Groundwater Overdraft in California's Central Valley:
Updated CALVIN Modeling Using Recent CVHM and C2VSIM Representations

By

HEIDI CHOU
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Approved:

____

Jay Lund

____

Timothy Ginn

____

Thomas Harter

Committee in Charge

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Updates have been made to the CALVIN hydro-economic optimization model of California's intertied water supply and delivery system. These updates better reflect water demands, groundwater availability, and local water management opportunities. This update project focused on improving groundwater representation in CALVIN, which included changing CALVIN groundwater parameters based on California Department of Water Resources' (DWR) California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the United States Geological Survey (USGS) Central Valley Hydrologic Model (CVHM) model inputs and results. Using these models, a CALVIN model with updated groundwater representation now exists.

In updating CALVIN, a detailed comparison between C2VSIM and CVHM was conducted and the results are discussed in this thesis. The updated CALVIN model was used to study the effects of different cases of overdraft on Central Valley groundwater basins. When compared to the updated CALVIN model's case of overdraft, ending overdraft in the entire Central Valley results in less available groundwater and higher economic scarcities in all regions, driving the model to use more surface water to try to meet demands and also to use more artificial recharge to even out variability in surface water availability.

Table of Contents

Acknowledgements .... **ii**
Abstract .... **iii**
CHAPTER 1 Introduction **1**
Groundwater in California *1*
CALVIN *1*
Previous CALVIN Studies *2*
CALVIN Groundwater *4*
Previous CALVIN Groundwater Representation *6*
New California Groundwater Modeling Efforts *6*
Project Description *7*
Overview of Thesis *8*
CHAPTER 2 CALVIN Groundwater Representation Based on CVHM **9**
CVHM Description *9*
CVHM Datasets *11*
CVHM Calculation of Terms *12*
Agricultural Return Flow Split 12
Agricultural Reuse 13
Return Flow of Total Applied Water 14
External Flows 15
Pumping Capacity 17
Pumping Lift 17
Storage 18
Calibration Flow 20
Urban Return Flow 21
Discussion *21*
CHAPTER 3 Comparison of Models and Calculated Terms **23**
Calculated Terms Comparison *23*
Agricultural Return Flow Splits 24
Agricultural Reuse Amplitudes 24
Applied Water Return Flow Fractions 25
External Flows 26
Pumping Terms 33
Storage Terms 34
Urban Return Flow 36
Conclusions *37*
CHAPTER 4 CALVIN with Updated Groundwater Representation **38**
Updated CALVIN *38*
Network & Schematic Improvements *39*

Updated CALVIN & Old CALVIN Input Comparisons ... *40*
Agricultural Return Flow, Reuse, and Total Applied Water Return Flow ... 40
External Flows ... 41
Pumping Terms ... 43
Storage Terms ... 44
Artificial Recharge ... 45
Urban Return Flow ... 47
Agricultural Water Demands ... 47

Calibration Summary ... *49*
Calibration Steps ... 49
UPDATED CALVIN C2VSIM Base Calibration ... 50
UPDATED CALVIN Delta Exports and Pumping Calibration ... 54

UPDATED CALVIN Results ... *55*
Targets, Deliveries, and Scarcities ... 55
Water Deliveries and Recharge ... 57
Change in Storage ... 58
System Costs ... 60

Results Summary ... *61*

Conclusions ... *62*

CHAPTER 5 Groundwater Overdraft in California's Central Valley ... 63

Background ... *63*

Case Description ... *63*

CALVIN Study Results ... *65*
Water Scarcity and Deliveries ... 65
Recharge ... 69
Storage ... 71
Willingness-to-pay and Scarcity Costs ... 74
Operating Costs ... 76

Results Summary ... *77*

Conclusions ... *78*

CHAPTER 6 Conclusions ... 80

CALVIN Improvements ... *80*
Central Valley ... 81
Delta Pumping ... 81
Network and Schematic ... 81

Conclusions from CALVIN Modeling ... *81*

Limitations and Further Work ... *82*

References ... 84

Appendix 1 CVHM Groundwater Term Calculations ... 88

Agricultural Return Flow Split ... *88*

Agricultural Reuse ... *90*

Return Flow of Total Applied Water *90*
External Flows: Inter-basin Flows *90*
External Flows: Stream Leakage *91*
External Flows: Deep Percolation from Precipitation *92*
External Flows: Boundary Inflow *93*
External Flows: Evapotranspiration / Non-recoverable losses *93*
Net External Flows *94*
Maximum Pumping Capacity *95*
Representative depth to Groundwater (Pumping Lift) *96*
Maximum Storage Capacity *97*
Initial & Ending Storage Capacity *98*
Appendix 2 Groundwater Pumping Lift Cost Calculation 100
Technical Note: Pumping Lift from DWR Well Data *101*
Introduction 101
Method 101
Results 103
Appendix 3 CALVIN Schematic & Network Improvements 105
Appendix 4 C2VSIM Streamflow Adjustments 107
Appendix 5 C2VSIM Surface Water Recoverable and Non-recoverable Losses ... 110

List of Tables

Table 1.1: Previous CALVIN Studies 3
Table 1.2: Groundwater Data Required by CALVIN for each GWSB 5
Table 2.1: CVHM layer thicknesses and depths 10
Table 2.2: CVHM Datasets 12
Table 2.3: Summary of Central Valley, California, crop categories and properties 13
Table 2.4: CVHM Agricultural Return Flow Splits, Composite Efficiencies, and Amplitudes of Return flow of Total Applied Water 14
Table 2.5: Average Annual 1980-1993 CVHM-CALVIN External Flows 16
Table 2.6: CVHM Pumping Terms and DWR Measured Well Depths 18
Table 2.7: CVHM Storage Capacity, Initial & Ending Storage, and Change in Storage . 19
Table 2.8: 13-year Average Annual Groundwater Mass Balance 21
Table 3.1: Agricultural Return Flow Splits to Groundwater 24
Table 3.2: Agricultural Reuse Amplitudes & Applied Water Return Flow Fractions 25
Table 3.3: Average Annual (1980-1993) Net External Flows 26
Table 3.3a: Average Annual Net External Flow Averages 28
Table 3.3b: Average Annual External Flows – Interbasin and Boundary Flows 29
Table 3.3c: Average Annual External Flows - Deep Percolation from Streams, Lakes, & Precipitation 30
Table 3.3d: Average Annual External Flows – Subsidence, Diversion Gains, and Losses from Groundwater 32
Table 3.4: Pumping Capacities and Depths 33
Table 3.5: Maximum Storage Capacity, Initial Storage, and Change in Storage 35
Table 3.6: Urban Return Flow Fractions 36
Table 4.1: Groundwater Data Required by Updated CALVIN 39
Table 4.2: UPDATED CALVIN and OLD CALVIN 40
Table 4.3: UPDATED CALVIN Return Flow to Groundwater, Reuse, and Applied Water Return Flow 41
Table 4.4: Net External Flow Averages Compared 43
Table 4.5: UPDATED CALVIN Pumping Terms Comparison 44
Table 4.6: UPDATED CALVIN Storage Terms and Overdraft 45
Table 4.7: Surface Water Diversion for Spreading 46
Table 4.8: Artificial Recharge Operation Costs 47
Table 4.9: Average Annual Agricultural Water Delivery Targets 48
Table 4.10: Average Annual Old CALVIN Calibration Outflow 49
Table 4.11: CALVIN Calibration Runs 50
Table 4.12: Average Annual Agricultural Water Scarcity Comparison 51
Table 4.13: Surface Water Diversion Capacity Calibration Adjustments 52
Table 4.14: Adjustments to Groundwater Terms 53
Table 4.15: Delta Pumping Constraints and Minimum Delta Outflow 54
Table 4.16: Average Annual Delta Pumping Results 55

Table 4.17a: UPDATED CALVIN and OLD CALVIN Agricultural Targets, Deliveries, and Scarcities 56
Table 4.17b: UPDATED CALVIN and OLD CALVIN Urban Targets, Deliveries, and Scarcities 57
Table 4.18: Average Annual Groundwater Pumping, Surface Water Deliveries, Groundwater Return Flow, and Artificial Recharge Results 58
Table 4.19: Average Annual Central Valley System Costs 61
Table 4.20: Updated CALVIN Summary – Average Annual Results 62
Table 5.1: Overdraft Cases Description 64
Table 5.2: 1921 – 1993 Overdraft Cases 65
Table 5.3: Overdraft Study Results – Average Annual Agricultural Water Scarcities 66
Table 5.4: Overdraft Study Results – Average Annual Delta Exports 67
Table 5.5: Overdraft Study Results – Average Annual Agricultural Water Deliveries 68
Table 5.6: Overdraft Study Results – Average Annual Urban Water Deliveries and Scarcities 69
Table 5.7: Overdraft Study Results – Recharge flows to Groundwater 71
Table 5.8: Overdraft Study Results – Average Annual Marginal Central Valley Agricultural Willingness-to-pay and Scarcity Costs 75
Table 5.9: Overdraft Study Results – Average Annual Central Valley System Costs 77
Table 5.10: Overdraft Study Summary – Average Annual Results 78
Table 6.1: Improvements to CALVIN 80
Table A1.1: Agricultural Return Flow Fractions to Groundwater and Surface Water 89
Table A1.2: Return Flow Fraction of Total Applied Water 90
Table A1.3: Average Annual Inter-basin Flow 90
Table A1.4: Average Annual Stream Leakage 91
Table A1.5: Average Annual Deep Percolation from Precipitation 92
Table A1.6: Average Annual Boundary Inflow 93
Table A1.7: Average Annual ET from Groundwater 94
Table A1.8: Average Annual External Flows 94
Table A1.8: Agricultural Maximum Monthly Pumping 95
Table A1.9: Groundwater Pumping Lift 96
Table A1.10: Maximum (Effective) Storage 97
Table A1.11: Initial Storage 98
Table A2.1: Estimated Agricultural Pumping Costs 100
Table A2.2: Average GSWS (feet) for measurements taken in 2000, Fall 2000, Spring 2000 and the total count of measurements used for the Year 2000 average 104
Table A4.1: Adjusted monthly flows to depletion and accretion areas in the Central Valley due to changes in historical streamflow exchanges before 1951 107
Table A4.2: Annual Average Net External Inflows in the Central Valley 108
Table A5.1: Surface Water Recoverable & Non-Recoverable Loss Amplitudes 110

List of Figures

Figure 1.1: CALVIN Coverage Area and Network 2
Figure 1.2: Groundwater Basins Modeled in CALVIN 4
Figure 1.3: Flows and Interactions in CALVIN Groundwater Sub-basins 5
Figure 2.1: Generalized hydrogeologic section (A-A') 10
Figure 2.2: Inflows and outflows simulated by the FMP 11
Figure 2.3: Groundwater Mass Balance Flows 20
Figure 3.1: 1980-1993 Average Annual Net External Flows 27
Figure 4.1 Updated CALVIN Groundwater Schematic 39
Figure 4.2: UPDATED CALVIN Sacramento Region Change in Storage 59
Figure 4.3: UPDATED CALVIN San Joaquin Region Change in Storage 59
Figure 4.4: UPDATED CALVIN Tulare Region Change in Storage 60
Figure 5.1: Overdraft Study Results – Sacramento Region (Basins 1-9) Storage 72
Figure 5.2: Overdraft Study Results – San Joaquin Region (Basins 10-13) Storage 73
Figure 5.3: Overdraft Study Results –Tulare Region (Basins 14-21) Storage 73
Figure A2: Distribution of wells measured in 2000 used for pumping lift estimate 103
Figure A3.1: Updated CALVIN Schematic for Agricultural Sector 106
Figure A3.2: Updated CALVIN Schematic for Urban Sector 106

CHAPTER 1

Introduction

This project included updating CALVIN's representation of Central Valley groundwater and revising some aspects of the CALVIN model framework to achieve more clarity in the terms representing groundwater conditions; this lays a streamlined framework for future CALVIN groundwater updates. With surface water reliability decreasing in California, groundwater continues to play a larger role in water supply. And because there is still much uncertainty in how much groundwater is actually available in California, this hydro-economic approach to modeling groundwater can be useful for water planners and managers. Using the updated model, several overdraft scenarios were examined to see how overdraft economically and physically affects Central Valley groundwater conditions and water users.

Groundwater in California

Groundwater provides about 30 percent of California's water demands in a normal year. In drought years and in the Central Valley, dependence on groundwater is even higher. An estimated 15 million acre-feet of water is pumped per year, which is more than what is being recharged, causing overdraft in some areas (Faunt et al. 2009; DWR 2003). Overdraft has negative effects on water quality, increases pumping costs, causes land subsidence, and eventually decreases groundwater availability. DWR estimates the overdraft in the state's groundwater basins to be one to two million acre-feet annually, mostly in the Tulare Basin. Even with substantial overdraft, there are no statewide regulations on groundwater pumping (DWR 2003). Groundwater availability in the Central Valley is particularly important for droughts, when the absence of surface water brings water users to pump more groundwater. The storage capacity in the Central Valley's aquifers is much larger than the water storage capacity of its surface water reservoirs, making groundwater pragmatic for long-term drought water storage.

CALVIN

CALVIN, the CALifornia Value Integrated Network model is an economic-engineering optimization model of California's water system. It covers 92% of California's population and 90% of the irrigated crop area (Howitt et al. 2012). The model uses a network flow optimization solver developed by the U.S. Army Corps of Engineers to provide results on surface and groundwater operations, and water use allocations based on maximizing statewide net economic benefit, or minimizing statewide water operations and scarcity costs. There are operating costs associated with infrastructure links in the system and scarcity costs are calculated from each area's water delivery demands. The current network consists of 41 urban demand areas, 25 agricultural demand areas, 44 reservoirs, 31 groundwater basins, and 1,767 links. Figure 1 shows the CALVIN coverage and network.

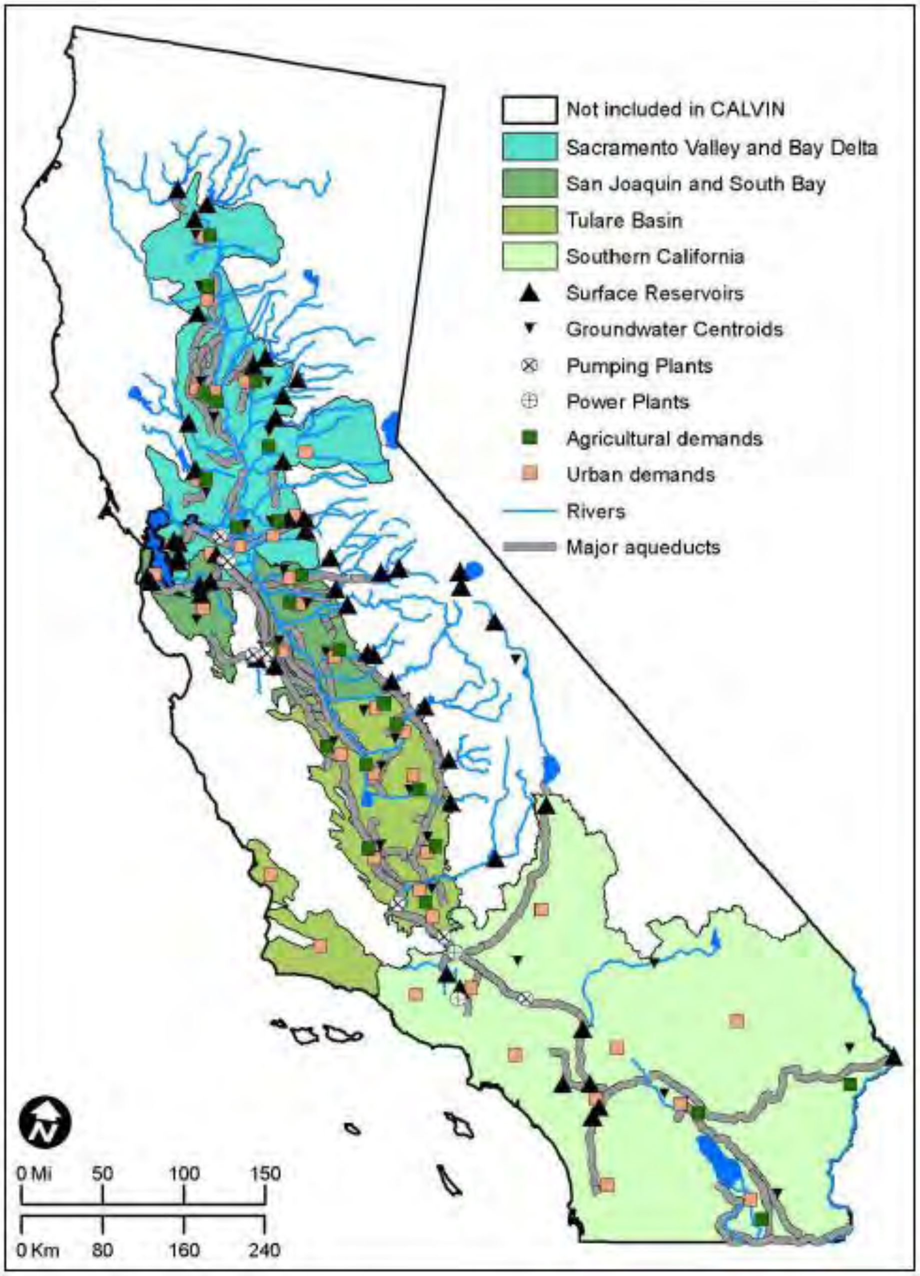


Figure 1.1: CALVIN Coverage Area and Network

Previous CALVIN Studies

CALVIN has been used to study a wide variety of different California water problems including infrastructure, water use, climate change, policy, and now–overdraft. These previous CALVIN studies are described in Table 1.1. This groundwater update project is the first major study of changes to CALVIN's Central Valley groundwater system since the model was developed in 2001.

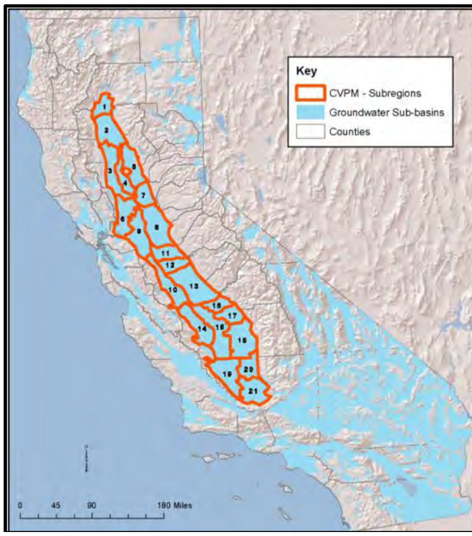
Table 1.1: Previous CALVIN Studies

Description	**Citation**
Integrated water management, water markets, capacity expansion, at regional and statewide scales	Draper et al. (2003); Jenkins et al. (2001; 2004); Newlin et al. (2002)
Conjunctive use and southern California	Pulido et al.(2004)
Hetch Hetchy restoration	Null (2004); Null and Lund (2006)
Perfect and limited foresight	Draper (2001)
Climate warming, wet and dry	Lund et al. (2003); Tanaka et al.(2006; 2008)
Climate warming, dry	Medellín-Azuara et al.(2008a; 2009)
Climate warming, dry and warm-only	Medellín-Azuara et al.(2008a; 2009); Connell (2009)
Severe sustained drought impacts and adaptation (paleodrought)	Harou et al. (2010)
Increasing Sacramento River outflows	Tanaka and Lund (2003)
Reducing Delta exports and increasing Delta outflows	Tanaka et al.(2006; 2008; 2011); Lund et al.(2007; 2008)
Colorado River delta and Baja California water management	Medellín-Azuara et al.(2006; 2007; 2008b)
Ending overdraft in the Tulare Basin	Harou and Lund (2008)
Cosumnes River restoration and Sacramento metropolitan area water management	Hersh-Burdick (2008)
Bay Area adaptation to severe climate changes	Sicke (2011)
Urban water conservation with climate change and reduced Delta pumping	Ragatz (2011)
Economic Responses to Water Scarcity in Southern California	Bartolomeo (2011)

(Adapted from Lund et al, 2010)

CALVIN Groundwater

Central Valley groundwater basins in CALVIN are represented by the Central Valley Production Model (CVPM) subregions as shown in Figure 1.2.



