to SWP operations.

I have been recognized by the federal district court as an expert in operations of the SWP in the Consolidated Delta Smelt cases (San Luis Delta Mendota Water Authority et. al. v. Salazar) and have testified in various federal cases as designated in my statement of qualifications attached as Exhibit DWR-21[1].

My testimony is submitted to explain the current operations of the SWP and CVP (collectively, SWP/CVP), the highly successful record of compliance with water quality standards[2] in the Bay-Delta, and the anticipated manner of SWP/CVP operations following construction of the California WaterFix (CWF) to continue meeting current and any future standards applicable to the SWP/CVP.

## II. OVERVIEW OF TESTIMONY

To understand how the proposed CWF can be operated in the future, my testimony begins with an overview of current SWP/CVP operations and their influence in managing the Sacramento – San Joaquin Delta (Delta) watershed. For purposes of Part 1 of the hearing on DWR's and Reclamation's Petition for Change in Point of Diversion/Rediversion, my testimony will focus on the effects of the CWF on other legal users of water. I will

[1] Exhibit DWR-21 is a true and correct copy of the document.
[2] When discussing the Water Quality Control Plan flow and water quality requirements and the associated water rights decisions, including D-1641, the terms "standards" and "objectives" are synonymous and frequently used interchangeably.

explain how the SWP/CVP are operated today, with existing infrastructure, and then explain how the system would be operated with the CWF.

First, I will describe the hydrologic conditions in the lower Sacramento-San Joaquin watershed that dictate SWP/CVP water supply system operations and explain how the system operates under those hydrologic conditions. Second, I will describe the real-time operations and operational challenges that influence SWP/CVP operations. Third, I will describe the success of the SWP/CVP in complying with water quality standards, both under Water Rights Decision 1485 (D-1485) and Decision 1641 (D-1641). (Exhibit SWRCB-23 and Exhibit SWRCB-21 respectively.) I will also describe how regulations imposed on the South Delta flows by the BiOps limit exports. In addition, I will describe how the SWP/CVP have responded to the unique challenges posed by the recent drought conditions. Finally, I will describe how the SWP/CVP, with the CWF, would operate to continue to comply with all applicable requirements on the SWP/CVP to ensure other legal users of water are able to exercise their water rights.

## III. OVERVIEW OF WATER SUPPLY SYSTEM OPERATIONS

A key point of my testimony is that SWP/CVP operates in real-time, which is very different than analyzing or critiquing possible project operations through model simulations. SWP/CVP operators have limited tools that can be used to influence Delta flow and water quality and to operate the system to meet their responsibilities for water quality control plan requirements, which is challenging in a tidal environment. Management of net Delta outflow is the fundamental way in which salinity is managed in the system[3] but there are uncontrollable and variable factors outside SWP/CVP control that influence net Delta outflow, including tidal and meteorological effects.

The SWP/CVP play a substantial role in managing the Sacramento River and San Joaquin River systems. DWR and Reclamation are currently responsible for meeting the Delta water quality and flow objectives in the Bay-Delta Water Quality Control Plan[4]

[3] For Agricultural and M&I beneficial uses, DWR monitors for salinity and chloride, respectively. Salinity serves as a proxy for chloride.

[4] The Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, last

(WQCP) as implemented by D-1641. (Exhibit SWRCB-27.) The SWP/CVP must ensure that higher priority requirements of the water system or "In-Basin Requirements" are met before developing water supply for their respective water supply contractors. For the purpose of this testimony, In-Basin Requirements include legal users of water in the Sacramento Basin (including settlement contractors[5]), and applicable Delta outflow and salinity requirements (most of which were adopted as part of the WQCP as implemented through D-1641).

The SWP also operates within its water rights permits. This includes operating within the maximum quantity, maximum rate, timing of diversion, place of use and purpose of use provisions. The petitioned change in point of diversion will not alter the ability of the SWP to continue to operate within the permit terms.

The unstored flow in the Sacramento-San Joaquin River watersheds including the Delta varies significantly from year to year and season to season. For the purposes of my testimony, "unstored flow" is flow in the system that would occur independent of the storage regulating operations of the Project reservoirs. "Unregulated flow" is unstored flow entering the valley downstream of the major Project reservoirs, independent of flow released from the SWP/CVP reservoirs. Typically, in the winter and early spring period unregulated flows plus SWP/CVP reservoir releases are in excess of all system needs. This condition is referred to as "excess" conditions. In late spring, summer, and fall, unregulated flows plus SWP/CVP reservoir releases are almost always insufficient to meet all system needs and the SWP/CVP are required to actively manage the system. This condition is referred to as "balanced."