Subregion	Location
1	Redding Basin
2	Chico Landing to Red Bluff
3	Colusa Trough
4	Colusa Landing to Knight's Landing
5	Lower Feather R. and Yuba R.
6	Sacramento Valley Floor, Cache Cr., Putah Cr., Yolo BP
7	Lower Sacramento R. below Verona
8	Valley Floor east of Delta
9	Sacramento -San Joaquin Delta
10	Valley Floor west of San Joaquin River
11	Eastern San Joaquin Valley above Tuolumne R.
12	Eastern Valley floor between San Joaquin R. & Tuolumne R.
13	Eastern Valley floor between San Joaquin R. & Merced R.
14	Westland
15	Mid-Valley Area
16	Fresno Area
17	Kings R. Area
18	Kaweah R. and Tule R. Area
19	Western Kern County
20	Eastern Kern County
21	Kern R. Area

Figure 1.2: Groundwater Basins Modeled in CALVIN

Since CALVIN is an optimization-based system engineering model, groundwater heads are not represented as in a groundwater model; changes in groundwater volumes are modeled instead (Draper et al. 2003). For each subregion, flows, volumes, and fractions have been extracted, calculated, and/or estimated from physical simulation groundwater models and inputted as parameters into CALVIN to represent the interactions within the subregions and storage volumes of these basins. These parameters are summarized in Table 1.2. More detailed descriptions of these terms and their calculations are found in Chapter 2 and Appendices 1, 2, and 4. Figure 1.3 describes the terms and how groundwater interacts in CALVIN.

Table 1.2: Groundwater Data Required by CALVIN for each GWSB

Item	Data for CALVIN	Data type
1	Agricultural return flow split (GW & SW)	Fraction (1a+1b=1)
2	Internal reuse	Amplitude (≥1)
3	Return flow of total applied water	Amplitude (<1)
4	External flows	Monthly time series
4-1	Inter-basin flows	Monthly time series
4-2	Deep percolation from streams and lakes	Monthly time series
4-3	Deep percolation from precipitation	Monthly time series
4-4	Boundary inflow	Monthly time series
4-5	Subsidence	Monthly time series
4-6	Gains from diversions (conveyance seepage)	Monthly time series
4-7	Non-recoverable losses	Monthly time series
5	Groundwater pumping capacity (maximum & minimum)	Number value
6	Depth to groundwater (pumping lift) for pumping cost	Number value & cost ($)
7	Initial Storage	Number value
8	Ending Storage	Number value
9	Storage capacity (maximum & minimum)	Number value
10	Calibration Flows	Monthly time series
11	Urban return flow	Amplitude (<1)

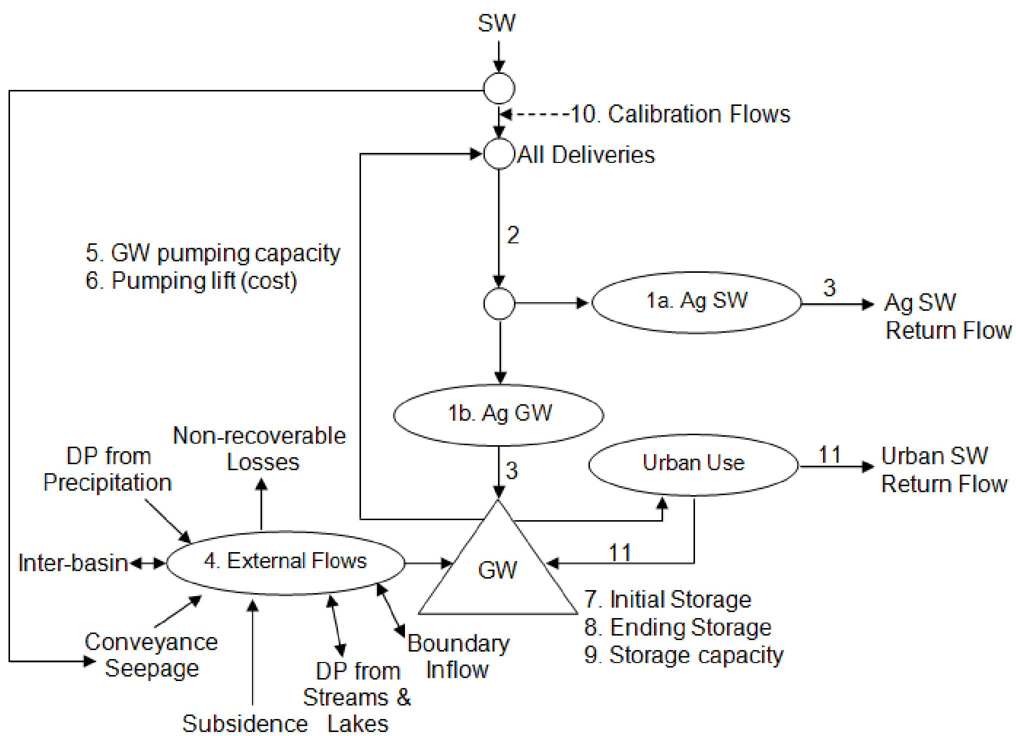


Figure 1.3: Flows and Interactions in CALVIN Groundwater Sub-basins

As seen in Figure 1.3, surface water and pumped groundwater come together at a node which represents all water deliveries to demand areas. These deliveries are then split between agricultural surface water and agricultural groundwater demands (term #1). A re-use amplitude (term #2) can be specified prior to this split. Following the water delivered to the surface water and groundwater demand areas, the return flow fraction (term #3) is the fraction of the water not used by the crops and is returned to groundwater or surface water. The external flows (term #4) include deep percolation from precipitation, inter-basin flows, boundary flows, stream leakage, subsidence, conveyance seepage, and non-recoverable losses (i.e. evapotranspiration and tile drain flows). Water pumped from the groundwater basin has capacity constraints (term #5) and also a pumping lift (term #6) to calculate pumping cost. The groundwater basin itself has initial, ending, minimum, and maximum storage constraints (terms #7-9). Any flows needed to maintain mass balance in the system or allow for feasible results are considered "Calibration flows" (term #10), which are added or removed prior to the delivery node to ensure that the appropriate amount of water can be delivered to the demand areas; calibration flows can be positive or negative. Such calibration flows also help reflect uncertainty in our understanding of California's hydrology. Urban return flow (term #11) is also represented as an amplitude, like term #3.

Previous CALVIN Groundwater Representation

Prior to this update project, CALVIN's groundwater representation was based on pre- and post-processing data and results from the Central Valley Ground Surface Water Model (CVGSM) 1997 No Action Alternative (NAA) run (USBR 1997). CVGSM is a special application of the Integrated Ground Surface Water Model (IGSM) to the Central Valley of California, used in the Central Valley Project Improvement Act (CVPIA) Programmatic Environmental Impact Statement (PEIS) of 1992. A description of CVGSM representation of CALVIN groundwater can be found in Jenkins et al. 2001 and Davis et al. 2001 (Appendix J).

Since CVGSM was used for CALVIN groundwater, new studies have shown that some of the old IGSM algorithms are very different from those used in MODFLOW, whose algorithms are widely tested and established, bringing some question in whether or not this version of IGSM's solutions are a good representation of the hydrologic system it is modeling (LaBolle et al. 2003). Considering that new and improved models like CVHM and C2VSIM (CVGSM's successor) have been developed, it was decided to update CALVIN groundwater based on one of the new, more detailed models. The groundwater terms calculated from the CVGSM model are compared with the new calculated terms from CVHM and C2VSIM in Chapter 3.

New California Groundwater Modeling Efforts

Several groundwater modeling efforts for California's Central Valley exist and are on-going. The Department of Water Resources (DWR) has developed and continues to update a groundwater model of California's Central Valley called the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) using the Integrated Water Flow Model (IWFM) (Brush et al. 2008). In addition, the United States Geological Survey (USGS) also developed a groundwater model for the Central Valley using MODFLOW and published its development in Professional Paper 1766 in 2009 (Faunt et al. 2009). This model also continues to be developed. These two models have been studied extensively to draw data and results for improving CALVIN's groundwater representation. C2VSIM, CVHM, and CVGSM (old CALVIN) use the same subregion definitions (CVPM regions) for groundwater basins, allowing for direct comparisons of data and results.

Using MODFLOW and the FMP, CVHM simulates key groundwater and surface water processes in the Central Valley for the 21 water-balance regions for water years 1962 to 2003. The model is based on year 2000 land use. A Geographic Information System (GIS) was used to develop a geospatial database to manage the data. The model is divided horizontally into a square grid of 20,000 square mile cells, and vertically into 10 layers, ranging in thickness from 50-750 feet. A geologic texture model was developed for CVHM to better characterize the Central Valley aquifer system. More information on CVHM is in Chapter 2 and Faunt et al. 2009.

Using the 3-D finite element code IWFM, C2VSIM simulates groundwater flow and groundwater-surface water interactions for the 21 subregions on a monthly basis from water years 1921 to 2003. The model is represented by three layers of 1392 elements. More information on C2VSIM can be found in Brush et al. 2008.

Although there are similarities in the two models' hydrologic inputs, the models operate differently and the outputs and results are significantly different in some areas. Some differences and the effects of those differences on this application to CALVIN are discussed here. A detailed comparison of the theory, approaches, and features of the two models can be found in Dogrul et al. 2011.

Project Description

This CALVIN groundwater update had several steps. First, CALVIN groundwater parameters were identified. Data for these parameters was then estimated based on C2VSIM and CVHM inputs and outputs for use and comparison with the previous CALVIN model (CVGSM) estimates. Following comparisons of these parameter estimates, separate simplified CALVIN model runs were conducted using these parameter values from each groundwater model. These results were compared and the decision was made to primarily use C2VSIM for the final CALVIN groundwater representation mostly due to C2VSIM's longer historical modeling period. Next, calibration of the 72-year CALVIN model based on C2VSIM was done and a new CALVIN model with updated groundwater representation based on C2VSIM emerged. Finally, additional studies were done by adjusting the overdraft scenarios based on CVHM and other simulated scenarios.

The major steps in this groundwater update project are summarized as follows:

1. Estimate, calculate, and/or extract terms from CVHM and C2VSIM to use as parameters (Table 1.2) for CALVIN update
2. Compare CVHM and C2VSIM terms and methods with CALVIN representation to determine which parameters from which model are to be used for the final CALVIN Groundwater update. Options included: CVHM, C2VSIM, or a combination of CVHM and C2VSIM.
3. Run the CALVIN model
4. Calibration of CALVIN model to ensure feasible and reasonable results
5. Additional overdraft studies to test updated model

Overview of Thesis

This thesis work updated CALVIN groundwater representation in the Central Valley and also improved many aspects of the CALVIN model. Chapter 2 describes CALVIN groundwater input terms and the groundwater representation based on CVHM. Chapter 3 discusses and compares the groundwater input terms from C2VSIM, CVHM, and CVGSM. Chapter 4 presents the updated CALVIN model with Central Valley groundwater representation primarily based on C2VSIM and the calibration process that resulted in the final updated model from this research project. This chapter also presents a comparison between the updated CALVIN model with the version of the model prior to the update. Chapter 5 applies the updated model to investigate the economic and physical effects of different cases of overdraft in the Central Valley. Finally, Chapter 6 summarizes the results from this research project, discusses the limitations, and presents some ideas for future work on the CALVIN model.

CHAPTER 2

CALVIN Groundwater Representation Based on CVHM

This chapter discusses the CVHM model and how it was used to calculate the groundwater input terms for CALVIN. This chapter also provides a description of the groundwater terms used for CALVIN and the CVHM calculated term results. Although CVHM was ultimately not used as the primary basis for Central Valley groundwater representation in CALVIN, studying the CVHM calculation of the groundwater terms was very useful for understanding CALVIN groundwater and the CVHM results were used for comparisons during model calibration (discussed in Chapter 4).

CVHM Description

CVHM was developed by the United States Geological Survey (USGS) to support a study assessing groundwater availability in California's Central Valley. This study, described in Faunt et al. 2009, had 3 major objectives:

1. To develop a better understanding of the freshwater-bearing deposits of the Central Valley; this objective was achieved by developing a new texture model.
2. To use improved water-budget analysis techniques to estimate water-budget components for the groundwater flow system in areas dominated by irrigated agriculture; this objective was achieved through the development of the Farm Process (FMP) to be used in conjunction with MODFLOW-2000 (MF2K).
3. To quantify the Central Valley's groundwater-flow system; this objective was accomplished by developing CVHM, which links the texture and landscape-process models with the groundwater-flow process model.

CVHM builds on many previous studies, but is primarily an update to the USGS Central Valley Regional Aquifer System and Analysis (CV-RASA), with the major update components being incorporating MODFLOW-2000 with the FMP into the model and spatial re-discretization of the model to finer spatial scales. Table 2.1 describes the model layer thicknesses and depths and Figure 2.1 shows a generalized vertical hydrogeologic cross section of the groundwater flow system. Figure 2.2 shows the farm process balance of the groundwater system. A detailed description of the CVHM development can be found in Faunt et al. 2009.

Table 2.1: CVHM layer thicknesses and depths (Table A3 from Faunt et al. 2009)

[Layers 4 and 5 represent Corcoran Clay where it exists; elsewhere a 1 foot thick phantom layer; they are kept only to keep track of layer numbers]

Layer	Thickness (feet)	Depth to base outside Corcoran Clay (feet)	Texture figure
1	50	50	A9(a)
2	100	150	—
3	150	300	A9(b)
4	Variable	301	A9(c)
5	Variable	302	A9(c)
6	198	500	A9(d)
7	250	750	—
8	300	1,050	—
9	350	1,400	A9(e)
10	400	1,800	—

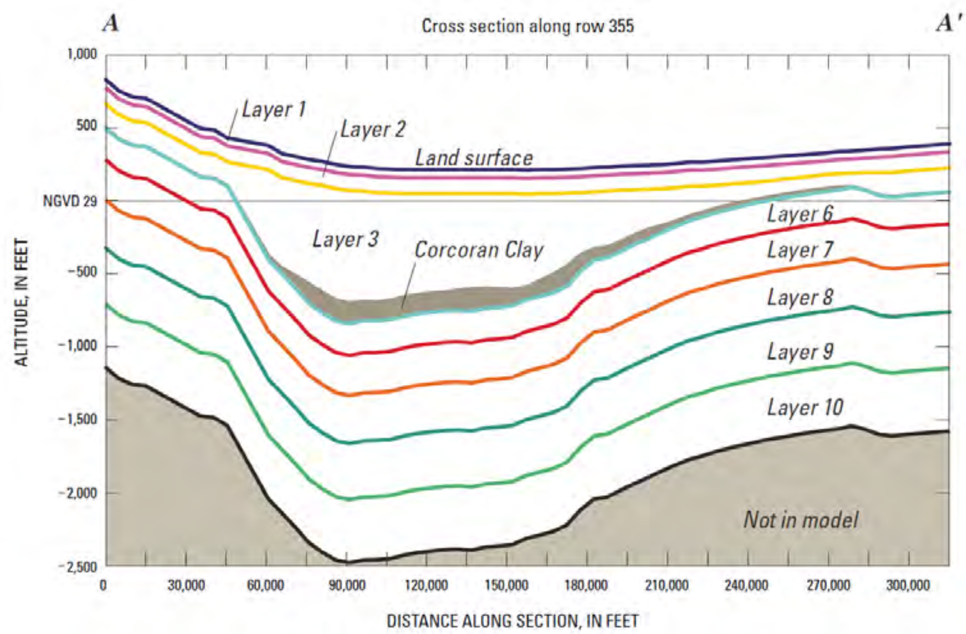


Figure 2.1: Generalized hydrogeologic section (A-A') (Figure A11 from Faunt et al. 2009)

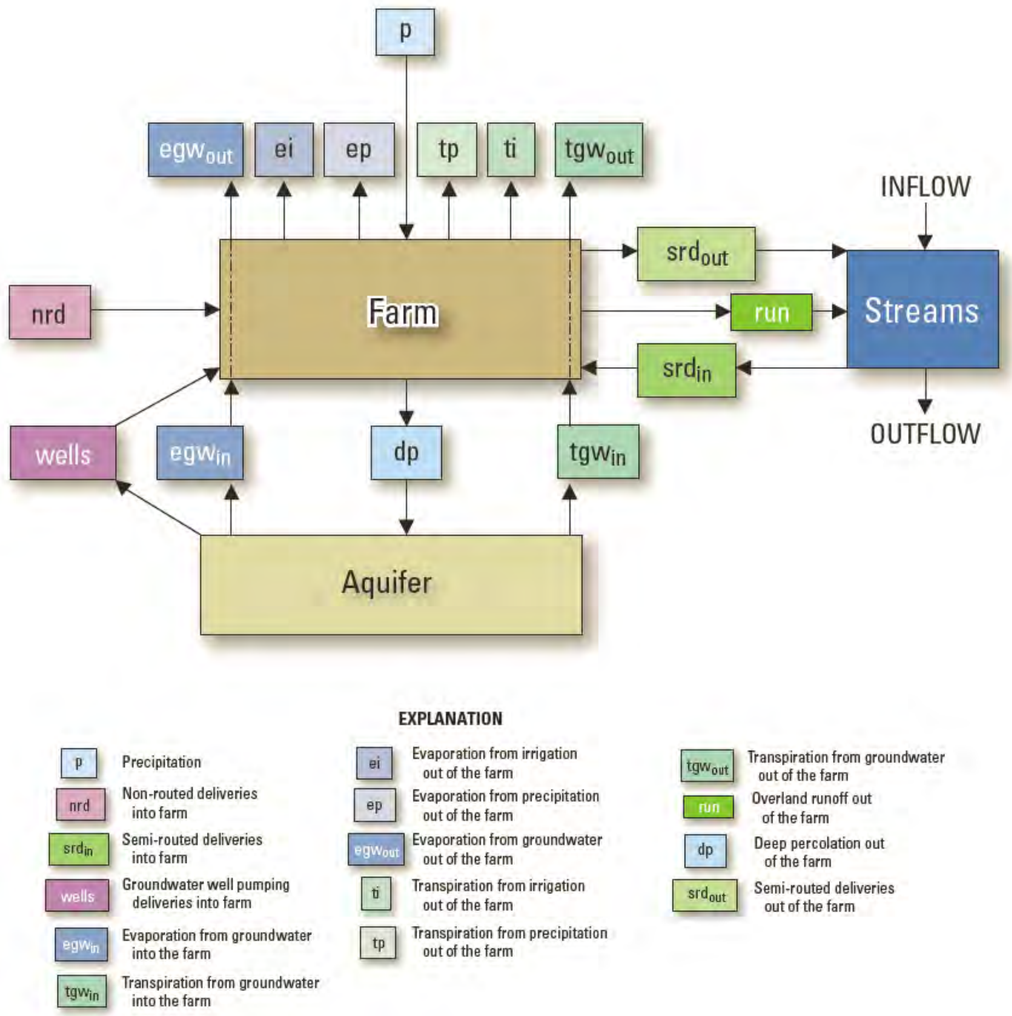


Figure 2.2: Inflows and outflows simulated by the FMP (Figure C5 from Faunt et al. 2009)

CVHM Datasets

Using pre- and post-processor results from CVHM, the parameters for CALVIN groundwater representation were calculated. The parameters were calculated for three different sets of data. The first set of data is based only on the data from 1980-2003 to focus on the time period after most major infrastructure changes in California ("CVHM Hist 1980-2003"). The second set of data is calculated from the entire historical time series (1961-2003) of the CVHM results ("CVHM Hist"). The third set of data is based on a CVHM run made with updated land use based on year 2000 ("CVHM 2000"). However, this run showed some obvious problems in Region 21 (in southern Tulare basin) and was ultimately not used, but its results were used for comparisons between the different CVHM datasets (Appendix 1).

Different approaches were taken when calculating the CALVIN groundwater parameters. The parameters summarized in this section will primarily be for calculations from results from the Zonebudget post-processor ("CVHM"), which estimates a mass balance for each region. Other versions of these calculations include results from FB_details.OUT and other input files, but these ultimately were not chosen to represent CVHM since it involved using terms from different post-processors that did not result in mass balance. However, these calculations still reflect reasonable methods to calculate these terms so some descriptions and results are summarized in Appendix 1. The calculations that were independent of these post-processors have the same results regardless of dataset. A summary of the different sets of CVHM data is shown in Table 2.2. This chapter presents and discusses the results used for CVHM to compare with C2VSIM and CVGSM.

Table 2.2: CVHM Datasets

Dataset name	Description
CVHM Historical (1980-2003) "CVHM Hist 1980-2003"	Based on historical CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1980-2003.
CVHM Historical (1961-2003) "CVHM Hist"	Based on historical CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1961-2003.
CVHM 2000 Land Use (1961-2003) "CVHM 2000"*	Based on an updated 2000 land use CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1961-2003.
CVHM Historical ZB (1980-1993) "CVHM"	Based on historical CVHM run using Zonebudget post-processor; averages based on 1980-1993. Used as final CVHM result for CALVIN comparisons with other groundwater models.

*Note that this run had obvious problems in some of the Tulare Basin regions so the results from this run were ultimately not used for any formal comparison.

CVHM Calculation of Terms

This section summarizes methods used to calculate the terms and the resulting values used for the final comparison between CVHM and the other models. For each term, there is a brief description followed by some tabulated results of calculated values. More details on these terms, alternative calculation methods, and a comparison of these terms' results are in Appendix 1.

<u>Agricultural Return Flow Split</u>

The agricultural return flow split term represents the fate of applied water that is not consumed by crops or other consumptive uses. Return flow may return either to groundwater by deep percolation or to surface water. This term defines the fraction of agricultural use which returns to surface water (1a) and to groundwater (1b) as shown in Figure 1.3. Applied water is the amount of water used to meet demands.

Using the crop categories and properties in Table 2.3 and the corresponding subregion index data in the model input files, the splits to surface water and groundwater return flows were estimated. Based on the crop distribution file from the input files (a matrix of crop category numbers), the average of all the fractions of surface water runoff from irrigation for each subregion was taken. This results in the proportion of return flow to surface water. The proportion of return flow to groundwater is 1 minus this value. CALVIN takes only one fraction for surface water and one fraction for groundwater for each region over the model time period; these split fractions do not change over time in CALVIN. The results are shown in Table 2.4.

Table 2.3: Summary of Central Valley, California, crop categories and properties (from Table C4 from Faunt et al 2009)

Virtual crop category #	Land Use	Fraction of SW Runoff from Precipitation	Fraction of SW Runoff from Irrigation
1	Water	0.050	0.010
2	Urban	0.015	0.010
3	Native classes	0.207	0.010
4	Orchards, groves, and vineyards	0.102	0.010
5	Pasture/Hay	0.102	0.017
6	Row Crops	0.102	0.061
7	Small Grains	0.102	0.045
8	Idle/fallow	0.060	0.010
9	Truck, nursery, and berry crops	0.102	0.100
10	Citrus and subtropical	0.102	0.010
11	Field crops	0.102	0.077
12	Vineyards	0.013	0.012
13	Pasture	0.102	0.017
14	Grain and hay crops	0.102	0.045
15	Semiagricultural	0.323	0.350
16	Deciduous fruits and nuts	0.107	0.048
17	Rice	0.011	0.030
18	Cotton	0.102	0.102
19	Developed	0.102	0.078
20	Cropland and pasture	0.102	0.078
21	Cropland	0.102	0.078
22	Irrigated Row and Field Crops	0.102	0.068

Agricultural Reuse

CVHM does not explicitly "reuse" water locally for repeated irrigation. This might be included in future versions of the model, but is not in the version used here. As far as basic representation of this term using CVHM, 1 is used for all regions indicating no reuse, meaning water delivered to the region is the same as the applied (and re-applied) water in the region.

Return Flow of Total Applied Water

This term represents the return flow of total applied water, which applies to return flow to both surface water and groundwater. This term can be calculated by using given information on irrigation efficiencies (evapotranspiration of applied water, ETAW). In CVHM, the irrigation efficiencies are specified as a matrix of efficiencies for each subregion and each crop for each monthly stress period. The efficiencies vary from crop to crop for different subregions and they change through time. Table C6 from Faunt et al. 2009 gives the average area-weighted composite efficiency, by decade, for each subregion. Using the values from Table C6, the Return Flow of Total Applied Water is calculated as follows: Return Flow (%) = 1-ETAW (%). The composite efficiency and return flow of total applied water values for year 2000 are in columns 4 and 5 in Table 2.4.

Table 2.4: CVHM Agricultural Return Flow Splits, Composite Efficiencies, and Amplitudes of Return flow of Total Applied Water

Subregion	Agricultural Return Flow Split to GW	Agricultural Return Flow Split to SW	Composite Efficiency (fraction to ETAW)	Return Flow of Total AW
1	0.99	0.01	0.74	0.26
2	0.98	0.02	0.73	0.27
3	0.97	0.03	0.83	0.17
4	0.96	0.04	0.79	0.21
5	0.97	0.03	0.8	0.2
6	0.97	0.03	0.77	0.23
7	0.98	0.02	0.77	0.23
8	0.98	0.02	0.75	0.25
9	0.96	0.04	0.78	0.22
10	0.95	0.05	0.79	0.21
11	0.97	0.03	0.77	0.23
12	0.96	0.04	0.76	0.24
13	0.97	0.03	0.79	0.21
14	0.92	0.08	0.87	0.13
15	0.94	0.06	0.76	0.24
16	0.98	0.02	0.81	0.19
17	0.97	0.03	0.8	0.2
18	0.96	0.04	0.79	0.21
19	0.97	0.03	0.77	0.23
20	0.97	0.03	0.81	0.19
21	0.96	0.04	0.81	0.19

External Flows

The External Flows time series is the sum of several source flows into and out of the groundwater subregion, excluding pumping and recharge of agricultural applied water, which are represented separately in CALVIN. These flows include groundwater-surface water interactions (stream leakage), inter-basin groundwater flows, deep percolation from precipitation, boundary inflows, subsidence, and evapotranspiration/non-recoverable losses. The sum of these individual time series comprise the net external flows monthly time series that are used as input source flow in CALVIN.

Inter-basin flows represent the groundwater flow between subregions. For CVHM, these numbers were extracted from ZoneBudget output, “Inter-zone.” Positive values are flow into the groundwater subbasin and negative values are flows out of the basin to adjoining basins.

Stream leakage flows represent groundwater-surface water interaction within each region. These values are extracted from the ZoneBudget output, **“**Stream Leakage.” Positive values are flows into the groundwater subbasin and negative values are flows out of groundwater to surface water flow.

Deep percolation of precipitation is the volume of water percolating into groundwater from precipitation. This term was estimated using fractions calculated from the FB_details.OUT and applying those fractions to the Zonebudget “Farm Net Recharge” term. Using FB_details.OUT, the fraction $ET_{precip} / (ET_{irrig} + ET_{precip})$ was computed, where ET_{irrig} is the evapotranspiration from irrigation (applied water) and ET_{precip} is the evapotranspiration from precipitation (also called effective precipitation). This fraction was multiplied by the “Farm Net Recharge” term from Zonebudget to estimate the recharge from precipitation. The underlying assumption is that the relative contribution of precipitation to recharge is the same as that to evapotranspiration.

Boundary flow is the flow at each region’s boundary from either surface or basins from outside of the 21 subregions (not including inter-basin flow). For CVHM, only Region 9, the Delta, has boundary inflows. Positive values are flow into the groundwater subbasin and negative values are flows out of the subbasin.

Subsidence flows represent the effects of subsidence in each respective region on groundwater storage. For CVHM, subsidence flows are accounted for in the “Interbed Storage” term in ZoneBudget. Since this term had resulting values that were both positive and negative, it was evident that this term was not solely subsidence. However, the interbed storage flow would need to be accounted for in the CALVIN mass balance regardless of if it was solely subsidence or not, so this term was included in the External

Flows. Positive values are flow into the groundwater subbasin and negative values are flows out of the subbasin.

Evapotranspiration from groundwater is estimated by taking the negative irrigation recharge values from Zonebudget. This would be the fraction of Farm Net Recharge that is not recharge from precipitation and is negative, indicating a loss from the groundwater basin.

The average annual flows per region are summarized in Table 2.5. These flows are from the groundwater perspective; positive values are flows into the groundwater basin and negative values are flows out of the basin.

Table 2.5: Average Annual 1980-1993 CVHM-CALVIN External Flows (TAF/month)

Subregion	Inter-basin	Stream Leakage	Deep Perc. from Precipitation	Boundary flow	Subsidence	ET from GW	Net External Flow
1	-312.1	-131.5	440.2	0.0	18.3	-8.0	6.8
2	44.2	-293.1	631.4	0.0	23.6	-0.0	406.1
3	-225.8	-234.0	613.5	0.0	1.7	-124.5	30.9
4	558.6	-533.4	260.6	0.0	-0.4	-262.2	23.2
5	-184.9	-213.3	690.1	0.0	0.0	-227.8	64.2
6	-47.2	13.8	556.4	0.0	-0.3	-69.3	453.5
7	19.4	-42.9	278.0	0.0	7.6	-75.8	186.2
8	50.3	84.8	546.4	0.0	5.1	-0.7	685.8
9	237.7	551.8	263.2	-90.5	-0.6	-515.5	446.1
10	-79.9	38.2	158.0	0.0	15.1	-101.4	30.0
11	-54.9	-102.3	180.7	0.0	0.6	-4.3	19.8
12	-73.4	20.7	137.5	0.0	2.2	-29.2	57.9
13	-0.8	125.3	350.6	0.0	92.7	-3.6	564.2
14	85.2	5.6	100.5	0.0	69.1	0.0	260.4
15	621.8	177.6	177.4	0.0	140.2	0.0	1117.0
16	-196.1	35.0	106.4	0.0	45.9	0.0	-8.8
17	-176.8	174.8	159.7	0.0	40.3	0.0	197.9
18	-20.1	106.9	217.6	0.0	259.9	0.0	564.3
19	212.2	0.0	93.7	0.0	103.8	0.0	409.7
20	-164.4	19.3	62.2	0.0	104.0	0.0	20.9
21	-292.9	107.2	79.3	0.0	42.4	0.0	-63.9
Sac TOTAL	140.1	-797.8	4279.9	-90.5	54.9	-1283.7	2302.9
SJ TOTAL	-209.0	81.9	826.8	0.0	110.6	-138.5	671.8
TL TOTAL	68.8	626.4	996.7	0.0	805.6	0.0	2497.5
CV TOTAL	0.0	-89.6	6103.4	-90.5	971.1	-1422.2	5472.2

Pumping Capacity

This term is the upper-bound constraint for groundwater pumping in CALVIN. These are estimated as the maximum values of pumping extracted from the ZoneBudget output, "Farm Wells" from 1980 to 1993. These capacities are shown in Table 2.6.

Pumping Lift

Depth to groundwater ("pumping depth" or "pumping lift") is used in CALVIN to determine agricultural pumping costs. CALVIN assumes a fixed cost per foot of lift and these calculated costs are used as model inputs (CALVIN Appendix G, 2001). Depth to Groundwater is essentially the ground surface elevation minus the water elevation. Taking these values from the input and output files for the original CVHM run for year 2000, the average lift per region was calculated. The head values used were from MODFLOW so they represent the average head for a 1 square mile cell, and not the water level in a well, which will typically be lower. This indicates that this value, in addition to all other assumptions, is likely to be an overestimate since the average head is likely to be a smaller value than the effective water level. These average lift values are summarized in Table 2.6.

Since DWR measured groundwater level data for year 2000 exists, it was decided that using measured data of groundwater heads would best represent pumping lift for these regions. Details of how these averages were calculated can be found in Appendix 2. These average lift values are also summarized in Table 2.6.

Table 2.6: CVHM Pumping Terms and DWR Measured Well Depths

Subregion	Pumping Capacity (TAF/mo)	CVHM 2000 Pumping Depth (ft)	DWR 2000 Average Measured Well Data (ft)
1	2.3	153	71
2	354.7	43	40
3	4.4	63	27
4	2.4	N.A.	16
5	25.1	14	27
6	181.8	57	25
7	73.8	19	40
8	474.5	17	90
9	90.0	43	24
10	7.9	73	17
11	22.8	22	47
12	19.0	42	68
13	524.5	113	75
14	214.8	176	235
15	1066.5	36	93
16	32.1	123	57
17	275.5	80	34
18	570.8	186	80
19	471.2	165	139
20	162.2	366	298
21	113.3	250	191

Storage

The maximum storage is the upper-bound constraint for groundwater storage capacity in CALVIN. The "Storage" term from the Zonebudget post-processor is used here. The data in Zonebudget represents change in storage. Effective storage is used for this term to represent the absolute maximum available water. Calculation is as follows:

1. Arbitrarily set the initial storage to a very large number ($1x10^9$) such that the created storage time series is never negative.
2. Once storage values are converted from change in storage to storage, the effective storage can be calculated: Absolute Maximum storage – Absolute Minimum Storage (note that the original arbitrarily high number is now cancelled out).

The initial storage was calculated to be the effective initial storage, the maximum amount of water available in September 2003. This was calculated: Storage in 2003- Absolute Minimum storage. The results are shown in Table 2.7 below. A more detailed discussion of the method can be found in Appendix 1.

Change in storage is also estimated directly from the Zonebudget storage change values. The totals of changes in storage per month for 1980-1993 are summed up by year and averaged to get the average annual change in storage. Then this yearly change in storage value is multiplied by 72 years to get an estimated storage change for 72 years. These storage changes are shown in the last column of Table 2.7. Positive values indicate overdraft and negative values indicate an increase in groundwater storage. The ending storage values were calculated from the initial storage minus the change in storage over 72 years. Additional overdraft scenarios and calculation methods will be discussed in Chapter 5.

Table 2.7: CVHM Storage Capacity, Initial & Ending Storage, and 1921-1993 Change in Storage (TAF)

Subregion	Maximum Storage Capacity	Initial Storage	Ending Storage	Change in Storage*
1	19,543	16,346	13,302	3,045
2	33,133	19,031	15,954	3,077
3	22,782	10,350	11,124	-773
4	15,730	8,552	9,810	-1,257
5	23,850	16,587	16,897	-311
6	34,350	11,683	15,140	-3,457
7	12,190	10,180	9,148	1,032
8	31,153	12,230	10,634	1,595
9	81,528	18,419	29,742	-11,323
10	20,844	11,311	11,061	251
11	10,704	4,905	4,617	289
12	16,651	3,683	4,407	-723
13	48,168	33,636	22,880	10,756
14	32,789	32,789	23,293	9,495
15	38,000	22,341	9,786	12,555
16	27,274	27,274	17,839	9,435
17	31,370	24,960	15,818	9,142
18	58,956	58,956	38,607	20,349
19	28,006	28,006	20,750	7,256
20	20,229	20,229	13,575	6,654
21	58,804	58,699	53,088	5,611
Sac TOTAL	274,260	123,377	131,750	-8,372
SJ TOTAL	96,367	53,536	42,964	10,572
TL TOTAL	295,428	273,254	192,757	80,497
CV TOTAL	666,055	450,167	367,470	82,697

* Positive values indicate overdraft and negative values indicate an increase in groundwater storage.

Calibration Flow

For each groundwater basin, a mass balance could be achieved with a calibration flow to correct for the model error. To determine the mass balance, only the flows that directly flow in and out of the groundwater basin were considered: external flows, pumping, recharge from applied water, and changes in storage. Figure 2.3 shows these components and flow interactions. Recharge to groundwater, pumping, and storage changes ultimately will be modeled explicitly in final CALVIN, since these are actively managed as decision variables with associated management costs. But to check CVHM's representation of groundwater flows, the recharge flows and changes in storage are extracted and used here. As mentioned earlier, the change in storage is an output in the Zonebudget post-processor. The recharge flows are only the positive recharge flows from applied water (irrigation) because the recharge from precipitation and negative recharge terms are included in the external flows term. The mass balance results are summarized in Table 2.8. As seen in the results, the calibration flows to achieve the mass balance are rather small, which agrees with CVHM results presented in Faunt et al. 2009. In the overall CALVIN network, if the calibration flow was to be added or removed from the system, it would not be a direct interaction with the groundwater basin, as shown in Figure 1.3.

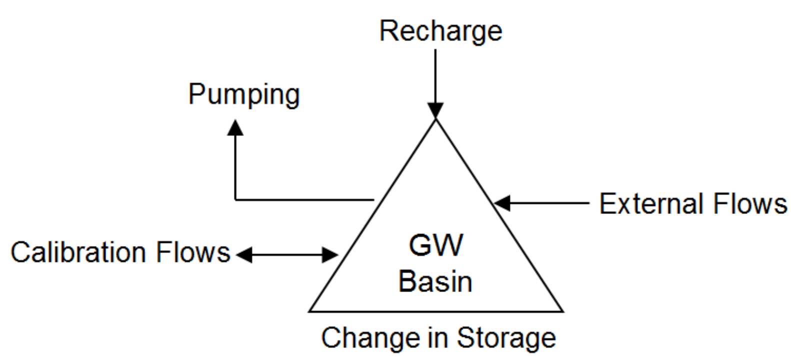


Figure 2.3: Groundwater Mass Balance Flows

Table 2.8: 13-year Average Annual Groundwater Mass Balance (TAF/yr)

Subregion	External Flows (+/-)	Pumping (-)	Total Recharge from Applied Water (+)	Change in Storage (+/-)	Calibration Flow (+/-)
1	7	49	0	-42	0
2	406	542	93	-43	0.02
3	31	32	12	11	0.04
4	23	6	1	17	0.08
5	64	62	2	4	0.02
6	453	414	8	48	0.18
7	186	201	1	-14	0.05
8	686	843	135	-22	0.03
9	446	284	2	157	3.44
10	30	45	13	-3	0.98
11	20	74	51	-4	0.12
12	58	59	13	10	0.88
13	564	816	104	-149	0.86
14	260	588	196	-132	0.01
15	1117	1837	547	-174	0.8
16	-9	184	62	-131	0.06
17	198	495	170	-127	0.18
18	564	1288	442	-283	0.09
19	410	725	215	-101	0.07
20	21	273	160	-92	-0.01
21	-64	183	170	-78	0.37
Sac Total	2303	2433	255	116	4
SJ Total	672	993	181	-147	3
TL Total	2498	5573	1961	-1118	2
CV Total	5472	8999	2396	-1149	8

Urban Return Flow

CVHM accounts for urban land use in its calculation of crop efficiencies; urban land use is considered a "virtual crop" as seen in Table 2.3 above. Specific fractions for just urban return flows were not separated for CVHM. Urban flows are generally small compared to agricultural flows so the return flows are also generally lower. CVGSM and C2VSIM do account for this term separately, and this is discussed in the next chapter, which compares the three models.

Discussion

This chapter focuses on how CVHM was summarized for the CALVIN update project. Although CVHM was ultimately not used as the groundwater basis for the updated CALVIN model, studying the model and calculating the terms provided useful insights during the calibration process and in the overdraft studies (Chapter 5). Future versions of CVHM will likely fit CALVIN purposes more closely and should be considered again when it is time for the next CALVIN groundwater update. The next chapter will present and compare the calculated terms for CALVIN from CVHM, C2VSIM, and CVGSM.