A. EXCESS CONDITIONS

During excess conditions unregulated runoff plus SWP/CVP reservoir releases are in excess of that needed to meet In-Basin Requirements. During excess conditions, if unused conservation space exists, the SWP diverts surplus runoff from rain and melting

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updated in 1995 and revised in 2006.

[5] Settlement contractors are senior water right holders who have entered into agreements with DWR and Reclamation to manage delivery of water under their water rights.

snow into Lake Oroville, the principal SWP upstream storage reservoir. The CVP diverts surplus runoff into its upstream reservoirs. Some of this excess runoff is diverted into the SWP facilities at Clifton Court Forebay and pumped at Banks Pumping Plant. The CVP pumps water at the Jones Pumping Plant. These SWP/CVP exports are used to meet the respective SWP/CVP water supply contracts. During high-flow periods, when the exported supply exceeds immediate demand, the surplus export is stored in San Luis Reservoir for release later in the year when SWP/CVP's demands exceed exports.

B. BALANCED CONDITIONS

Beginning typically in late spring and extending through the fall, unregulated flows plus SWP/CVP reservoir releases often no longer exceed the downstream demands. In other words, system supply is "in balance" with system demand and the SWP/CVP are actively managing the system. All unstored flow goes first to meet In-Basin Requirements. The SWP/CVP can only divert unstored flow if surplus flows remain after all In-Basin Requirements are being met. WQCP objectives are met by reducing exports or by increasing releases from Lake Oroville and appropriate CVP upstream reservoirs, such as Lake Shasta and Folsom Lake, so as to ensure sufficient flow in the system downstream of the SWP/CVP reservoirs.

If unstored flows are insufficient to meet In-Basin Requirements, then the SWP/CVP release previously stored water from upstream reservoirs to meet these demands. If there is sufficient storage, additional releases can be made from SWP and CVP upstream reservoirs into the Delta for re-diversion at the export facilities to meet SWP/CVP water supply contractors' demand south of the Delta.

As described below in Section V, the actions SWP/CVP will take to ensure In-Basin Requirements are met before any water is diverted for export will remain unchanged with the implementation of the CWF.

## IV. REAL-TIME OPERATIONS TO MEET WATER QUALITY OBJECTIVES

The SWP/CVP are required by D-1641 to meet water quality objectives for Municipal and Industrial (M&I), Agricultural, and Fish and Wildlife beneficial uses. For Part 1 of this hearing, my testimony is focused on real-time SWP/CVP operations employed to meet the water quality objectives for Agricultural and M&I beneficial uses as contained in Tables 1 and 2 of D-1641. The real-time operations used to satisfy SWP/CVP permit obligations can be challenging, although, as later explained, the operators have been highly successful in meeting this challenge by having the ability to respond to changes in observed conditions.

### A. REAL-TIME MONITORING AND CONTROL

Many water quality monitoring stations are deployed throughout the Delta. These monitoring stations are equipped with telemetry that captures and reports water quality measurements in real-time on the Department's California Data Exchange Center web site. SWP/CVP operators use this data to obtain a comprehensive picture of Delta salinity conditions resulting from all the various factors influencing Delta hydrodynamics. SWP/CVP operators are generally able to respond to changing conditions by making real-time adjustments to operations of the SWP/CVP as necessary to meet water quality objectives.

### B. DELTA HYDRODYNAMICS

Delta hydrodynamics are defined by complex interactions between tributary inflows, tides, in-Delta diversions, and SWP/ CVP operations. Changes in any of the hydrodynamic variables affect water quality in the Delta, particularly with regard to salinity. Each day two high and two low tides of differing magnitudes (flood and ebb tides) cause large fluctuations in flow in the Delta estuary. The positive and negative Delta outflow caused by these tidal forces is the reason that Delta outflow is defined in terms of an average or "net" Delta outflow. The strength of the tides also varies within the month depending on the position of the sun and the moon (spring-neap cycle) and is also greatly influenced by atmospheric conditions such as wind and barometric pressure. Each flood tide has the potential to bring a large volume of high salinity ocean water into the Delta, and can be exacerbated by storm surge conditions.  Managing this saltwater intrusion from encroaching too far into the interior Delta is crucial to protecting freshwater supplies for in-Delta and SWP/CVP water users.

To prevent saltwater from encroaching too far into the Delta during balanced periods, SWP/CVP operators repel it with the tools available to them: primarily by either reducing diversions from the south Delta; or by increasing releases from upstream reservoirs to increase flows into the Delta, thereby increasing net Delta outflow.  Whereas diversion reductions in the south Delta have a relatively quick effect, there is a delayed response from changes in upstream releases.  The assumed travel times to the western Delta is five days from Lake Shasta on the main stem of the Sacramento River, three days from Lake Oroville on the Feather River and one day from Folsom Lake on the American River.

A quantitative analysis of system operations under both the current system and the outer boundaries can be found in the modeling testimony of Mr. Munévar and Mr. Nader-Tehrani.  The modeling testimony describes the analytical framework and the limitations of the modeling used for evaluating the CWF.  Some of the more germane modeling results as they relate to Part 1 of this hearing are simulated operations to meet WQCP water quality objectives.  Although any proposed project must rely on a simulated model of operations to assess the relative performance and general feasibility, many particulars exist in real world operations that cannot be accurately simulated by a model.  These real world operations can often be adjusted to satisfy flow and water quality requirements that are not possible with fixed modeling assumptions.

## V. SWP/CVP RECORD OF COMPLIANCE WITH WQCP OBJECTIVES

SWP/CVP operators have had a high degree of success in meeting all operative water quality standards since 1978.  My opinion is that regulatory compliance with the CWF will be at least as good, if not better, as today given that CWF will add infrastructure flexibility to system operations.  Even though rare instances of water quality exceedances have occurred, these instances have been due to factors beyond the SWP/CVP's reasonable control.

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. Such extraordinary circumstances are best managed in the context of temporary adjustments as occurred pursuant to the Water Board's authority, as delegated to the Executive Director, to approve temporary urgency change petitions (TUCPs).

A. SWP/CVP RECORD OF COMPLIANCE

As noted above, the SWP/CVP are required to meet their responsibilities under by D-1641. Exhibit DWR-404 summarizes the various Bay-Delta standards as they currently exist under D-1641.[6]

On any given day there will be a multitude of flow, salinity, export restriction and other operational standards in effect. For example, in late May there will be a habitat protection outflow, an export-to-inflow ratio requirement, a San Joaquin River minimum flow requirement as measured at Vernalis, and a Delta Cross Channel Gate closure requirement for fish and wildlife protections in effect. On that same day there will be several M&I water quality objectives and several Western, Interior, and Southern Delta salinity objectives as well.

My staff routinely tracks SWP/CVP compliance record with the Bay-Delta objectives. They, at my direction, have compiled tables that tabulate exceedances of D-1641 standards as well as standards that were operative previously under D-1485. The exceedance record for D-1485 standards and D-1641 standards can be found as Exhibits DWR-401 and DWR-402 of this testimony, respectively[7]. Exhibit DWR-401 shows that D-1485 standards were exceeded 0.5 percent of the time. Exhibit DWR-402 shows that the exceedances of D-1641 standards occurred 1.5 percent of the time through 2015 and the

[6] Exhibit DWR-404 is a true and correct copy of the document.
[7] Exhibits DWR-401 and 402 are true and correct copies of the documents.

combined D-1485 and D-1641 standards were exceeded 1.1 percent of the time through 2015.

The methodology employed by my staff to determine these exceedance percentages was to track the exceedance status of every operative standard for every day. For example, on a given day there may be as many as ten objectives in effect. If on such a day one standard was exceeded but the other nine were not this would represent only 10 percent of standards being in exceedance of applicable standards in effect on that one-day period. If on the next day all ten objectives were met, the exceedance rate for the two-day period would drop to 5 percent. My staff used this methodology for the 21 years that the D-1641 standards have been operative[8] and the 16 years prior to that when the D-1485 standards were in effect.