CHAPTER 3

Comparison of Models and Calculated Terms

This chapter discusses and compares the CALVIN calculated terms from C2VSIM, CVHM, and CVGSM. CVGSM was based on IGSM, a basin planning model that includes groundwater, surface water, groundwater quality and reservoir operation simulation routines (USBR 1997). C2VSIM is based on IWFM, whose precursor was the IGSM, but has been renamed to IWFM since many major changes and improvements were made. The calculated CALVIN terms show this similarity in the basis of the model's results in similar calculations and representations of some terms. CVHM is MODFLOW based with the Farm Process (FMP) package, which treats and represents many terms very differently than IWFM and IGSM, so some calculated terms differ greatly. However, some terms show strong agreement between CVHM and C2VSIM when compared with CVGSM, likely due to the more detailed discretization, calibration, and use of accepted and tested algorithms. IWFM and MODFLOW-FMP are newer models that address the physical and economic water balance in a watershed, allowing for simulations that account for both physical flow processes and water management practices. A detailed description and comparison of the theory, approaches, and features of the two models can be found in Dogrul et al. 2011. A comparison of IGSM and older versions of MODFLOW can be found in LaBolle et al. 2003.

Calculated Terms Comparison

The 21 groundwater subbasins (subregions) in all three models correspond with the CVPM regions used in CALVIN, allowing for direct comparisons. The same calculated terms for each model often account for additional flows or features that might be accounted for in a different term in the other model. Many different term calculation methods were used and the ultimate decision to use one method over others was based on trying to capture the term as best suited for representation in CALVIN, as a water management model, and looking at how the term compared with the other models and measured data. Different methods used in the calculations cause some differences in the calculated terms. Because C2VSIM output terms are similar to those of CVGSM, the calculations used for these two models were often more similar than the calculations used to calculate CALVIN terms from CVHM results. The effects of the differences in methods will be discussed in the sections below and the detailed descriptions of the terms can be found in Appendix J (Jenkins et al. 2001 and Davis et al. 2001), and Appendix 1 and 3 of this thesis. The various parameters representing groundwater in CALVIN are summarized in Table 1.2 and Figure 1.3. The comparison is structured by these sections below.

Agricultural Return Flow Splits

Table 3.1 shows some large differences for Agricultural Return Flow Splits between the models. The calculations for C2VSIM and CVGSM follow similar methods but result in very different splits. Detailed calculations and equations can be found in Appendix J and Appendix J-2 (II) (Zikalala et al. 2012). C2VSIM and CVGSM fractions are based on using model outputs and taking fractions of these to represent these splits. C2VSIM's fractions generally have higher return flows to groundwater, which agrees with CVHM, whose methods are based on taking the averages of fractions of surface water runoff from irrigation for each subregion from CVHM input files. Both newer groundwater models imply more irrigation return flow is to groundwater throughout the Central Valley.

Table 3.1: Agricultural Return Flow Splits to Groundwater

Subregion	C2VSIM	CVHM	CVGSM (1997)
	GW	GW	GW
1	0.28	0.99	0.45
2	1.00	0.98	0.69
3	0.60	0.97	0.60
4	0.99	0.96	0.12
5	0.72	0.97	0.59
6	0.98	0.97	0.37
7	1.00	0.98	0.42
8	0.93	0.98	0.14
9	1.00	0.96	0.74
10	0.94	0.95	0.21
11	0.94	0.97	0.65
12	0.94	0.96	0.22
13	0.97	0.97	0.25
14	1.00	0.92	1.00
15	1.00	0.94	0.30
16	0.84	0.98	0.13
17	1.00	0.97	0.42
18	1.00	0.96	0.99
19	1.00	0.97	1.00
20	0.82	0.97	0.59
21	1.00	0.96	0.94

Agricultural Reuse Amplitudes

As mentioned in Chapter 2, the non-reuse amplitude is 1 (no reuse) for all CVHM regions, neglecting local tailwater reuse. For CVGSM, the reuse fractions were a direct output in the model, but as seen in Table 3.2, amplitudes were quite high for reuse. When these amplitudes were used for the original CALVIN groundwater, they were some of the first to be adjusted (decreased significantly) during calibration, as discussed in the Chapter 4. In C2VSIM, the reuse amplitudes were calculated by summing the applied water and reused water and dividing that net sum by the applied water for the 1980 to 2003 time period. These values in Table 3.2 are significantly smaller than the earlier CVGSM values and seem fairly close to CVHM.

Table 3.2: Agricultural Reuse Amplitudes & Applied Water Return Flow Fractions

Subregion	Agricultural Reuse Amplitude			Agricultural Return Flow Fraction		
	C2VSIM	CVHM	CVGSM	C2VSIM	CVHM	CVGSM
1	1	1	1.32	0.47	0.26	0.39
2	1	1	1.26	0.14	0.27	0.29
3	1.086	1	1.28	0.20	0.17	0.35
4	1.001	1	1.21	0.14	0.21	0.35
5	1.049	1	1.283	0.21	0.2	0.37
6	1.001	1	1.08	0.06	0.23	0.28
7	1	1	1.3	0.25	0.23	0.45
8	1.003	1	1.23	0.12	0.25	0.33
9	1	1	1.21	0.09	0.22	0.21
10	1.003	1	1.33	0.20	0.21	0.4
11	1.005	1	1.272	0.22	0.23	0.43
12	1.004	1	1.18	0.16	0.24	0.34
13	1.002	1	1.18	0.12	0.21	0.27
14	1	1	1.22	0.18	0.13	0.26
15	1	1	1.21	0.12	0.24	0.27
16	1.015	1	1.18	0.28	0.19	0.45
17	1	1	1.17	0.13	0.2	0.27
18	1	1	1.25	0.18	0.21	0.31
19	1	1	1.21	0.03	0.23	0.29
20	1.014	1	1.17	0.10	0.19	0.3
21	1	1	1.25	0.10	0.19	0.32

Applied Water Return Flow Fractions

Table 3.2 shows that Agricultural Return Flow Fractions for CVHM and C2VSIM are generally lower than those of CVGSM. C2VSIM's fractions are calculated as the total applied water not consumptively used divided by the total applied water, where the terms used were determined following the calculations for Agricultural Return Flow Split. CVHM's values were determined by using the published composite efficiency values (evapotranspiration of applied water, ETAW) per region as discussed in Chapter 2 (Return Flow % = 1-ETAW %). CVGSM's return flow fractions are based on CVGSM NAA output data (Return Flow % = 1 – On-farm Efficiency %). DWR Bulletin 160-98 also had efficiencies published at the time, and they were generally higher than those from the CVGSM output, resulting in lower return flow fractions. So that was a primary basis for adjusting the CVGSM return flow fractions when calibrating the groundwater system in CALVIN in 2001. The calibration steps taken for the current update CALVIN are discussed in Chapter 4.

External Flows

External flows are entered into CALVIN for each subregion as a source time series. Some external flow terms were directly extracted from results files of the groundwater models, but a few required some calculations, as discussed below. Overall, the average annual external flows for C2VSIM and CVHM seem to follow a similar trend throughout the regions when comparing the 1980-1993 time period, which can be seen in Table 3.3 and Figure 3.1.

Table 3.3: Average Annual (1980-1993) Net External Flows (TAF/yr)

Subregion	C2VSIM[a]	CVHM[b]
1	16.5	6.8
2	342.8	406.1
3	0.5	30.9
4	75.9	23.2
5	199.6	64.2
6	250.4	453.5
7	224.8	186.2
8	613.9	685.8
9	116.8	446.1
10	146.1	30.0
11	49.9	19.8
12	119.9	57.9
13	529.6	564.2
14	391.1	260.4
15	815.1	1117.0
16	65.6	-8.8
17	226.2	197.9
18	257.5	564.3
19	493.3	409.7
20	180.8	20.9
21	389.5	-63.9
SAC TOTAL	1841.2	2302.9
SJ TOTAL	845.5	671.8
TL TOTAL	2819.1	2497.5
CV TOTAL	5505.8	5472.2

[a] C2VSIM averages are based on adjusted flows for 1980-1993
[b] CVHM averages based on 1980-1993, same as Table 2.5

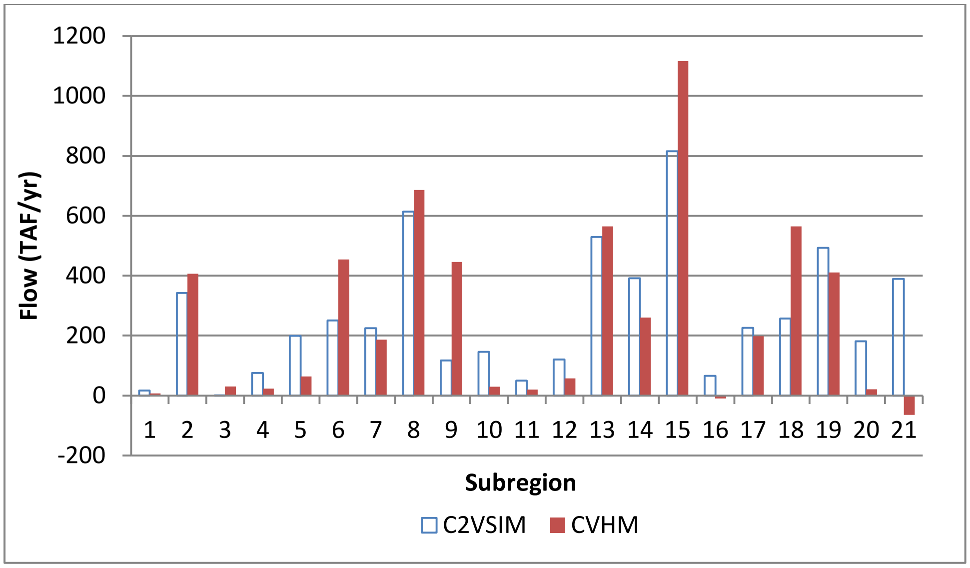


Figure 3.1: 1980-1993 Average Annual Net External Flows

The time period annual averages used to represent the models' external flows in CALVIN (1921-2009 for C2VSIM, 1980-1993 for CVHM, and 1921-1990 for CVGSM) are shown in Table 3.3a; these are the values that were input in CALVIN when comparing between models. These different time period-based external flows were used for each of the models because they were considered to be the best representation of updated land use and infrastructure. The CVGSM values are based on the entire time period of the CALVIN model run because that is what was used in the previous version of CALVIN. As seen in Table 3.3a, the average annual external flows for CVGSM are much larger than that of C2VSIM and CVHM. The newer models generally have more terms than CVGSM because the newer models break down the different terms more explicitly and it was decided to include all the time series terms to the external flow term so that a mass balance could be achieved. The breakdown yearly averages of each of the flows that comprise the net external flows averages are presented below in Tables 3.3b-d.

Table 3.3a: Average Annual Net External Flow Averages (TAF/yr)

Subregion	C2VSIM[a]	CVHM[b]	CVGSM[c]
1	28.2	6.8	1.6
2	176.8	406.1	402.5
3	-8.9	30.9	8.9
4	-95.5	23.2	260.6
5	66.9	64.2	144.2
6	180.4	453.5	367.1
7	168.2	186.2	277.5
8	401.5	685.8	747.4
9	84.8	446.1	13.7
10	72.2	30.0	296.1
11	-1.3	19.8	-158.8
12	48.7	57.9	155.1
13	344.1	564.2	863.1
14	278.2	260.4	308.6
15	594.2	1117.0	1160.8
16	51.2	-8.8	279.7
17	95.8	197.9	359.7
18	262.9	564.3	483.7
19	368.0	409.7	162.2
20	100.8	20.9	220.0
21	289.7	-63.9	387.2
SAC TOTAL	1002.4	2302.9	2223.5
SJ TOTAL	463.7	671.8	1155.5
TL TOTAL	2040.7	2497.5	3361.9
CV TOTAL	3506.8	5472.2	6740.9

[a] C2VSIM averages are based on adjusted flows for1921-2009
[b] CVHM averages based on 1980-1993
[c] CVGSM averages based on 1921-1993

Table 3.3b shows the Interbasin and Boundary Flows. Both terms are direct time series output results from the models or their post-processors. CVGSM shows a major problem with the interbasin flows because the net sum of the terms is not zero. Since interbasin flows are only the flows between basins, and not flows from outside the model boundary, the net sum of interbasin flows between regions should equal zero if a proper mass balance is to be represented. Although C2VSIM and CVHM have significant differences in their representation of interbasin flows, their overall totals are zero. This is a good example of the differences that arise between C2VSIM and CVHM due to their different methods and assumptions, but still achieve a mass balance. The Boundary Flows show significant differences between the three models.

Table 3.3b: Average Annual External Flows – Interbasin and Boundary Flows (TAF/yr)

Subregion	Interbasin Flows			Boundary Flows		
	C2VSIM[a]	CVHM[b]	CVGSM[c]	C2VSIM[a]	CVHM[b]	CVGSM[c]
1	25.7	-312.1	-28.2	84.0	0	0
2	-26.8	44.2	11.7	132.0	0	114.1
3	-18.5	-225.8	-72.8	45.6	0	14.4
4	49.4	558.6	115.1	0.0	0	0
5	-7.6	-184.9	-74.6	17.5	0	83.7
6	-24.3	-47.2	85.0	25.0	0	-9.2
7	-9.9	19.4	-3.2	75.3	0	62.5
8	91.7	50.3	278.9	111.7	0	22
9	-18.1	237.7	-127.4	13.8	-90.5	-16.1
10	-83.9	-79.9	-42.3	28.8	0	73.7
11	-60.4	-54.9	-118.0	0.0	0	0
12	-1.4	-73.4	-14.8	0.0	0	25.1
13	73.2	-0.8	184.8	0.0	0	70.2
14	72.6	85.2	-119.5	0.0	0	0
15	266.3	621.8	-1483.8	-53.4	0	15.1
16	-106.9	-196.1	160.2	7.8	0	54.2
17	-62.5	-176.8	48.1	3.9	0	6.8
18	-150.8	-20.1	72.8	23.5	0	67.7
19	56.1	212.2	-128.0	4.1	0	234.1
20	-110.7	-164.4	86.9	49.2	0	85.4
21	46.9	-292.9	-361.4	52.1	0	58.6
SAC TOTAL	61.6	140.1	184.5	504.9	-90.5	271.4
SJ TOTAL	-72.6	-209.0	9.7	28.8	0.0	169.0
TL TOTAL	11.0	68.8	-1724.7	87.2	0.0	521.9
CV TOTAL	0.0	0.0	-1530.5	620.9	-90.5	962.3

[a] C2VSIM averages are based on adjusted flows for1921-2009
[b] CVHM averages based on 1980-1993
[c] CVGSM averages based on 1921-1993

Table 3.3c shows groundwater-surface water (GW/SW) interaction from streams and lakes, and deep percolation of precipitation. GW/SW interaction from streams and lakes are direct outputs from the models or their post-processors. As can be seen in the table, CVHM does not represent GW/SW interaction from lakes (a small matter for the current Central Valley). Overall, the differences for GW/SW interaction from streams vary widely. And since this term is a direct output from the models, no adjustments were made here. This is another good example showing the differences between models and their representation of surface water and groundwater interaction.

The deep percolation from precipitation terms for C2VSIM and CVGSM are calculated in similar methods following the calculations for agricultural return flow splits. CVHM calculation of this term is based on the farm net recharge output and evapotranspiration splits. This term is significantly higher for CVHM than C2VSIM and CVGSM, likely largely due to the calculation method. The precipitation input data for C2VSIM and CVHM were compared and confirmed to be very similar. So this difference in deep percolation from precipitation between the two models is likely due to both the CALVIN term calculation methods and the methods in the groundwater models themselves. These differences are substantial, especially for the Sacramento Valley.

Table 3.3c: Average Annual External Flows - Deep Percolation from Streams, Lakes, & Precipitation (TAF/yr)

Subregion	GW/SW Interaction: streams			GW/SW Interaction: lakes			DP from Precipitation		
	C2VSIM[a]	CVHM[b]	CVGSM[c]	C2VSIM[a]	CVHM[b]	CVGSM[c]	C2VSIM[a]	CVHM[b]	CVGSM[c]
1	-235.3	-131.5	-77.6	0	0	0	137.3	440.2	107.4
2	-73.1	-293.1	46.6	0	0	0	134.4	631.4	223.7
3	-161.0	-234.0	-38.1	0	0	0	87.8	613.5	95.7
4	-323.1	-533.4	102.0	0	0	0	101.7	260.6	43.5
5	-190.7	-213.3	-18.4	0	0	0	144.8	690.1	148.3
6	45.2	13.8	201.5	0	0	0	109.0	556.4	74.7
7	9.1	-42.9	158.3	0	0	0	61.7	278.0	45.7
8	64.7	84.8	373.2	0	0	0	121.2	546.4	71.5
9	-3.1	551.8	15.3	0	0	0	84.0	263.2	141.9
10	-127.3	38.2	140.3	0	0	0	101.7	158.0	44.0
11	-180.0	-102.3	-324.8	0	0	0	78.8	180.7	153.8
12	-133.6	20.7	21.7	0	0	0	62.8	137.5	36.1
13	-34.9	125.3	388.9	0	0	0	163.9	350.6	92.5
14	0.0	5.6	0.0	0	0	352.7	45.6	100.5	51.3
15	-231.8	177.6	125.6	-53.4	0	2311.4	91.1	177.4	41.0
16	12.3	35.0	0.0	0	0	0	80.0	106.4	16.6
17	-23.0	174.8	144.2	0	0	0	112.3	159.7	61.0
18	-33.5	106.9	125.1	0	0	0	105.5	217.6	91.3
19	-160.5	0.0	0	0	0	0	46.1	93.7	51.3
20	26.5	19.3	0	0	0	0	61.7	62.2	36.3
21	80.5	107.2	205.4	-6.7	0	389.2	46.1	79.3	75.7
SAC TOTAL	-867.3	-797.8	762.8	0	0	0	981.9	4279.9	952.4
SJ TOTAL	-475.8	81.9	226.1	0	0	0.0	407.3	826.8	326.4
TL TOTAL	-329.4	626.4	600.3	-60.1	0	3053.3	588.5	996.7	424.5
CV TOTAL	-1672.6	-89.6	1589.2	-60.1	0	3053.3	1977.6	6103.4	1703.3

[a] C2VSIM averages are based on adjusted flows for1921-2009
[b] CVHM averages based on 1980-1993
[c] CVGSM averages based on 1921-1993

Table 3.3d shows the subsidence, diversion losses to groundwater (gains to groundwater), and losses from groundwater. For C2VSIM and CVHM, subsidence results are directly from model outputs or from post-processors. There seems to be some trends between the two models for subsidence, but CVHM generally has more subsidence gains to the basin than C2VSIM. No subsidence term was used from CVGSM.

Diversion losses to groundwater, or conveyance seepage flows, are a loss from the surface water irrigation or conveyance system, which is a gain to the groundwater basin. CVHM does not explicitly represent this term but it is accounted for when calculating the crop efficiencies, which is discussed in Chapter 2 and in Appendix 1. This term is an input to CVGSM and is reported in C2VSIM's result post-processor. Estimated canal losses have decreased over time, as seen from time series data for the individual regions. It is unlikely that an up-to-date model like C2VSIM would suggest higher diversion losses over time so the likely reason there are more diversion losses from canals represented in C2VSIM than CVGSM could be that CVGSM was somehow underestimating diversion water that was being lost to the groundwater basins.

Tile drain outflow represents the practice of removing excess water from upper layers of some groundwater basins. Of the 3 models, this is only represented in C2VSIM and only in regions 10 and 14.

Evapotranspiration losses from groundwater are a time series output from CVHM (from FB_Details.OUT). This term is not included in external flows for CALVIN since the non-recoverable (and recoverable) losses are accounted for by an amplitude on the surface water side. This was necessary for CVHM due to the methods used to calculate some of the other terms in CVHM. Evapotranspiration losses needed to be subtracted in the net external flows for CVHM because terms like the deep percolation from precipitation have significantly higher flows to the groundwater basins because the evapotranspiration losses are accounted for separately as its own term, which does not seem to be the case for C2VSIM or CVGSM. CALVIN and C2VSIM represent evapotranspiration losses and conveyance losses as a fraction on the surface water side, and these are discussed and tabulated in Appendix 5. This is another reason CVHM was not ultimately used for the update project because trying to account for this difference would have required more changes to CALVIN's basic framework (CALVIN's surface water loss fractions would all need to be changed to 1 to indicate no non-recoverable or recoverable losses on the surface water side for CVHM). Although the loss on the surface water side is accounted for by the loss fraction in C2VSIM and CVGSM, the recoverable loss from the surface water as a gain to the groundwater side needs to be added back to the system. Since the CALVIN network does not represent this directly, the external flows term includes that recoverable loss from surface water as a gaining flow to the groundwater system.

Table 3.3d: Average Annual External Flows – Subsidence, Diversion Gains, and Losses from Groundwater (TAF/yr)*

Subregion	Subsidence[1]			Diversion Losses to GW (Gains)			Tile Drain Outflow	Evapo-transpiration Loss
	C2VSIM[a]	CVHM[b]	CVGSM[c]	C2VSIM[a]	CVHM[b]	CVGSM[c]	C2VSIM[s]	CVHM[b]
1	-0.02	18.27	0	16.5	0	0	0	-8.0
2	0.01	23.61	0	10.4	0	6.4	0	0
3	0.78	1.69	0	36.5	0	9.7	0	-124.5
4	0.90	-0.37	0	75.6	0	0	0	-262.2
5	0.00	0.05	0	103.0	0	5.2	0	-227.8
6	5.13	-0.33	0	20.2	0	15.1	0	-69.3
7	0.01	7.56	0	32.0	0	14.2	0	-75.8
8	0.05	5.07	0	12.1	0	1.8	0	-0.7
9	0.11	-0.60	0	8.1	0	0	0	-515.5
10	42.35	15.11	0	141.4	0	80.4	-30.8	-101.4
11	0.01	0.57	0	160.2	0	130.2	0	-4.3
12	0.02	2.20	0	120.9	0	87	0	-29.2
13	9.21	92.70	0	132.6	0	126.7	0	-3.6
14	128.39	69.07	0	33.2	0	24.1	-1.5	0
15	78.99	140.19	0	496.5	0	151.5	0	0
16	0.14	45.87	0	57.8	0	48.7	0	0
17	0.25	40.29	0	64.8	0	99.6	0	0
18	70.69	259.94	0	247.5	0	126.8	0	0
19	43.97	103.84	0	378.2	0	4.8	0	0
20	46.59	103.96	0	27.5	0	11.4	0	0
21	48.77	42.43	0	22.0	0	19.7	0	0
SAC TOTAL	7.0	54.9	0	314.4	0	52.4	0	-1283.7
SJ TOTAL	51.6	110.6	0	555.2	0	424.3	-30.8	-138.5
TL TOTAL	417.8	805.6	0	1327.4	0	486.6	-1.5	0
CV TOTAL	476.4	971.1	0	2196.9	0	963.3	-32.3	-1422.2

*Positive values are flows into the groundwater basin and negative values are flows out of the basin.
[1]Subsidence for CVHM was actually the Interbed storage, which includes subsidence but is not entirely subsidence alone.
[a] C2VSIM averages are based on adjusted flows for1921-2009
[b] CVHM averages based on 1980-1993
[c] CVGSM averages based on 1921-1993

Although both C2VSIM and CVHM seem to represent Central Valley groundwater much better than the older CVGSM, there are still significant differences between the new, improved models, implying some level of uncertainty in the general understanding of Central Valley groundwater.

Pumping Terms

The pumping capacities and pumping depths are shown in Table 3.4. The pumping capacities for C2VSIM and CVHM are the maximum values of pumping for the period1980-1993. CVGSM capacities are the maximum monthly pumping for the period 1922-1990. If pumping volume is greater than 100 TAF, capacity is set to 110% of maximum value; otherwise, capacity is set to 105% of maximum value. The values shown in Table 3.4 do not include the correction factor.

The pumping depths for C2VSIM and CVHM were explicitly calculated using the heads from the input files. CVGSM depths to groundwater were not available for the previous CALVIN study so the depths to groundwater were pieced together from analyses for the Draft CVPIA PEIS (USBR 1997). Since there was some uncertainty in the C2VSIM and CVHM calculations and DWR measured groundwater level data exists, measured static water level was assumed to be the most appropriate and accurate set of data to be used for the CALVIN groundwater update (Appendix 2).

Table 3.4: Pumping Capacities and Depths

Subregion	Pumping Capacity (TAF/month)			Pumping Depth (ft)			
	C2VSIM	CVHM	CVGSM	C2VSIM	CVHM	Old CALVIN	DWR*
1	7.2	2.3	18.9	175	153	130	71
2	93.2	354.7	145.9	144	43	120	40
3	175.8	4.4	162.8	104	63	100	27
4	109.2	2.4	105.2	17	NA	60	16
5	240.1	25.1	214.9	35	14	75	27
6	85.7	181.8	141	64	57	70	25
7	120.5	73.8	87.3	95	19	95	40
8	185.6	474.5	198.5	148	17	110	90
9	43.9	90	67.1	30	43	80	24
10	185.2	7.9	188.5	80	73	60	17
11	64.9	22.8	47.5	54	22	75	47
12	86.9	19	73.2	48	42	90	68
13	225.8	524.5	277.1	108	113	125	75
14	221.1	214.8	317	373	176	350	235
15	335.3	1066.5	388.5	73	36	210	93
16	61.8	32.1	55.2	59	123	130	57
17	152.6	275.5	145.1	145	80	130	34
18	238.4	570.8	332.3	180	186	200	80
19	213.7	471.2	163	407	165	310	139
20	125.3	162.2	103	429	366	310	298
21	265.6	113.3	217.4	592	250	310	191

* Average Measured Groundwater Level Data

Constraining a minimum pumping rate would ideally help represent parts of the Central Valley that exclusively depend on groundwater. However, none of the models seemed to have sufficiently detailed calibrations to provide such insights.

Storage Terms

Table 3.5 shows the storage related terms. The storage values for C2VSIM are output by the results post-processor. The maximum storage capacity was set by taking the maximum storage at any time from 1980-2003. For C2VSIM, the initial storage was set to be the storage at the end of 2005. CVHM's storage terms are calculated by using the maximum effective storage for the maximum capacity (maximum value minus minimum value for 1980-1993) and the effective storage based on September 2003 (September 2003 storage minus minimum value for 1980-1993). CVGSM storage capacities were extracted directly from the model output, as with C2VSIM.

Actual groundwater storage capacity in California is unknown and is not accurately measureable at this time. The California DWR Groundwater Bulletin 118 estimates that the groundwater storage capacity for the whole state can be anywhere between 850 million acre-feet (MAF) to 1.3 billion acre-feet. The C2VSIM results for maximum storage are a much larger estimate of groundwater storage, since the sum total for just the Central Valley exceeds the Bulletin's estimates for the whole state. CVHM's storage seems comparable to the estimates presented in the Groundwater Bulletin. It is important to have a reasonable initial storage since CALVIN does not model water levels, but change in storage; the initial storage is essentially a reference starting point. But ultimately, when considering CALVIN results, the change in storage results could be applied to any initial storage so long as there is still water available in the basin.

Overdraft is estimated directly from the change in storage values for CVHM and C2VSIM. The storage change per month is summed over a long time period and divided by the number of years in that time period to get the average annual storage change for that time period. C2VSIM's average was based on 1980-2009 (29 years) and CVHM's average was based on 1980-1993 (13 years). Then this yearly storage change value is multiplied by 72 years to estimate total change in storage for 72 years. Positive values indicate overdraft and negative values indicate recharge to groundwater. CVGSM storage change was estimated for Table 3.5 by subtracting the initial storage from the ending storage from the model output.

As seen in the change in storage region totals at the bottom of Table 3.5, the differences are large in the Sacramento region, with CVHM showing overall gain to the groundwater storage and C2VSIM showing 12 MAF of overdraft. The estimated overdraft for the San Joaquin region also differs widely between the three models, with CVGSM being 8 MAF less than CVHM, and CVHM 4 MAF less than C2VSIM. The total Central Valley modeled overdraft from 1921-1993 are close for C2VSIM and CVHM, at 80 MAF, which is significantly less in CVGSM, at about 28 MAF. The largest difference in magnitude of overdraft between the three models is the Tulare region. If only the San Joaquin and Tulare regions were totaled, CVHM would have 20 MAF more overdraft than C2VSIM, but with the addition of 8 MAF of groundwater inflow modeled in CVHM's Sacramento region, C2VSIM and CVHM have very close total Central Valley estimated overdraft values. Given the variability in groundwater use and recharge, estimates of overdraft are also quite variable with different method used for long term averaging. Additional overdraft scenarios and calculation methods will be discussed in Chapter 5.

Table 3.5: Maximum Storage Capacity, Initial Storage, and Change in Storage (TAF)

Subregion	Maximum Storage Capacity			Initial Storage			Change in Storage from 1921-1993*		
	C2VSIM	CVHM	CVGSM	C2VSIM	CVHM	CVGSM	C2VSIM	CVHM	CVGSM
1	38,510	19,543	5,448	38,447	16,346	1902	-990	3,045	128
2	136,757	33,133	24,162	136,494	19,031	24,905	-882	3,077	601
3	133,958	22,782	22,127	132,687	10,350	31,526	939	-773	-200
4	61,622	15,730	15,362	60,728	8,552	16,750	220	-1,257	-231
5	92,020	23,850	24,399	91,113	16,587	29,285	656	-311	991
6	175,719	34,350	22,864	174,968	11,683	34,169	-307	-3,457	1,871
7	58,484	12,190	12,270	56,539	10,180	14,448	5,330	1,032	-2,143
8	193,433	31,153	32,842	190,665	12,230	38,110	7,836	1,595	6,090
9	139,752	81,528	23,395	139,472	18,419	33,723	-362	-11,323	-2,730
10	91,920	20,844	29,250	90,210	11,311	72,159	3,155	251	-1,264
11	59,302	10,704	15,543	58,838	4,905	22,157	592	289	2,201
12	43,510	16,651	13,919	42,602	3,683	19,687	1,737	-723	966
13	142,508	48,168	47,484	138,216	33,636	53,506	9,656	10,756	-26
14	181,001	32,789	65,235	178,840	32,789	120,766	6,831	9,495	5,312
15	313,759	38,000	90,978	309,643	22,341	145,888	2,977	12,555	79
16	64,915	27,274	11,650	64,696	27,274	13,739	257	9,435	6,359
17	98,836	31,370	13,942	97,214	24,960	12,820	3,561	9,142	306
18	322,480	58,956	59,544	321,375	58,956	59,454	-11,063	20,349	6,828
19	147,060	28,006	68,266	141,750	28,006	77,268	13,526	7,256	-2
20	141,457	20,229	40,814	137,073	20,229	27,178	11,937	6,654	-773
21	351,327	58,804	81,622	341,142	58,699	88,838	27,903	5,611	4,007
SAC TOTAL	1,030,255	274,260	182,869	1,021,114	123,377	232,622	12,441	-8,372	4,377
SJ TOTAL	337,241	96,367	106,196	329,867	53,536	167,509	15,140	10,572	1,876
TL TOTAL	1,620,834	295,428	432,051	1,591,732	273,254	545,951	55,930	80,497	22,116
CV TOTAL	2,988,329	666,055	721,116	2,942,713	450,167	946,082	83,511	82,697	28,369

*Positive values represent overdraft and negative values represent gains to groundwater.

Urban Return Flow

As mentioned above, CVHM includes urban land use in the calculation of the farm efficiencies. C2VSIM and CVGSM include urban return flows separately so a return flow fraction can be calculated. C2VSIM simulates land use processes within the urban areas including groundwater pumping and surface water supply to meet urban demand, urban water supply shortage or surplus, and flow in excess of demand is returned to surface water bodies or to groundwater. In urban areas, a *Rootzone budget output* file tabulates monthly volumes of precipitation, runoff, applied water to urban regions, net return flow of applied water to surface water, and water that goes to the unsaturated zone as deep percolation. The algorithms for separating infiltration of applied water from the total monthly volume infiltrated and calculation of total return flows to SW and GW are similar to that described above. Calculated fractions show that for the Sacramento region, all water returned from urban regions returns to SW, whereas for the San Joaquin and Tulare regions all of the return flow infiltrates to GW. As seen in Table 3.6, C2VSIM representation of urban return flow fraction varies widely across all regions.

Table 3.6: Urban Return Flow Fractions

Subregion	Urban Return Flow to GW		Urban Return Flow to SW		Total Urban Return Flow	
	C2VSIM	CVGSM	C2VSIM	CVGSM	C2VSIM	CVGSM
1	0	0.501	0.496	0	0.496	0.501
2	0.001	0.522	0.521	0	0.522	0.522
3	0.001	0.503	0.495	0	0.496	0.503
4	0.001	0.504	0.497	0	0.498	0.504
5	0.001	0.515	0.508	0	0.509	0.515
6	0.004	0.533	0.524	0	0.528	0.533
7	0.002	0.006	0.519	0.53	0.521	0.536
8	0.002	0.005	0.532	0.522	0.534	0.527
9	0.001	0.524	0.524	0	0.525	0.524
10	0.455	0.528	0	0	0.455	0.528
11	0.477	0.537	0	0	0.477	0.537
12	0.474	0.528	0	0	0.474	0.528
13	0.464	0.526	0	0	0.464	0.526
14	0.452	0.512	0	0	0.452	0.512
15	0.449	0.51	0	0	0.449	0.51
16	0.476	0.005	0	0.516	0.476	0.521
17	0.471	0.522	0	0	0.471	0.522
18	0.468	0.528	0	0	0.468	0.528
19	0.448	0.512	0	0	0.448	0.512
20	0.5	0.518	0	0	0.5	0.518
21	0.465	0.005	0	0.514	0.465	0.519

Conclusions

CVHM and C2VSIM are up-to-date groundwater models whose methods and results have been reviewed and confirmed to be significant improvements from previous Central Valley groundwater models (i.e., CVGSM). Both new groundwater models have been designed and built with added detail to represent Central Valley groundwater hydrology and management practices. Both models are also undergoing improvements and updates. Although there are many differences between the models' methods and results, both can be useful for water managers and planners. The benefits and drawbacks of each model are subjective to the users of the model and what the models are being used for. Dogrul et al. 2011 discusses the differences of the theory, approaches, and features of the two models. Schmid et al. 2011 compares the models using a common hypothetical example.

For this CALVIN groundwater representation update, C2VSIM was used primarily because the model period for C2VSIM (1921-2009) matches the model period for CALVIN (1921-1993). It would have been possible to use CVHM (1961-2003), but a thoroughly estimated hydrology match would have been needed to extend CVHM's data back to 1921 in order for CVHM results to be used for the CALVIN external flows term. Another benefit was that since C2VSIM is essentially an updated and improved version of CVGSM, many of the calculation methods used in the past remained relevant. C2VSIM also had all the terms previously represented in CALVIN plus some updates, whereas CVHM sometimes combined some representation of CALVIN required terms in other areas and there was some doubt associated with the methods used to split these back out to CALVIN terms. However, throughout this project, there was much valuable correspondence with USGS regarding the uses of CVHM for CALVIN and many of the components that were difficult to calculate or not present in this version of CVHM will be present in future versions. Future updates to CALVIN groundwater should re-visit the idea of using CVHM for groundwater representation. CVHM is based on the widely used MODFLOW and many of the results in the current version are comparable with other studies (i.e. storage results) and physical measurements. The CVHM calculated terms and results were largely considered when calibrating the C2VSIM inputs to updated CALVIN; Chapter 4 discusses some of these considerations and presents the results of the updated CALVIN model.

CHAPTER 4

CALVIN with Updated Groundwater Representation

As discussed in the last chapter, the updated CALVIN groundwater representation is based primarily on C2VSIM. Another update that affects groundwater management is Delta pumping constraints, which are updated based on CALSIM II 2009 results (DWR 2011). This chapter presents the final terms used in CALVIN, discusses the calibration process, shows CALVIN network improvements, and compares the updated CALVIN with the previous version.

Updated CALVIN

The previous chapter compared the input terms between the groundwater models. However, C2VSIM had additional components that were not directly accounted for in CVHM and/or CVGSM. Table 4.1 shows the C2VSIM terms required to achieve a mass balance and used for the updated CALVIN model. Figure 4.1 is a schematic of the flows and interactions of these terms in the groundwater system in the updated CALVIN network. This schematic is similar to the flow interaction diagram in Chapter 1, but has some differences and also includes the nodes and links as in the updated CALVIN network. The schematic shows the hidden nodes, which are used in the model to separate the shadow value of the diversion from the shadow value of the delivery. This schematic does not show the calibration flow term since calibration flows were small and ultimately were not included. This schematic also includes artificial recharge, which was not previously explicit in the CALVIN groundwater system. Along with artificial recharge, some network improvements and simplifications were made by adding a few hidden nodes, and these changes are shown in red in the schematic.