Some of the standards govern operations much more frequently than others due in part to their geographical location in the Delta. [9] (Exhibit DWR-405.) To ensure all standards are met, the SWP/CVP are operated to meet the most constraining standards. For example, if the Western Delta Agricultural salinity at Jersey Point on the lower San Joaquin River is being met, then in all likelihood the Interior Delta standards at San Andreas and Terminous will be met as well. Another example is the M&I chloride standard at the Contra Costa Canal Pumping Plant #1 (CCC PP#1) in Rock Slough. In my experience, if the salinity profile necessary to ensure compliance with this standard is being met then all of the other M&I water quality standards will be met as well. A third key standard driving operations is the Western Delta Agricultural salinity standard at Emmaton on the lower Sacramento River.

To more comprehensively evaluate compliance with Bay-Delta objectives my staff used the same methodology that was employed for aggregate compliance to calculate compliance success at these key objective locations. Exhibit DWR-403 of this testimony contains the percent of time in compliance with the CCC PP#1, Emmaton, and Jersey Point

[8] The SWP/CVP began operating to the current set of WQCP standards in 1995 as agreed to in the 1994 Bay-Delta Accord prior to being assigned responsibility under D-1641.
[9] Exhibit DWR-405 is a true and correct copy of the document.

objectives. These standards first came into effect as part of D-1485. The percent of time that each of these standards have been exceeded since D-1485 went into effect is 0.2 percent, 2.6 percent, and 0.4 percent respectively.

As discussed more completely in the modeling testimony, modeling simulations of compliance at these same key locations show exceedance rates to be higher than the historical record. The record of actual operations demonstrates that the SWP/CVP are able to respond to real-time conditions in a way that simulation models are unable to completely emulate.

B. THE SOUTH DELTA SALINITY OBJECTIVES

When reviewing the exceedance record, a subset of objective locations stand out as not having had the same success rate as the objectives on the aggregate. These problematic locations are located in the Southern Delta where more stringent salinity objectives for agricultural beneficial uses were imposed in April 2005. These standard locations were first identified as part of 1995 Water Quality Control Plan for the Bay-Delta. The standards have been the joint obligation of the SWP/CVP since 2000, but in 2005 the standard changed from 1.0 EC year-round to a more stringent 0.7 EC April through August. (Exhibit SWRCB-27(D-1641, p. 79).) Specifically, the three locations identified in Table 2 of D-1641 are Old River at Tracy Road Bridge (P-12), Old River at Middle River (C-8), and the San Joaquin River at Brandt Bridge (C-6).

My staff, under my direction, compiled the exceedance record for these three stations. Exhibit DWR-413 of this testimony contains the percent of time in exceedance of the three objective locations. The percent of time objectives at P-12, C-6, and C-8 have been exceeded since 1995 are 16.3 percent, 2.2 percent, and 2.9 percent respectively. Since 2005, the exceedances increased, due to the more stringent standard. (Exhibit SWRCB-27.)

When not including these three locations in the aggregate computation of exceedances for the SWP/CVP jointly responsible Bay-Delta standards, the exceedance record drops to 0.2 percent for D-1641 objectives. Another way to put this into context is that 89.1 percent of the 1.5 percent comprehensive exceedances of the D-1641 standards were due to exceedances at the three Southern Delta objective locations. Consistent with D-1641, DWR and Reclamation have reported to the State Water Board that these standards are beyond the reasonable control of the SWP/CVP due to localized effects and the lack of sufficient circulation within the south Delta channels. The joint obligation to meet the south Delta salinity standards is found in D-1641 and is further addressed as part of Order 2010-0002 in the matter of Cease and Desist Order WR 2006-0006 against the Department of Water Resources and the United States Bureau of Reclamation in Connection with Water Right Permits and License for the SWP and CVP (CDO).[10] Order 2010-0002 requires DWR and Reclamation to; report to the State Water Board potential and actual exceedances of Southern Delta objectives, operate and improve the temporary barriers in consultation with South Delta Water Agency (SDWA) to improve local water quality; study the feasibility of controlling salinity by implementing measures other than the temporary barriers, and submit quarterly reports to the State Board on DWR/USBR compliance status with the Order. (Order 2010-0002, p.20-27.) Pursuant to the Order, DWR has conducted monthly coordination meetings with SDWA, USBR, and State Board staff regarding installation and operations of the temporary barriers to improve circulation and water quality in balance with protecting water levels adequate for agricultural diversions.