Table 4.1: Groundwater Data Required by Updated CALVIN

Item	Data for CALVIN	Data type
1	Agricultural return flow split (GW & SW)	Fraction (1a+1b=1)
2	Internal reuse	Amplitude (≥1)
3	Return flow of total applied water	Amplitude (<1)
4	External flows	Monthly time series
4-1	Inter-basin flows	Monthly time series
4-2	Deep percolation from streams & lakes	Monthly time series
4-3	Deep percolation from precipitation	Monthly time series
4-4	Boundary inflow	Monthly time series
4-5	Subsidence	Monthly time series
4-6	Gains from diversions (conveyance seepage)	Monthly time series
4-7	Non-recoverable losses	Monthly time series
5	Groundwater pumping capacity (maximum & minimum)	Number value
6	Pumping lift (for pumping cost)	Number value & Cost ($)
7	Initial Storage	Number value
8	Ending Storage	Number value
9	Storage capacity (maximum & minimum)	Number value
10	Artificial Recharge Operation Cost	Cost ($)
11	Artificial Recharge Rate	Amplitude (<1)
12	Urban return flow	Amplitude (<1)

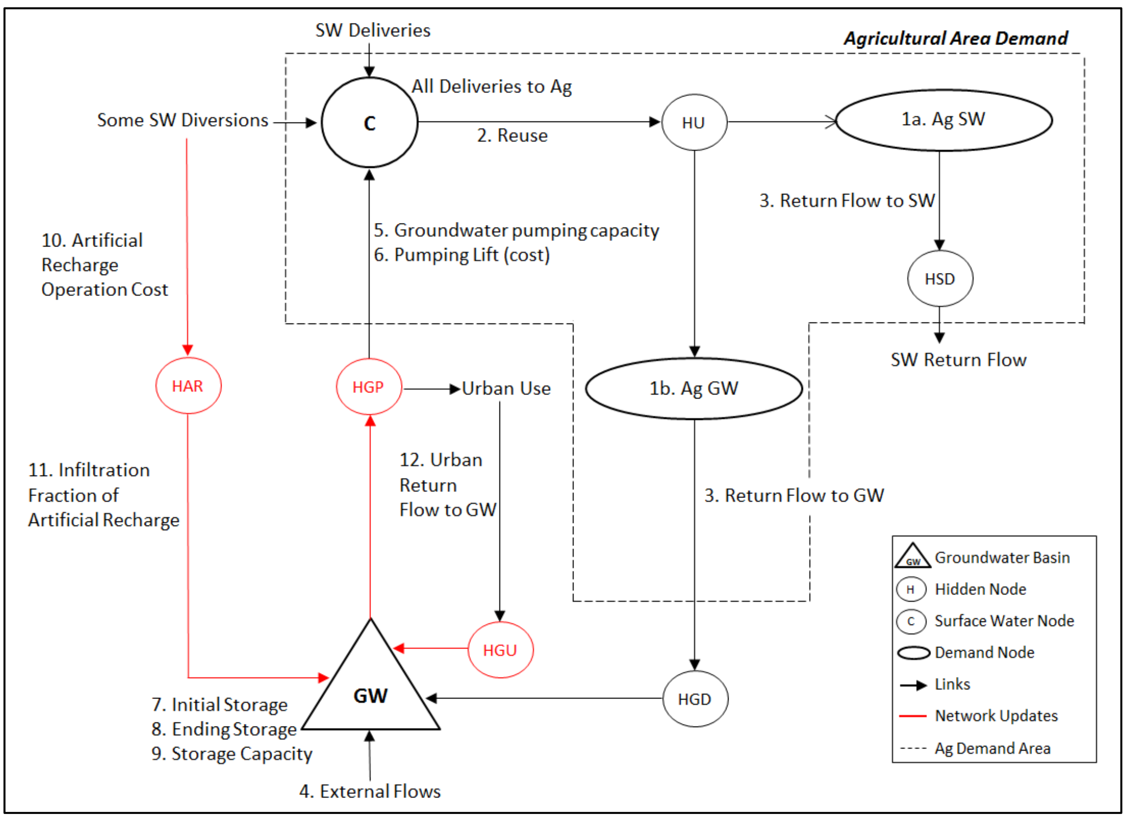


Figure 4.1 Updated CALVIN Groundwater Schematic

Network & Schematic Improvements

The schematic included the addition of the hidden nodes to simplify the direct groundwater interaction. The previous version of CALVIN had multiple pumping links and urban return flow links connected with the groundwater basins. Adding node "HGP" provides a link from groundwater which represents total pumping from the groundwater basin. From HGP, pumping is split between agricultural pumping and urban pumping. Similarly, the previous CALVIN had multiple urban return flows returning to the groundwater basin, and now combines return flows at "HGU" before returning to the aquifer. The link between HGU and the groundwater basin is the total urban return flow. Since C2VSIM represents artificial recharge for basins 13, 15-21, nodes and links for artificial recharge were added for those basins. A detailed description of the schematic updates is provided in Appendix 3.

Updated CALVIN & Old CALVIN Input Comparisons

The tables in this section compare the updated, calibrated CALVIN model and the CALVIN model prior to this groundwater update project. Table 4.2 shows the run numbers and a description of each run. Updated CALVIN will be referred to as "UPDATED CALVIN" and the previous version will be called "OLD CALVIN." These comparison tables will show and discuss the final values used for UPDATED CALVIN. A summary of the calibration process and reasons for some adjustments from the original C2VSIM inputs is discussed below.

Table 4.2: UPDATED CALVIN and OLD CALVIN

Run Name	Run Number	Description
"OLD CALVIN"	R17I03	The results from this run are discussed in Bartolomeo 2011. This is the "base" model for the groundwater update project.
"UPDATED CALVIN"	S07I14	This is the final calibrated run based primarily on C2VSIM groundwater terms and a hybrid CALSIM II-OLD CALVIN-based delta pumping & exports constraints.

<u>Agricultural Return Flow, Reuse, and Total Applied Water Return Flow</u>

Table 4.3 shows the Agricultural Return Flow to Groundwater fractions, the Reuse amplitudes, and the Total Applied Water Return Flow amplitudes. There are significant differences between old and UPDATED CALVIN for all three of these terms. UPDATED CALVIN has generally higher return flows to groundwater and lower reuse amplitudes. Many of the OLD CALVIN terms here were adjusted from the CVGSM based values in the groundwater calibration project from 2001. Details of why those earlier adjustments were made can be found in Appendix J and O (Jenkins 2001).

For the UPDATED CALVIN columns, the values adjusted during calibration are shown in bold italics and red. These particular values were adjusted based on comparisons with CVHM results and consideration of how reasonable the C2VSIM calculated value was. A summary of the calibration changes is in the calibration section below.

Table 4.3: UPDATED CALVIN Return Flow to Groundwater, Reuse, and Applied Water Return Flow

Subregion	Split Ag Return Flow to GW Fraction		Reuse Amplitude		Applied Water Return Flow Amplitude	
	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN*	OLD CALVIN
1	0.28	0.44	1	1	0.47	0.32
2	1	0.77	1	1	***0.26***	0.26
3	0.6	0.78	1.086	1.05	0.2	0.28
4	0.99	0.18	1.001	1.13	0.14	0.21
5	0.72	0.74	1.049	1.06	0.21	0.283
6	0.98	1	1.001	1.32	***0.12***	0.08
7	1	0.55	1	1.08	0.25	0.3
8	0.93	0.21	1.003	1.1	0.12	0.23
9	1	0.7	1	1.1	***0.1***	0.21
10	0.94	0.26	1.003	1.05	0.2	0.33
11	0.94	1	1.005	1.04	0.22	0.272
12	0.94	0.38	1.004	1.1	***0.18***	0.18
13	0.97	0.34	1.002	1.1	***0.13***	0.18
14	1	1	1	1	0.18	0.22
15	1	0.4	1	1.05	0.12	0.21
16	0.84	0.31	1.015	1.1	0.28	0.18
17	1	0.61	1	1.1	0.13	0.17
18	1	1	1	1	0.18	0.25
19	1	1	1	1	0.03	0.21
20	0.82	0.99	1.014	1.07	0.1	0.17
21	1	1	1	1	0.1	0.25

* Red Bold Italics indicate values adjusted during calibration

External Flows

Table 4.4 shows the average annual net external flows for UPDATED CALVIN and OLD CALVIN, along with the original C2VSIM flow averages since this term was adjusted significantly for many basins. Specifically, the external flow time series term that was adjusted was groundwater-surface water interaction from streams. Differences in stream exchanges before and after 1951 are due to the change in aquifer levels and therefore changes in surface-groundwater interactions. Stream-aquifer connections have changed over time so streams that may have gained water from aquifers before 1951 have reversed to losing water to aquifers. If the historical time series of stream-aquifer flows was used, there would likely have been a million acre-feet per year of water that was not accounted for correctly in the Central Valley. As a result, streamflow exchanges before 1951 were adjusted based on if the annual average difference for subregions was above 50 TAF/yr. Adjusted subregions are 2, 4, 5, 6, 9, 11, 13, 15, 18, 19 and 21 (shown in bold italics and red in Table 4.4). To maintain mass balance of water available within the subregion, the difference between historical and adjusted stream inflows was accounted for in the depletion areas of respective subregions or as depletions or accretions to major streams in these subregions. A more detailed description of this adjustment is in Appendix 4.

Effectively, the C2VSIM external flow values are used; some of the water was just moved from the external flows term to the depletions and accretions to account for the changes in aquifer levels after 1951. Overall, UPDATED CALVIN has much less external flows entering the groundwater system than OLD CALVIN's external flows entering the groundwater system. The individual flows that summed to be net external flows are discussed in Chapter 3.

As mentioned in the previous chapter, C2VSIM represents evapotranspiration losses as a surface water loss fraction so it is not accounted for in the external flows time series. More details on the C2VSIM surface loss fractions can be found in Appendix 5.

Table 4.4: Net External Flow Averages Compared (TAF/yr)

Subregion	UPDATED CALVIN*	C2VSIM	OLD CALVIN (CVGSM)
1	28	28	2
2	***235***	177	403
3	-9	-9	9
4	***-68***	-96	261
5	***91***	67	144
6	***225***	180	367
7	168	168	278
8	402	402	747
9	***134***	85	14
10	72	72	296
11	***29***	-1.3	-159
12	49	49	155
13	***365***	344	863
14	278	278	309
15	***688***	594	1161
16	51	51	280
17	96	96	360
18	***241***	263	484
19	***424***	368	162
20	101	101	220
21	***322***	290	387
SAC TOTAL	***1206***	1002	2224
SJ TOTAL	***515***	464	1156
TL TOTAL	***2201***	2041	3362
TOTAL	***3922***	3507	6741

* Red Bold Italics indicate values adjusted during calibration

Pumping Terms

Table 4.5 shows the pumping related terms (capacity, depth, and unit costs) for CALVIN (UPDATED and OLD). The maximum pumping values from C2VSIM were used as pumping constraints except for a few regions (shown in bold italics and red). These exceptions were increased during calibration because it was found that the maximum pumping constraints were being hit often, and when comparing the C2VSIM maximum pumping capacities with CVHM, C2VSIM's maximum pumping values were significantly lower, indicating that the actual maximum could be larger.

Pumping depths and costs were not adjusted in the calibration phase. Since the data is based on average measured DWR groundwater level data, those pumping depths were used to calculate the pumping cost. Adjustments were made to the pumping costs to reflect year 2008 economic dollars. Details of the how pumping costs were calculated can be found in Appendix 2.

Table 4.5: UPDATED CALVIN Pumping Terms Comparison

Subregion	Maximum Pumping (TAF/month)		Pumping Depth (feet)		Pumping Cost[1] ($)	
	UPDATED CALVIN*	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN
1	7.2	20.76	71	130	$ 23.59	$ 30.00
2	93.2	153.23	40	120	$ 15.82	$ 28.20
3	175.8	170.98	27	100	$ 11.93	$ 23.80
4	109.2	110.47	16	60	$ 9.33	$ 16.00
5	240.1	225.65	27	75	$ 11.93	$ 18.80
6	85.7	148.06	25	70	$ 11.93	$ 18.20
7	120.5	96.02	40	95	$ 23.07	$ 28.80
8	185.6	208.38	90	110	$ 31.89	$ 28.60
9	***50***	73.77	24	80	$ 11.93	$ 20.40
10	185.2	197.88	17	60	$ 9.07	$ 15.60
11	64.9	52.21	47	75	$ 19.45	$ 20.60
12	86.9	80.56	68	90	$ 24.89	$ 23.60
13	225.8	290.96	75	125	$ 25.93	$ 30.00
14	221.1	332.85	235	350	$ 69.22	$ 76.40
15	335.3	407.88	93	210	$ 30.08	$ 46.60
16	61.8	60.76	57	130	$ 19.70	$ 29.80
17	152.6	152.39	34	130	$ 16.07	$ 31.60
18	***300***	348.95	80	200	$ 27.48	$ 45.20
19	213.7	171.1	139	310	$ 44.85	$ 68.40
20	125.3	108.1	298	310	$ 84.00	$ 67.20
21	265.6	228.31	191	310	$ 59.37	$ 69.60

* Red Bold Italics indicate values adjusted during calibration
[1]Note that UPDATED CALVIN pumping costs are based on year 2008$ dollars and OLD CALVIN costs are based on year 2000$ dollars

Storage Terms

The storage terms are shown in Table 4.6. The values in the table reflect the maximum, initial, ending, and average annual change in storage for the 72 year time period for water years 1921-1993.

For UPDATED CALVIN, the maximum storage constraint was not actually used in the final run since the initial and ending storages were set to simulate overdraft. The initial storage values were set based on C2VSIM initial storage values. The ending storages were set based on the calculated overdraft/change in storage discussed in Chapter 3, with some calibration adjustments. The change in storage calculated for the OLD CALVIN run was based on the initial storage minus the ending storage. The initial and ending storages for OLD CALVIN differ from the original groundwater calibration based on CVGSM, due to other CALVIN calibrations in the past 10 years.

As can be seen in the storage change numbers, there is some agreement that much more overdraft occurs in the Tulare basin than the other two Central Valley basins. The ending storages for UPDATED CALVIN that were adjusted from C2VSIM's calculated overdraft for the regions are shown in bold italics. Reasons behind this adjustment will be discussed in the next section.

In general, estimates of long-term overdraft vary widely, as such calculations are quite sensitive to the selection of periods, durations, and flows over wet and dry periods.

Table 4.6: UPDATED CALVIN Storage Terms and Overdraft

Subregion	Maximum Storage Capacity (TAF/mo)		Initial Storage (TAF/mo)		Ending Storage* (TAF/mo)		Average Annual Storage Change for 1921-1993 (TAF/yr)[1]	
	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN*	OLD CALVIN	UPDATED CALVIN	OLD CALVIN
1	38,510	5,448	38,447	1,902	39,437	1,774	-13.8	1.8
2	136,757	24,162	136,494	11,843	***136,494***	11,242	***0.0***	8.3
3	133,958	22,127	132,687	13,345	131,748	13,545	13.0	-2.8
4	61,622	15,362	60,728	10,350	60,508	10,581	3.1	-3.2
5	92,020	24,399	91,113	15,552	90,457	14,561	9.1	13.8
6	175,719	22,864	174,968	17,948	175,275	16,077	-4.3	26.0
7	58,484	12,270	56,539	10,025	51,209	12,168	74.0	-29.8
8	193,433	32,842	190,665	22,366	182,829	16,276	108.8	84.6
9	139,752	23,395	139,472	17,744	139,834	20,474	-5.0	-37.9
10	91,920	29,250	90,210	22,213	87,055	23,477	43.8	-17.6
11	59,302	15,543	58,838	10,948	58,246	8,747	8.2	30.6
12	43,510	13,919	42,602	10,380	40,865	9,414	24.1	13.4
13	142,508	47,484	138,216	31,143	128,560	31,169	134.1	-0.4
14	181,001	65,235	178,840	51,075	172,009	45,763	94.9	73.8
15	313,759	90,978	309,643	70,494	306,666	70,415	41.3	1.1
16	64,915	11,650	64,696	6,359	64,439	0	3.6	88.3
17	98,836	13,942	97,214	7,311	93,653	7,005	49.5	4.3
18	322,480	59,544	321,375	40,775	***321,375***	33,947	***0.0***	94.8
19	147,060	68,266	141,750	43,085	128,224	43,087	187.9	0.0
20	141,457	40,814	137,073	22,630	125,136	23,403	165.8	-10.7
21	351,327	81,622	341,142	51,595	***324,302***	47,588	***233.9***	55.7
SAC TOTAL	1,030,255	182,869	1,021,113	121,075	1,008,673	116,698	172.8	60.8
SJ TOTAL	337,240	106,196	329,866	74,684	314,726	72,807	210.3	26.1
TL TOTAL	1,620,835	432,051	1,591,733	293,324	1,535,804	271,208	776.8	307.2
TOTAL	2,988,330	721,116	2,942,712	1,902	2,859,203	909,908	1159.8	394.0

* Red Bold Italics indicate values adjusted during calibration
[1]Positive values represent overdraft and negative values represent gains to groundwater.

Artificial Recharge

In C2VSIM, subregions 13, and 15-21 manage their groundwater supplies with artificial recharge of imported or local surface water. Artificial recharge flows to groundwater are reported as C2VSIM diversions and are described in the simulation application's *CVdivspec.dat* file, which specifies diversions for spreading and destination subregions for infiltration facilities. In C2VSIM, spreading facilities have a recoverable fraction of 0.95 (an assumed infiltration rate). The groundwater budget output file has a "Recharge" term, which includes both diversion losses and water from spreading facilities. To separate artificial recharge volumes from the total recharge volume, an infiltration rate of 0.95 was applied to monthly diversion volumes for surface water diversions for spreading, where diversions for spreading are listed in Table 4.7. Monthly volumes of Diversion times 0.95 was taken as recharge from spreading facilities and was therefore separated from the total recharge term for subregions 13, and 15-21. Figure 4.1 shows the added nodes and links (in bold italics and red) that represent this artificial recharge addition to the CALVIN network. Artificial recharge was not explicitly represented in OLD CALVIN; historical artificial recharge was included in select inflows.

Table 4.7: Surface Water Diversion for Spreading

C2VSIM Source Node	Destination Subregion	Artificial Recharge Infiltration Rate	Non-recoverable Losses	Description
84	13	0.95	0.05	Chowchilla R riparian SR13 Spreading
74	13	0.95	0.05	Fresno R riparian SR13 Spreading
28	15	0.95	0.05	Kings R Main Stem to SR15 Spreading
43	15	0.95	0.05	Kings R North Fork to SR15 Spreading
37	15	0.95	0.05	Kings R South Fork to SR15 Spreading
52	15	0.95	0.05	Kings R Fresno Slough to SR15 Spreading
24	16	0.95	0.05	Kings R to Fresno ID SR16 Spreading
Import	16	0.95	0.05	Friant-Kern Canal to SR16 Spreading
25	17	0.95	0.05	Kings R to Consolidated ID SR17 Spreading
25	17	0.95	0.05	Kings R to Alta ID SR17 Spreading
Import	17	0.95	0.05	Friant-Kern Canal to SR17 Spreading
420	18	0.95	0.05	Kaweah R Partition A to SR18 Spreading
422	18	0.95	0.05	Kaweah R Partition B to SR18 Spreading
422	18	0.95	0.05	Kaweah R Partition C to SR18 Spreading
420	18	0.95	0.05	Kaweah R Partition D to SR18 Spreading
426	18	0.95	0.05	Kaweah R to Corcoran ID SR18 Spreading
18	18	0.95	0.05	Tule R riparian to SR18 Spreading
Import	18	0.95	0.05	Friant-Kern Canal to SR18 Spreading
7	19	0.95	0.05	Kern R to SR19 Spreading
Import	19	0.95	0.05	California Aqueduct to SR19 Spreading
Import	19	0.95	0.05	Friant-Kern Canal to SR19 Spreading
2	20	0.95	0.05	Kern R to SR20 Spreading
Import	20	0.95	0.05	Friant-Kern Canal to SR20 Spreading
Import	20	0.95	0.05	Cross-Valley Canal to SR20 Spreading
3	21	0.95	0.05	Kern River to Subregion 21B spreading
4	21	0.95	0.05	Kern River to Subregion 21C spreading
Import	21	0.95	0.05	California Aqueduct to SR21 Spreading
Import	21	0.95	0.05	Friant-Kern Canal to SR21 Spreading
Import	21	0.95	0.05	Cross-Valley Canal to SR21 Spreading

Table 4.8 shows the annual average historical artificial recharge per C2VSIM simulation and operation costs of artificial recharge facilities updated from OLD CALVIN artificial recharge costs. These are calculated to reflect operating costs for these agricultural groundwater recharge activities, which limit facility operations and the opportunity cost of land used for recharge basins.

Table 4.8: Artificial Recharge Operation Costs

Subregion	CALVIN Link	Diversions for Spreading	Average Annual Artificial Recharge (TAF/yr)	Operating Cost ($/AF)[1]
13	HAR13_GW-13	Chowchilla R riparian & Fresno R riparian	4	6.5
15	HAR15_GW15	Kings R	138	6.5
16	HAR15_GW16	Kings R & Friant-Kern Canal	24	6.5
17	HAR15_GW17	Kings R & Friant-Kern Canal	23	6.5
18	HAR15_GW18	Kaweah R, Tule R riparian & Friant-Kern Canal	178	6.5
19	HAR15_GW19	California Aqueduct, Kern R and Friant-Kern Canal	79	6.5
20	HAR15_GW20	Kern R, Friant-Kern Canal & Cross-Valley Canal	66	6.5
21	HAR15_GW21	Kern R, California Aqueduct, Friant-Kern Canal & Cross Valley Canal	208	6.5

[1]OLD CALVIN cost (5 $/AF) converted to 2008 dollars

<u>Urban Return Flow</u>

The urban return flow fractions used for UPDATED CALVIN are based on C2VSIM's representation of urban return flow, as discussed in Chapter 3 (Table 3.6). These can be compared with the urban return flow fractions for OLD CALVIN, which are from CVGSM (also shown in Table 3.6).

<u>Agricultural Water Demands</u>

Along with updating the input terms related to CALVIN groundwater, agricultural demands were also updated. Results from an improved and updated Statewide Agricultural Production Model – SWAP (Howitt et al. 2012) were used for UPDATED CALVIN's agricultural demands. Table 4.9 shows agricultural demands for OLD CALVIN and UPDATED CALVIN. The differences in the water delivery targets can be attributed to improvements made in SWAP crop production model in that some CVPM regions (3, 10, 14, 15, 19 and 21) were further discretized for better representation. A detailed description of SWAP is in Howitt et al. 2012.

Table 4.9 shows that overall net demand target for UPDATED CALVIN is slightly lower. Generally, this could imply that decreased shortages in deliveries can be expected in UPDATED CALVIN. The calibration steps were based primarily on determining if shortages reflected in the results of each run were "true" shortages or if a specific calculated input term caused the shortage, such as local capacity constraints, leading to scarcities even in very wet years. The calibration process to reduce these "untrue" shortages is discussed in the next section.

Table 4.9: Average Annual Agricultural Water Delivery Targets (TAF/yr)

Agricultural Demand Area	OLD CALVIN	UPDATED CALVIN
CVPM 1	126	139
CVPM 2	497	473
CVPM 3	2,196	1,315
CVPM 4	956	884
CVPM 5	1,313	1,485
CVPM 6	619	732
CVPM 7	429	413
CVPM 8	802	737
CVPM 9	926	1,208
CVPM 10	919	1,403
CVPM 11	855	777
CVPM 12	772	760
CVPM 13	1,506	1,679
CVPM 14	1,358	1,129
CVPM 15	1,701	1,828
CVPM 16	345	368
CVPM 17	797	739
CVPM 18	1,759	2,119
CVPM 19	887	842
CVPM 20	829	640
CVPM 21	1,195	999
SAC TOTAL	7,864	7,386
SJ TOTAL	4,052	4,620
TL TOTAL	8,871	8,664
TOTAL	20,787	20,670

During the calibration phase of OLD CALVIN in 2001, it was found that there was too much excess water in the system, so a calibration outflow was needed for CALVIN to have reasonable results. These calibration outflows were constrained time series that dumped water from the C delivery node (shown in Figure 4.1) before reaching the demand nodes, effectively increasing water use. Table 4.10 shows these averaged annual calibration flows from the 2001 calibration. These calibration flows were a primary reason CALVIN needed to be updated.

Table 4.10: Average Annual Old CALVIN Calibration Outflow (TAF/yr)

Subregion	Calibration Outflow
1	5
2	0
3	0
4	63
5	114
6	259
7	46
8	33
9	0
10	389
11	242
12	16
13	247
14	0
15	0
16	194
17	62
18	0
19	216
20	23
21	170
SAC TOTAL	520
SJ TOTAL	894
TL TOTAL	665
TOTAL	2,079

Calibration Summary

The results presented in the sections above for UPDATED CALVIN reflect the already calibrated values (shown in bold italics). This section discusses and summarizes calibration adjustments made to the original C2VSIM inputs.

Calibration Steps

The previous section compared UPDATED CALVIN and OLD CALVIN. This calibration section discusses the key differences between these two successfully calibrated runs. Table 4.11 presents those runs, their numbers, and a description of the runs. Starting with OLD CALVIN as a base, the newly calculated C2VSIM-based input terms were used for the "UPDATED CALVIN C2VSIM Base" run. The model solves, but the shortages were quite high in unusual ways, indicating some possibly "untrue" localized scarcity. Calibration adjustments were made for different terms in runs S07I05-S07I08 to try to minimize unrealistic scarcity. Run S07I08 is called "UPDATED CALVIN Old Delta" since it is the successfully calibrated CALVIN run with updated groundwater representation based primarily on C2VSIM, but does not include the updated Delta term constraints. Calibration adjustments were made for Delta terms in runs S07I08-S07I14. UPDATED CALVIN represents the final, calibrated run with all updates, including the updated Delta terms.

Table 4.11: CALVIN Calibration Runs

Run Name	Run Number	Description
"UPDATED CALVIN C2VSIM Base"	S07I05	The results from this run are based primarily on C2VSIM inputs as originally calculated prior to any calibration changes (external flows adjustment is included). Delta terms are based on OLD CALVIN.
"UPDATED CALVIN Old Delta"	S07I08	This is the final calibrated run based primarily on C2VSIM groundwater terms with Delta terms based on OLD CALVIN.
"UPDATED CALVIN"	S07I14	This is the final calibrated run based primarily on C2VSIM groundwater terms and a hybrid CALSIM II-OLD CALVIN-based delta pumping & exports constraints.

The calibration process was essentially split into two parts: 1) the calibration of CALVIN based on C2VSIM input terms (from UPDATED CALVIN C2VSIM Base to UPDATED CALVIN Old Delta), and 2) the calibration of the new Delta exports and pumping constraints (from UPDATED CALVIN Old Delta to UPDATED CALVIN). The section below summarizes the changes made in the entire calibration process, discussing the base calibration first, then the Delta terms calibration. A detailed description of the entire calibration process can be found in Appendix J(2) (Zikalala et al. 2012).

UPDATED CALVIN C2VSIM Base Calibration

Table 4.12 shows the resulting annual average shortages (scarcities) for the major runs. As can be seen between the UPDATED CALVIN C2VSIM Base run and the UPDATED CALVIN Old Delta run, there are significant decreases in scarcities in regions 2, 4, 6, and 18. Small decreases occur in regions 9, 12, 13, 20, and 21. These reductions in shortages are due to adjusting surface water diversion capacities, amplitudes for return flows, maximum pumping capacities, and calculated overdraft. These adjustments were made based on examining the results from each run and determining what term or factor might be causing that region to have unrealistic shortages, particularly shortages in very wet years caused by localized capacity constraints and amplitudes. Dual values for node conveyances to the subregions were considered to assess if the capacities or upper bounds were realistic for the physical system. Values that were not believed to represent "true" groundwater or capacity conditions were adjusted; these adjustments were based on comparisons with CVHM results or measured data. The shortages for each run (S07I05-S07I08) and the changes made between runs are described in more detail in Appendix J(2).

Table 4.12: Average Annual Agricultural Water Scarcity Comparison

Agricultural Demand Area	CALVIN Schematic Demand Node	CALVIN Delivery Link	Annual Average Water Shortages (TAF/yr)			
			OLD CALVIN*	UPDATED CALVIN C2VSIM Base	UPDATED CALVIN Old Delta	UPDATED CALVIN
CVPM 1	Ag-GW	HU1-CVPM 1G	0.0	0.7	0.8	1.0
	Ag-SW	HU1-CVPM 1S	0.0	0.4	0.7	1.1
CVPM 2	Ag-GW	HU2-CVPM 2G	0.0	189.0	0.0	0.0
	Ag-SW	HU2-CVPM 2S	0.0	0.0	0.0	0.0
CVPM 3	Ag-GW	HU3-CVPM 3G	0.0	0.0	0.0	0.0
	Ag-SW	HU3-CVPM 3S	15.0	0.0	0.0	0.0
CVPM 4	Ag-GW	HU4-CVPM 4G	0.0	70.7	0.0	0.0
	Ag-SW	HU4-CVPM 4S	0.0	1.7	0.0	0.0
CVPM 5	Ag-GW	HU5-CVPM 5G	0.0	0.0	0.0	0.0
	Ag-SW	HU5-CVPM 5S	0.0	0.0	0.0	0.0
CVPM 6	Ag-GW	HU6-CVPM 6G	0.0	45.5	7.3	28.5
	Ag-SW	HU6-CVPM 6S	0.0	1.2	0.5	0.5
CVPM 7	Ag-GW	HU7-CVPM 7G	0.0	0.0	0.0	0.0
	Ag-SW	HU7-CVPM 7S	0.0	0.0	0.0	0.0
CVPM 8	Ag-GW	HU8-CVPM 8G	0.0	0.0	0.0	0.0
	Ag-SW	HU8-CVPM 8S	0.0	0.0	0.0	0.0
CVPM 9	Ag-GW	HU9-CVPM 9G	0.0	8.3	0.1	12.7
	Ag-SW	HU9-CVPM 9S	0.0	0.0	0.0	0.0
CVPM 10	Ag-GW	HU10-CVPM 10G	0.0	48.4	48.7	51.4
	Ag-SW	HU10-CVPM 10S	0.0	3.3	3.4	3.5
CVPM 11	Ag-GW	HU11-CVPM 11G	0.0	0.3	0.3	0.7
	Ag-SW	HU11-CVPM 11S	0.0	0.0	0.0	0.0
CVPM 12	Ag-GW	HU12-CVPM 12G	0.0	25.4	22.6	23.4
	Ag-SW	HU12-CVPM 12S	22.0	1.6	1.1	1.5
CVPM 13	Ag-GW	HU13-CVPM 13G	0.0	75.9	74.5	74.9
	Ag-SW	HU13-CVPM 13S	0.0	2.4	2.3	2.4
CVPM 14	Ag-GW	HU14-CVPM14G	0.0	0.0	0.0	0.0
	Ag-SW	HU14-CVPM14S	0.0	0.0	0.0	0.0
CVPM 15	Ag-GW	HU15-CVPM15G	0.0	0.0	0.0	0.0
	Ag-SW	HU15-CVPM15S	0.0	0.0	0.0	0.0
CVPM 16	Ag-GW	HU16-CVPM16G	0.0	7.8	8.0	13.3
	Ag-SW	HU16-CVPM16S	0.0	2.6	2.6	2.7
CVPM 17	Ag-GW	HU17-CVPM17G	0.0	33.6	33.6	34.8
	Ag-SW	HU17-CVPM17S	0.0	0.0	0.0	0.0
CVPM 18	Ag-GW	HU18-CVPM18G	0.0	151.0	107.6	106.0
	Ag-SW	HU18-CVPM18S	0.0	0.0	0.0	0.0
CVPM 19	Ag-GW	HU19-CVPM19G	0.0	0.0	0.0	0.0
	Ag-SW	HU19-CVPM19S	0.0	0.0	0.0	0.0
CVPM 20	Ag-GW	HU20-CVPM20G	0.0	25.5	22.1	21.9
	Ag-SW	HU20-CVPM20S	0.0	5.3	4.8	4.9
CVPM 21	Ag-GW	HU21-CVPM21G	0.0	42.6	39.9	38.6
	Ag-SW	HU21-CVPM21S	0.0	0.0	0.0	0
Sacramento			**15.0**	**317.5**	**9.4**	**43.8**
San Joaquin			**22.0**	**157.3**	**152.9**	**157.8**
Tulare			**0.0**	**268.4**	**218.6**	**222.3**
Central Valley Total			**37.0**	**743.2**	**380.9**	**423.8**

*Note that OLD CALVIN had different SWAP targets

Since the surface water loss fractions were changed in this update, the surface water diversion capacities were examined more closely for the regions with significant shortages. Table 4.13 shows the changes made to the upper bound conveyance capacity for the surface water diversions and reasons for the adjustments. In most cases, the surface water loss amplitudes (discussed in Appendix 5) are lower for UPDATED CALVIN, indicating higher surface water losses so the upper bound capacities were increased to compensate for greater losses. The link that represents surface water diversion recoverable and non-recoverable losses comes after the link that the upper bound capacity is on in the CALVIN network. To better represent the "true" upper bound capacity, the upper bound capacities were increased so that when the flow reaches the link with the associated surface water loss, the original upper bound capacity could still be delivered.

Table 4.13: Surface Water Diversion Capacity Calibration Adjustments

Subregion	CALVIN SW Diversion Link	Upper Bound Capacity (TAF/month)		Source or Reason for Adjustment
		OLD CALVIN	UPDATED CALVIN	
2	D77-HSU2D77	12.7	29.7	USBR website
	C1-HSU2C1	1.8	1.98	Compensation for increased SW losses
	C11-HSU2C11	0.7	1.03	C2VSIM
	HSU2C9-C6	26.4	29.3	C2VSIM
4	D30-HSU4D30	194.1	236	Compensation for increased SW losses
6	C314_HSU6C314	32.1	34	Compensation for increased SW losses
	C16_HSUC16	36.3	38.5	Compensation for increased SW losses
	C21_HSUC21	40.5	42.9	Compensation for increased SW losses
12	D645-HSU12D645	5.4	5.94	Compensation for increased SW losses
	D649-HSU12D649	12.2	13.42	Compensation for increased SW losses
	D662-HSU12D662	107.1	117.81	Compensation for increased SW losses
	D664-HSU12D664	2	2.2	Compensation for increased SW losses
	D699-HSU12D699	4.5	4.95	Compensation for increased SW losses
13	D645-HSU13D645	111.4	122.54	Compensation for increased SW losses
	D649-HSU13D649	4.3	4.73	Compensation for increased SW losses
	D634-HSU13D634	42.9	47.19	Compensation for increased SW losses
	D624-HSU13D634	57.2	62.92	Compensation for increased SW losses
	D694-HSU13D694	0.5	0.55	Compensation for increased SW losses
18	C56-HSU18C56	179.6	197.56	Compensation for increased SW losses
	C58-HSU18C58	23.1	25.41	Compensation for increased SW losses

Calibration adjustments also were made to the C2VSIM calculated groundwater terms. Table 4.14 compares the final values used for UPDATED CALVIN and the original C2VSIM calculated values. These adjustments were not all made in just one run at one time; the changes were made throughout runs S07I05-S07I08 (discussed in detail in Appendix J(II) (Zikalala et al. 2012)).

The first column of Table 4.14 shows adjustments for total applied water return flow amplitudes. These amplitudes were increased to allow more water to return to the groundwater basins. The increases for this term were mostly justified based on comparisons with CVHM return flow amplitudes (Table 3.2).

The maximum pumping capacities were adjusted for regions 9 and 18. This was done because there were large shortages that seemed unreasonable for those regions. Additionally, maximum pumping was being reached even during normal water years and comparisons of the maximum pumping capacity for those regions with CVHM values indicated that they could be higher (Table 3.4).

Change in storage values were adjusted for regions 1, 18, and 21 because the C2VSIM-based calculations of storage change did not seem to reflect physically likely storage changes in those regions. Increased groundwater storage for regions 2 and 18 just did not seem realistic, so they were adjusted to have no storage change. Considering region 21's physical area, the C2VSIM calculated overdraft of 27,903 TAF seemed too high and unlikely to be true. So rather than eliminate region 18's recharge to groundwater, that addition of groundwater was accounted for in region 21 instead. Although this doesn't follow conventional calibration methods, regions 18 and 21 are both in the Tulare region, so making this adjustment seemed reasonable, from an overall Tulare basin perspective; the total overdraft for the Tulare region based on C2VSIM is not affected. Additionally, when compared with CVHM's region 21 calculated overdraft of 5,611 TAF, the UPDATED CALVIN value is much closer than the C2VSIM calculated value.

Table 4.14: Adjustments to Groundwater Terms

Subregion	Total Applied Water Return Flow Amplitude		Maximum Pumping Capacity (TAF/month)		Overdraft (TAF)	
	C2VSIM	UPDATED CALVIN	C2VSIM	UPDATED CALVIN	C2VSIM	UPDATED CALVIN
2	0.14	0.26	-	-	-990	0
6	0.06	0.12	-	-	-	-
9	0.09	0.10	43.9	50	-	-
12	0.16	0.18	-	-	-	-
13	0.12	0.13	-	-	-	-
18	-	-	238.4	300	-11063	0
21	-	-	-	-	27903	16840

Note that "-" just indicates that no changes were made for that term for that region.

The adjustments discussed above allowed for about an average annual 360 TAF of localized scarcities to be removed from the system, as seen in Table 4.12 when comparing shortages between UPDATED CALVIN C2VSIM Base and UPDATED CALVIN Old Delta. Adjustments were made until it was obvious that regardless of reasonable adjustments, the scarcities would remain, implying real scarcity in those regions not due to unrealistic local constraints. UPDATED CALVIN Old Delta was used as a base case for the next part of the update project – updates to Delta terms.

UPDATED CALVIN Delta Exports and Pumping Calibration

Table 4.15 compares the input constraints that affect the Delta. The major pumping plants for the Delta are Banks and Tracy Pumping Plants. For this update, the Tracy pumping upper-bound constraint was left as it was in OLD CALVIN; the CALSIM II Tracy pumping constraint had comparable maximums as the constraints used in OLD CALVIN. The Banks upper-bound pumping constraint used for UPDATED CALVIN is a hybrid of CALSIM II 2009 results (DWR 2011) and OLD CALVIN's constraints. Although CALSIM's complex Delta flow restrictions would be a better representation of real Delta exports than OLD CALVIN's constraints, using CALSIM results alone as constraints would be too inflexible and would result in optimization infeasibilities. The hybrid version was used so that the final Banks pumping constraint is updated to be more comparable with CALSIM II 2009 results while still being able to achieve feasible results through CALVIN's optimization methods.

A cumulative distribution was plotted for CALSIM II's Banks pumping constraint and it was determined that the maximum of 465 TAF was a reasonable maximum to use for the new constraint. Then, in order to bring OLD CALVIN's Banks upper-bound to a lower value, any value for pumping for OLD CALVIN that exceeded the 465 TAF maximum was set to 465 TAF. It appeared that every value was greater than 465 TAF so 465 TAF was used to be the Banks constraint, with adjustments for number of days per month.

The Required Delta Outflow is a constrained minimum flow in CALVIN. The constraint used for UPDATED CALVIN was based on both CALSIM II 2009 and OLD CALVIN. At every month, the maximum value for Delta Export Outflow between CALSIM II 2009 and OLD CALVIN was used as the constraint for UPDATED CALVIN. This results in UPDATED CALVIN having a larger annual average Delta Export Outflow constraint.

Table 4.15: Delta Pumping Constraints and Minimum Delta Outflow

Model	Banks Pumping Upper-bound Constraint		Tracy Pumping Upper-bound Constraint		Total Delta Pumping Upper-bound Constraint		Minimum Delta Outflow	
	Annual Average (TAF/yr)	Maximum (TAF/mo)	Annual Average (TAF/yr)	Maximum (TAF/mo)	Annual Average (TAF/yr)	Maximum (TAF/mo)	Annual Average (TAF/yr)	Maximum (TAF/mo)
UPDATED CALVIN	5475	465	2169	283	7644	748	6314	1713
CALSIM II 2009	2593	472	3331	283	5924	755	4944	1320
OLD CALVIN	6158	523	2169	283	8327	806	5593	1713

Table 4.12 shows that shortages for UPDATED CALVIN are higher than that of UPDATED CALVIN Old Delta. This is expected because in an attempt to have pumping capacity constraints and Delta exports be closer in comparison to CALSIM II 2009, there is less pumping and more required Delta outflow in UPDATED CALVIN than in OLD CALVIN (and UPDATED CALVIN Old Delta). As seen in the results, when the Delta terms were updated, there was more scarcity in the Sacramento region, which also agrees with the idea of more export outflow and lower pumping.

Table 4.16 shows the results from the CALVIN run for the Banks Pumping Plant and Tracy Pumping Plant. Although new constraints were used, the total annual average Delta pumping remained very close in comparison between the two models. This is interesting considering that UPDATED CALVIN has more Delta required outflow, and a tighter constraint for Banks pumping plant. This indicates that the upper bound constraint is reached more often in the Banks pumping plant in UPDATED CALVIN.

Table 4.16: Average Annual Delta Pumping Results (TAF/yr)

	UPDATED CALVIN	OLD CALVIN	CALSIM II 2009
Banks Pumping	4,383	4,906	2,984
Tracy Pumping	942	462	2,496
Total Delta Pumping	5,325	5,368	5,479

UPDATED CALVIN Results

This section presents and discusses the major run results for UPDATED CALVIN and compares them with OLD CALVIN's results.