DWR has also been working with SDWA and State Board staff to investigate sources and patterns of high salinity in the south Delta. DWR contracted with consultant ICF, International, to investigate and evaluate these sources and patterns, and recommend alterative actions that might be taken to reduce salinity measures at the Old River at Tracy Road Bridge (P-12) compliance station. The draft report indicates that higher salinity water

[10] In 2010, the State Water Board modified the compliance schedule of the 2006 CDO in recognition that the NMFS 2009 BiOp prohibited DWR from constructing permanent, operable gates in the southern Delta. These gates were part of a proposed multi-barrier program to improve water levels and circulation in the south Delta and was a central component of DWR and Reclamation's plan to meet the south Delta salinity objectives. The 2010 order extended the schedule of compliance until after review of the Bay-Delta WQCP and subsequent water right proceeding to implement any updated south Delta salinity objectives. The update of the south Delta objectives and water rights implementation proceeding have not yet occurred.

from upstream ends of tidal sloughs Paradise and Sugar Cuts appear to be the dominant sources of increased salinity observed at (P-12). A final report will be available in summer 2016 on DWR's temporary barriers web site at http://baydeltaoffice.water.ca.gov/sdb/index.cfm. The investigation of sources in the draft report of high salinity supports DWR and Reclamation's contention that exceedances of the south Delta objective at compliance station P-12 are the result of actions beyond their reasonable control.

C. REASONS FOR EXCEEDANCES

For the objectives to which the SWP/CVP have reasonable control, the rare occurrence of an exceedance can be explained by the fact that the SWP/CVP often operate to a better level of water quality than required by D-1641 to buffer against potential unpredictable events as outlined in the Real-Time Operations section above. However, the magnitude or suddenness of the event may be too great for the SWP/CVP to respond given the limitations of the tools available to them.

A good example of this would be the SWP/CVP exceedance of the agricultural salinity standard at Jersey Point for a brief period in July of 2015. In mid-July, a strong westerly Delta breeze and low barometric pressure resulted in tidal stages significantly higher than projected which caused a salinity intrusion event. Under more normal hydrologic conditions, SWP/CVP would have been able to drop exports quickly to increase the Net Delta Outflow and manage this salinity intrusion event. Unfortunately, because of the exceptionally dry conditions this past year, SWP/CVP exports were operating at historically low levels in July 2015[11] and therefore were unable to reduce exports further to provide additional outflow. In addition, because of limited supplies in upstream reservoirs, the SWP/CVP were only able to increase releases by a modest amount in an attempt to control the resulting exceedance of the Jersey Point standard. Because of the time it takes for water to flow from upstream reservoirs to the Delta, releases from Folsom Lake and

[11] In the case of the SWP exports in July 2015 exports average less than 300 cfs, which was minimum rate necessary to meet South Bay Aqueduct (SBA) health and safety demands. The SBA contractors are unable to access their SWP demands from San Luis Reservoir because the intake of the SBA is located upstream of San Luis Reservoir, just downstream of Banks Pumping Plant along the California Aqueduct. Typically, SWP exports would be several thousand cfs during the summer months.

Lake Oroville delayed the response time to manage this event and this resulted in a brief exceedance of this Western Delta agricultural standard.

VI. MODIFIED STANDARDS OVER THE PAST 3 YEARS OF DROUGHT

The tabulation of SWP/CVP compliance record did not include exceedances of standards if approval was granted under orders by the State Water Board approving joint TUCPs filed by DWR and Reclamation to modify the SWP/CVP's obligation to meet the requirements. Notable recent examples of these modifications occurred during the past three years of exceptional drought.

The WQCP standards provide for less onerous flow and salinity objectives under dry and critically dry years. However, due to exceptionally dry conditions existing over the past three years, there was insufficient supply to meet these reduced requirements and to also meet all beneficial uses of water in the Sacramento-San Joaquin River basin. As a result, DWR and Reclamation submitted TUCPs to the State Water Board to modify a subset of the Bay-Delta standard obligations contained in D-1641 in 2014 and 2015. These petitions were approved by the State Water Board with only minor modifications.

Exhibits DWR-406, DWR-407, and DWR-408 were prepared at my direction by Michael Anderson, the State Climatologist employed by DWR.[12] The exhibits show the abnormally dry conditions that have occurred over the past four years of exceptional drought. These three graphs, combined with two additional graphs which I compiled, show hydrologic and temperature conditions that are at or beyond the extreme ends of the historical record and should be considered statistical outliers from what would be within the expected range of conditions.

Exhibit DWR-406 depicts the four year running sums of statewide precipitation from 1899 through 2015.[13] As noted on Exhibit DWR-406, the 4-year total ending with 2015 was the driest 4-year period over the entire record and significantly drier than any comparable period in modern times – since 1934.

[12] Exhibits DWR-406 through 408 are true and correct copies of the documents.
[13] Source – Western Regional Climate Center: (http://www.wrcc.dri.edu)

Exhibit DWR-407 is a graph that plots the annual average temperatures on the x-axis versus the annual total precipitation on the y-axis for the Sacramento River watershed.[14] As shown, the last four years of high temperature and low precipitation are at the extreme end of the historic record. Calendar year 2013 was the all-time driest year on record, 2014 was the all-time warmest year on record, and 2015 was an outlier with respect to a combination of both lack of precipitation and high temperature. High temperatures [15]increase evapotranspiration rates of soil and vegetation and reduce snowpack.

Exhibit DWR-408 is a graph that plots average minimum temperatures in the Sierra Nevada[16] on the x-axis versus April 1 snowpack percent of average on the y-axis. Exhibit DWR-408 illustrates how snowpack over each of the past four years has been less than 50% of average. 2014 tied the previous record low snowpack of 25 percent of average which occurred in 1977 only to be surpassed by the snow pack from this past year, which completed shattered that record and was only 5 percent of average April 1 snowpack. In addition, average minimum temperatures for the past two years of have been at the warmest edge of observations going back to 1950. Remarkably, for 2015 the average minimum temperature for the entire Sierra Nevada range was above freezing.

Exhibit DWR-409 is a graph that plots the eight-river full natural flow 4-year average runoff volume for the period of record.[17] The eight rivers are the principal four rivers in the Sacramento River watershed, (Sacramento River at Bend Bridge, the Feather River at Lake Oroville, the Yuba River at Smartsville, and the American River below Folsom Lake) and the four principal rivers in the San Joaquin River watershed, (the Stanislaus River [18]below Goodwin Reservoir, the Tuolumne River below La Grange Reservoir, the Merced River below Merced Falls, and the San Joaquin River at Millerton Lake). In Exhibit DWR-409 the eight-river 4-year averages from 1909 until 2015 have been sorted from highest to

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[14] Source – Western Regional Climate Center: (http://www.wrcc.dri.edu)
[15] Exhibit DWR-409 is a true and correct copy of the document.
[16] Source – California Climate Tracker http://www.wrcc.dri.edu/monitor/cal-mon/
[17] California Data Exchange Center
[18] Exhibit DWR-410 is a true and correct copy of the document.

lowest. As can be seen from Exhibit DWR-409 the 4-year average ending in 2015 was the lowest on record.

Exhibit DWR-410 is a graph that plots the eight-river full natural flow 3-year average runoff volume for the April through July period.[19] April through July represents the peak snowmelt runoff period. As would be expected, there is a strong correlation between snow pack accumulation and April through July runoff. Exhibit DWR-410 shows that the April through July runoff for the three years ending in 2015 was the lowest on record by a wide margin.

The earlier melt of the reduced snowpack in recent years as illustrated by the record low April through July runoff has had a dramatic effect of decreasing the amount of unregulated flow available in the system during the critical late spring and summer periods when it is most needed to help meet Bay-Delta objectives.

## VII. SOUTH DELTA OPERATIONAL CONSTRAINTS ON PROJECT DELIVERIES UNDER BiOps

Diversions from the south Delta SWP/CVP pumping facilities are limited by the restrictions placed on SWP/CVP export operations in the south Delta by the BiOps.[20] These BiOps restrictions focus on reducing the reverse net flow on Old and Middle Rivers just north of the SWP/CVP export facilities from as early as December to as late as June; and San Joaquin River inflow-to-export requirements during the April through May period. These relatively new operating regulations have significantly reduced the overall SWP/CVP delivery capabilities because of coincident timing of periods when excess inflow is entering the Delta and when pumping restrictions for the protections of endangered fishery are deemed necessary by the BiOps at the south Delta diversion locations.

The south Delta export constraints limit diversion of excess flows under excess conditions and the re-diversion of the SWP/CVP's upstream stored water during balanced conditions.

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[19] California Data Exchange Center

[20] BiOps will be discussed in Part 2

As described below, in years of abundant snowpack and surplus upstream storage, the proposed North Delta Diversion (NDD) will add operational flexibility and allow an alternative diversion location for conveying water supplies and avoid potential effects to listed species associated with diversions from the south Delta.

## VIII. CWF WILL ADD SIGNIFICANT NEW FLEXIBILITY TO ENSURE CONTINUED COMPLIANCE

Finally, and most important, the NDD will provide added flexibility in ensuring compliance with flow and salinity criteria required by the State Water Board and any other regulatory obligations for CWF, including for the protection of listed species. The Project Description testimony by Ms. Pierre describes the proposed CWF, including adaptive management that could allow variation in operations. Even with the potential for some variation in operational criteria, the CWF will increase the options available to SWP/CVP operators to more effectively balance the Bay-Delta system in real-time to protect all beneficial uses of water whether for water supply, water quality, or fishery protection purposes.

### A. ENHANCED FLEXIBILITY WITH THE NDD TO MEET REGULATORY REQUIREMENTS

With the NDD, pursuant to D-1641, the SWP/CVP still will be required to meet all salinity and flow objectives regardless of which diversion location is being used. The variable split between north and south diversions will allow for a flexible and improved approach in meeting compliance with flow and salinity standards. For example, if salinity increases were occurring at the Emmaton compliance point on the lower Sacramento River, SWP/CVP could opt to utilize the south Delta diversion location to a greater extent, thereby allowing greater flow to travel down the lower Sacramento River. By contrast if salinity increases were occurring at the Jersey Point compliance point on the lower San Joaquin River, SWP/CVP could decrease the amount of water diverted at south Delta points of diversion and move a greater percentage of the diversions to the NDD thereby limiting reverse flows in the Central Delta near Jersey Point, which may at times have the effect of drawing saltier bay water into the Central Delta. The additional location for SWP/CVP diversions enhances the flexibility of the water management system and would therefore allow SWP/CVP operators to more optimally balance flows for more precise salinity management.

Based on my knowledge and experience it is my opinion that the SWP/CVP will continue to meet existing Delta water quality and fishery objectives and any additional regulatory requirements for the CWF at a similar success rate as demonstrated historically. Increased diversion flexibility afforded through the approval of the CWF would only enhance the capabilities of SWP/CVP to meet existing Bay-Delta requirements. As a result, the proposed CWF operations will continue to be as protective, if not more, of existing beneficial uses as described in D-1641.

B. EXAMPLE OF HOW THE SYSTEM WILL BENEFIT WITH THE CWF

Exhibit DWR-411 is a graph of Delta outflow and CVP/SWP exports from December 1, 2015 through April 30, 2016. Precipitation in the northern part of the State was well above average during much of this period. However, due to the ongoing drought conditions in the fall of 2015, Delta inflows were extremely low and salinity had intruded deeply into the interior Delta. As a result of the extremely dry watershed, above average precipitation in December did not initially produce significant runoff. The salinity profile of the Delta did not change significantly until early January. Not until January 6 did Delta outflow become greater than what was required to meet D-1641 flow and salinity objectives. As sustained rains continued into late January, and again in March, the resulting Delta outflow was significantly greater than required to meet Bay Delta objectives.

At the same time Delta exports were severely limited primarily by operational restrictions necessary to protect the endangered delta smelt and NMFS protected species. The inability of the SWP/CVP to divert these excess flows represents a substantial lost opportunity to provide critically needed water supplies at a time when inflow to the Delta far exceeds that needed to meet water quality objectives. The CWF would have allowed diversion of these excess flows at a location designed to minimize potential effects to sensitive species. The hydrologic conditions that existed this past winter and spring illustrate the potential benefits of the proposed facilities could provide to the State's water supply, particularly in light of the extremely low level of water deliveries allocated in recent years. Allocations to SWP water supply contractors were 35 percent, 5 percent, and 20 percent of requested demand for the years 2013, 2014, and 2015 respectively.

At my direction, my staff has been keeping an on-going estimate of how much additional water could have been diverted from the Delta if CWF were in place with the current hydrologic conditions. This example does not change upstream SWP/CVP operations.

Exhibit DWR-411[21] depicts the actual diversions of both the SWP/CVP as a solid red line and actual Delta outflow as a solid blue line. The graph also depicts the Delta outflow necessary to meet all D-1641 flow and salinity objectives during the entire period with a dashed blue line. In December and the first few days of January the actual Delta outflow was necessary to meet Bay-Delta objectives. However, beginning in early January and continuing through April the accumulated sum of the difference between the actual and required Delta outflow was 4.4 million acre-feet. What is also shown in Exhibit DWR-411 is a potential increase in SWP/CVP diversions if the CWF with its proposed 9,000 cubic feet per second (cfs) diversions were being utilized as a dotted red line and the resulting Delta outflow as dotted blue line. The additional water that could have been diverted is estimated to be 1.2 million acre-feet (MAF) from January 6 through April 30, 2016. If this additional diversion were removed from the actual Delta outflow the result still would be well over three million acre-feet (MAF) of Delta outflow in excess of that necessary to meet the objectives during this period.

Alternative 4A H3 criteria, as described in Ms. Pierre's testimony, was used as part of this conceptual estimate to test any potential impacts to other beneficial users of water.

At my direction, my staff analyzed historical and adjusted salinity conditions assuming the CWF were operating. These adjustments were made using the Department's

[21] Exhibit DWR-411 is a true and correct copy of the document.

Delta Simulation Model (DSM2), which simulates hydrodynamic conditions in the Delta. The salinity conditions with and without the higher export and lower Delta outflow scenario were simulated with DSM2[22]. The differences between the two scenarios can be applied to historical observations to estimate the effects of CWF operations as conceptualized in Exhibit DWR-412. A station which is a good generalized representation of central Delta salinity conditions is the salinity monitoring station on Old River near Bacon Island. Exhibit DWR-412 shows historical salinity conditions and estimates of how these salinity conditions would have changed under a scenario where the CWF alternative 4A H3 were in operation. The high Delta outflows in both scenarios produce very fresh conditions at this location with minimal difference in salinity conditions. The exhibit designates the approximate equivalent levels of M&I chloride standards as described in Table 1 of D-1641. All M&I diversion locations as identified in Table 1 of D-1641 were receiving water quality conditions significantly better than the WQCP objectives under both scenarios for the January through April when the CWF would have enabled higher export rates.

Although the foregone diversions total over 1.2 MAF, this does not necessarily represent an equivalent increase in the total annual SWP/CVP diversions. On average, the annual amount of water diverted and stored by the SWP/CVP, as a result of CWF with the Initial Operational Criteria indicates that the combined SWP/CVP average annual combined diversions may be the same as the no action alternative or may increase up to approximately 500 thousand acre feet (TAF). Though just over 1.2 MAF of water could have been diverted and stored January through April 2016 with the project in place, the proposed operating rules for CWF would require reduced pumping during drier periods in order to protect the environment. CWF would enhance our ability to divert and store water during periods of high excess Delta flows at a location where there is less risk to native fish and fewer effects to Delta water quality. The water supply developed during these periods may be offset in part by reduced pumping at other periods of less favorable hydrology.

## IX. CONCLUSION

[22] Exhibit DWR-412 is a true and correct copy of the document.

Operation of the SWP/CVP occurs in a dynamic and challenging environment. Among other things, SWP/CVP operations are constantly adjusted to compensate for hydrologic and tidal influences to ensure that SWP/CVP remain in compliance with the flow and water quality standards established by the State Water Board to protect other legal users of water as well as the environment.

The new CWF diversion locations will increase the options available to SWP/CVP operators and increase the flexibility to more effectively balance the Bay-Delta system in real-time to protect all beneficial uses of water whether for water supply, water quality, or fishery protection purposes. Based on the successful compliance record of the SWP/CVP and my experience and knowledge, it is my opinion that the compliance with existing or any future flow and water quality standards will be at least as good if not better with these infrastructural enhancements.

In order to assess the long-term effects of the CWF it is necessary to rely on simulation models. Although our state of the art models are not sophisticated enough to replicate the nuances of real-time operations, they do represent the best available tools for analyzing the feasibility of any significant change to the water operation system as is the case with the CWF. The testimony provided by Mr. Munévar and Mr. Nader-Tehrani will provide a discussion of modeling conducted and the analysis of the results.

Executed on this 31st day of May, 2016 in Sacramento, California.

John Leahigh