<u>Targets, Deliveries, and Scarcities</u>

Table 4.17a shows the agricultural targets, deliveries and shortages for the model results. As mentioned before, the targets are different between the models because results from an updated version of SWAP were used to define water delivery targets for UPDATED CALVIN. One major problem with OLD CALVIN was that 2 million acre-feet of calibration flows out of the system were needed to have reasonable results, indicating that there was generally too much inflow in the system. With too much water in the system, scarcity is likely to be small, as seen in the last column of Table 4.17a. The scarcities for UPDATED CALVIN, though larger, are more reasonable and seem to better represent actual water scarcity, and omit the earlier 2 MAF/yr of calibration demands. The updated model has a much better physical basis.

Table 4.17a: UPDATED CALVIN and OLD CALVIN Agricultural Targets, Deliveries, and Scarcities (TAF/yr)

CALVIN Delivery Link	Target		Delivery		Scarcity	
	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN
HU1-CVPM1G	38.9	55.6	37.9	55.6	1.0	0.0
HU1-CVPM1S	100.0	70.7	98.8	70.7	1.1	0.0
HU2-CVPM2G	473.4	382.4	473.4	382.4	0.0	0.0
HU2-CVPM2S	0.0	114.2	0.0	114.2	0.0	0.0
HU3-CVPM3G	789.2	1713.1	789.2	1713.1	0.0	0.0
HU3-CVPM3S	526.2	483.2	526.2	468.2	0.0	15.0
HU4-CVPM4G	875.1	172.1	875.1	172.1	0.0	0.0
HU4-CVPM4S	8.9	784.0	8.9	784.0	0.0	0.0
HU5-CVPM5G	1069.5	971.3	1069.5	971.3	0.0	0.0
HU5-CVPM5S	415.9	341.2	415.9	341.2	0.0	0.0
HU6-CVPM6G	716.9	619.0	688.4	619.0	28.5	0.0
HU6-CVPM6S	14.7	0.0	14.2	0.0	0.5	0.0
HU7-CVPM7G	413.1	235.9	413.1	235.9	0.0	0.0
HU7-CVPM7S	0.0	193.0	0.0	193.0	0.0	0.0
HU8-CVPM8G	685.3	168.4	685.3	168.4	0.0	0.0
HU8-CVPM8S	51.6	633.4	51.6	633.4	0.0	0.0
HU9-CVPM9G	1207.5	648.4	1194.9	648.4	12.7	0.0
HU9-CVPM9S	0.0	277.9	0.0	277.9	0.0	0.0
HU10-CVPM10G	1318.8	238.9	1267.4	238.9	51.4	0.0
HU10-CVPM10S	84.2	680.1	80.6	680.1	3.5	0.0
HU11-CVPM11G	730.4	855.4	729.6	855.4	0.7	0.0
HU11-CVPM11S	46.6	0.0	46.6	0.0	0.0	0.0
HU12-CVPM12G	714.8	293.3	691.4	293.3	23.4	0.0
HU12-CVPM12S	45.6	478.5	44.1	456.5	1.5	22.0
HU13-CVPM13G	1629.0	512.1	1554.1	512.1	74.9	0.0
HU13-CVPM13S	50.4	994.0	48.0	994.0	2.4	0.0
HU14-CVPM14G	1129.0	1357.7	1129.0	1357.7	0.0	0.0
HU14-CVPM14S	0.0	0.0	0.0	0.0	0.0	0.0
HU15-CVPM15G	1828.0	680.5	1828.0	680.5	0.0	0.0
HU15-CVPM15S	0.0	1020.7	0.0	1020.7	0.0	0.0
HU16-CVPM16G	309.0	106.9	295.7	106.9	13.3	0.0
HU16-CVPM16S	58.9	237.9	56.1	237.9	2.7	0.0
HU17-CVPM17G	738.6	486.3	703.8	486.3	34.8	0.0
HU17-CVPM17S	0.0	310.9	0.0	310.9	0.0	0.0
HU18-CVPM18G	2119.4	1759.5	2013.4	1759.5	106.0	0.0
HU18-CVPM18S	0.0	0.0	0.0	0.0	0.0	0.0
HU19-CVPM19G	841.8	886.7	841.8	886.7	0.0	0.0
HU19-CVPM19S	0.0	0.0	0.0	0.0	0.0	0.0
HU20-CVPM20G	525.0	820.5	503.1	820.5	21.9	0.0
HU20-CVPM20S	115.2	8.3	110.4	8.3	4.9	0.0
HU21-CVPM21G	999.3	1195.4	960.7	1195.4	38.6	0.0
HU21-CVPM21S	0.0	0.0	0.0	0.0	0.0	0.0
Sacramento	7386	7864	7342	7849	44	15
San Joaquin	4620	4052	4462	4030	158	22
Tulare	8664	8871	8442	8871	222	0
Central Valley Total	20670	20787	20246	20750	424	37

Table 4.17b shows the urban targets, deliveries, and scarcities. As seen in the table, there are no differences between OLD CALVIN and UPDATED CALVIN in the Central Valley. Slight differences between the models in deliveries and scarcities can be seen in Southern California. Since the differences in urban deliveries are very small in comparison to the agricultural deliveries, the rest of this chapter will focus on the differences that apply to the agricultural side of the models.

Table 4.17b: UPDATED CALVIN and OLD CALVIN Urban Targets, Deliveries, and Scarcities (TAF/yr)

CALVIN Delivery Region	Target		Delivery		Scarcity	
	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN
Sacramento	1609	1609	1609	1609	0.3	0.3
San Joaquin	1571	1571	1571	1571	0.0	0.0
Tulare	1284	1284	1279	1279	5.1	5.1
Central Valley Total	4464	4464	4459	4459	5.4	5.4
Southern California	6840	6840	6648	6649	192.1	190.5

Water Deliveries and Recharge

Total water deliveries include water pumped from the ground and surface water deliveries. The first two columns of Table 4.18 show the groundwater pumping and surface water deliveries. The targets are different between the two runs (as shown in Table 4.17), but it is still useful to compare the total pumping and total surface water deliveries. As seen in groundwater pumping column, UPDATED CALVIN pumps over 2 MAF less groundwater than OLD CALVIN. Similarly on the surface water side, UPDATED CALVIN uses over 2.5 MAF more surface water than OLD CALVIN. This is due mostly to the successful removal of 2 MAF/yr of calibration demands present in OLD CALVIN.

With smaller total deliveries, it could be expected that the groundwater return flow is also smaller for UPDATED CALVIN. However, UPDATED CALVIN has additional representation of artificial recharge in the Tulare region. Interestingly, when considering total recharge to the groundwater basins for UPDATED CALVIN, it sums to be more recharge than in OLD CALVIN.

Table 4.18: Average Annual Groundwater Pumping, Surface Water Deliveries, Groundwater Return Flow, and Artificial Recharge Results (TAF/yr)

Subregion	GW Pumping		SW Deliveries		GW Return Flow		Artificial Recharge
	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN	OLD CALVIN	UPDATED CALVIN
1	39	41	98	86	18	18	-
2	145	410	328	86	123	99	-
3	109	463	1207	1719	158	480	-
4	12	274	872	682	123	36	-
5	227	391	1258	921	225	275	-
6	171	394	532	225	69	50	-
7	125	44	289	384	103	71	-
8	462	627	275	175	82	39	-
9	78	31	1117	896	119	136	-
10	305	299	1044	620	253	79	-
11	65	0	711	855	161	233	-
12	106	142	629	607	124	53	-
13	610	849	992	657	202	92	29
14	599	600	530	758	203	299	-
15	916	1,261	912	441	219	143	27
16	24	235	327	110	83	19	0
17	213	301	490	496	91	83	90
18	793	812	1221	947	362	440	302
19	601	298	241	589	25	186	0
20	215	211	399	618	50	139	0
21	177	602	783	593	96	299	1
Sacramento	1,368	2,675	5,974	5,174	1,020	1,203	-
San Joaquin	1,086	1,290	3,376	2,740	740	456	-
Tulare	3,539	4,319	4,903	4,552	1,131	1,608	449
Total CV	5,993	8,284	14,254	12,466	2,891	3,267	449

Change in Storage

CALVIN does not model actual storage capacities, but models the change in storage volume. The initial storage, as mentioned earlier, is an input term to CALVIN and is essentially just a reference starting point for the model. CALVIN outputs actual storage values, but they are relative to the set initial storage. For these models, change in storage has to be compared rather than the model output for storage since the initial storages differ between models. The changes in storage were calculated based on the model run output storage values for each region. Figures 4.2 - 4.4 show the change in storage by Central Valley region (Sacramento, San Joaquin, and Tulare) for UPDATED CALVIN and OLD CALVIN. Sacramento is the sum of Regions 1-9, San Joaquin is the sum of Regions 10-13, and Tulare is the sum of regions 14-21. Negative change in storage values indicate overdraft.

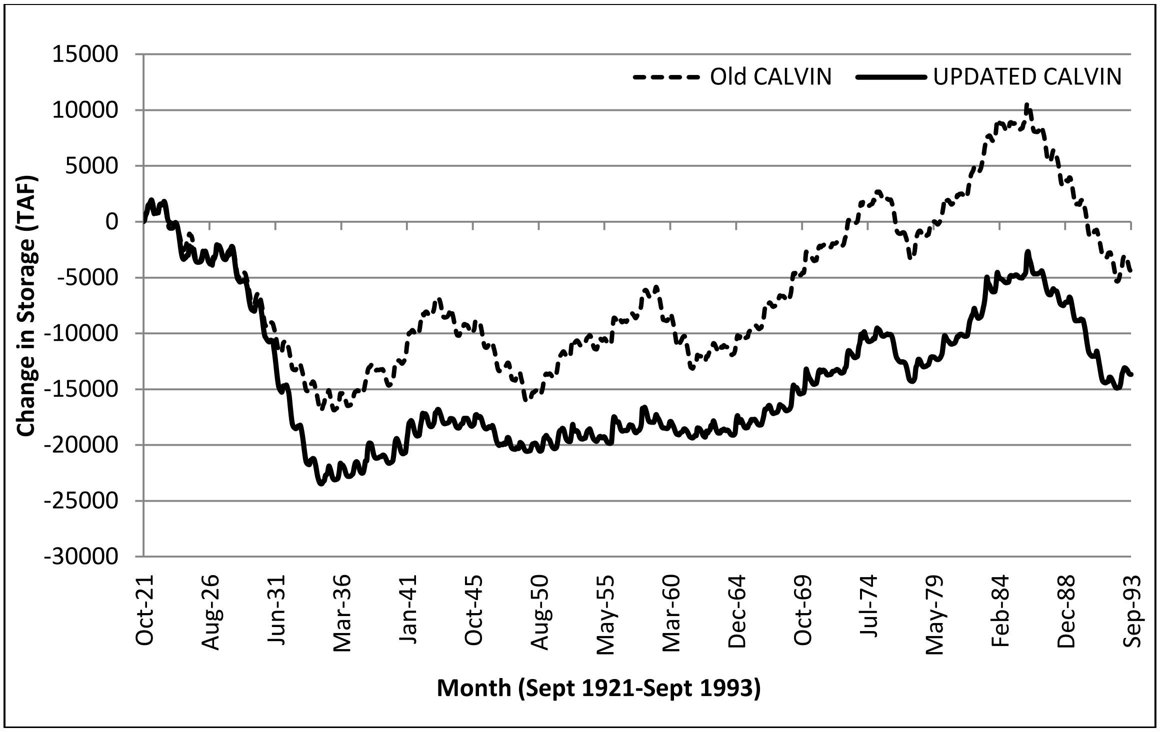


Figure 4.2: UPDATED CALVIN Sacramento Region (Basins 1-9) Change in Storage

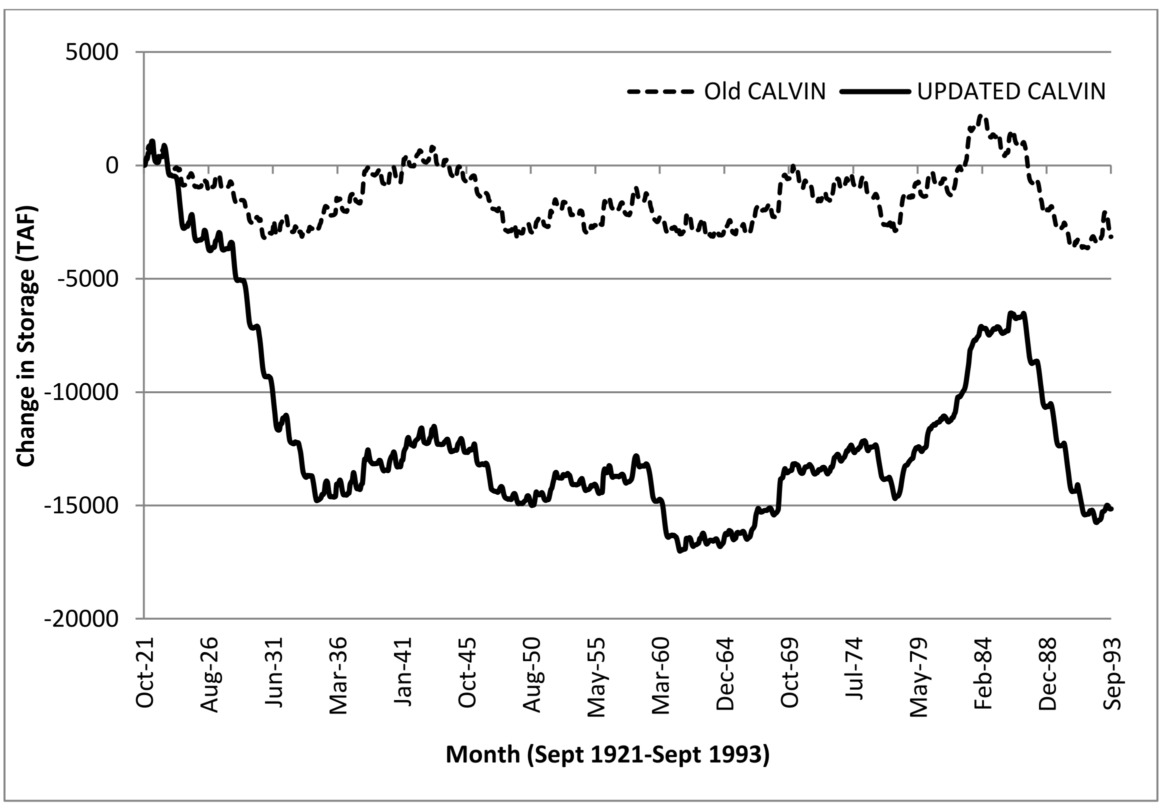


Figure 4.3: UPDATED CALVIN San Joaquin Region (Basins 10-13) Change in Storage

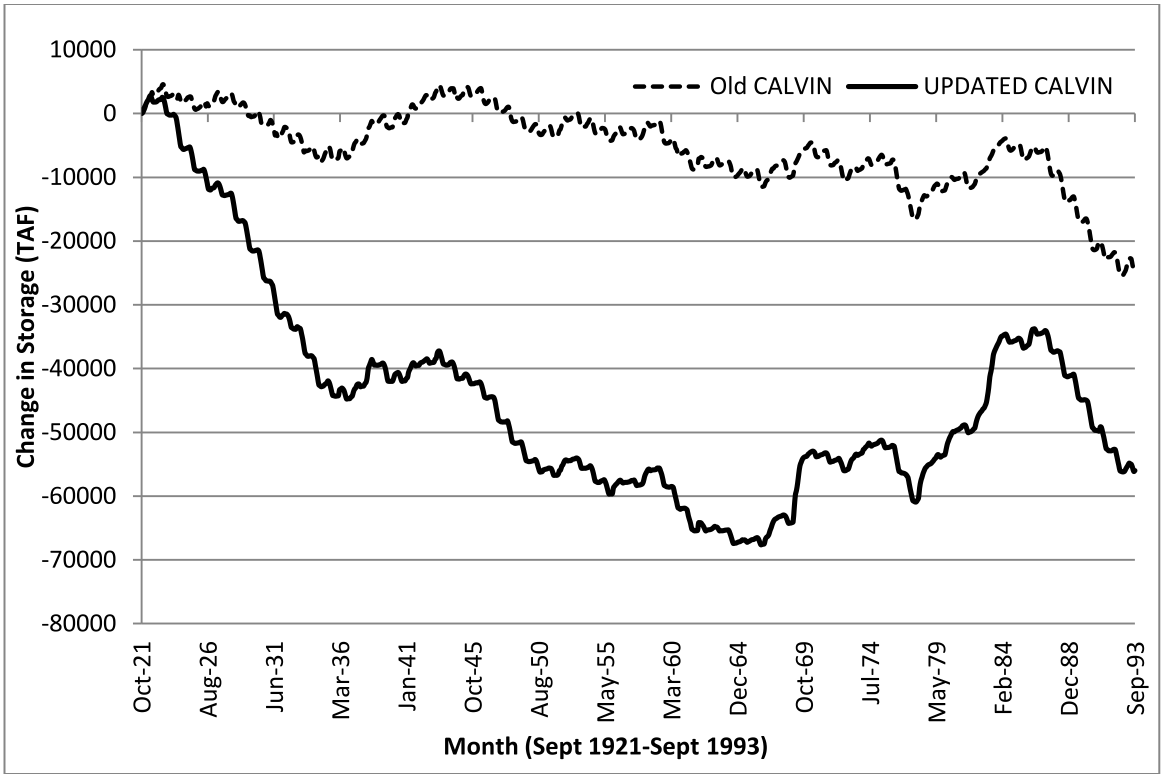


Figure 4.4: UPDATED CALVIN Tulare Region (Basins 14-21) Change in Storage

For all three Central Valley regions, UPDATED CALVIN has more overdraft overall than OLD CALVIN, agreeing more with both C2VSIM and CVHM. Change in Storage for both CALVIN models follow similar trends that agree with seasonal variations and year types, but UPDATED CALVIN's changes are greater and have more overdraft. These change in storage results help confirm the scarcity results in Table 4.16. Considering the Tulare region, scarcities were much higher for UPDATED CALVIN, and as can be seen in Figure 4.4, the overdraft difference is large. This also falls into line with the impression that OLD CALVIN had too much water in the system and its representation of groundwater was not always reasonable. The overdraft implied by UPDATED CALVIN agrees better with other studies on overdraft in the Central Valley, including CVHM's representation. Chapter 5 will discuss some different overdraft scenarios and their effects on the Central Valley.

<u>System Costs</u>

Many changes were made to UPDATED CALVIN, so the system's overall costs were affected. Table 4.19 shows the average annual system costs. The only changes to operating cost values for this update project were the groundwater pumping lift costs and the added artificial recharge costs; all other operating costs were not changed. These changes are reflected in the costs in the table. Scarcity costs are directly related to the scarcity estimates (Table 4.17), but follow seasonal patterns of demands and availability.

UPDATED CALVIN has overall lower pumping costs in the Central Valley, agreeing with Table 4.5, with lower pumping lifts and costs for UPDATED CALVIN. Surface water and other operating costs are not affected much. UPDATED CALVIN's artificial recharge adds an average annual $3 million/year in average costs. OLD CALVIN has much lower scarcity costs because there was much less scarcity in that version of CALVIN (Table 4.17). Overall, UPDATED CALVIN has about an annual average of $40 million (4%) less system costs than OLD CALVIN.

Table 4.19: Average Annual Central Valley System Costs ($millions/yr)

Costs	UPDATED CALVIN	OLD CALVIN
Groundwater Pumping	361	450
Surface Water Pumping	426	427
Artificial Recharge	3	0
Other[1]	294	264
Central Valley Operating Costs*	**$1,084**	**$1,141**
Scarcity Costs	21	4
Central Valley System Costs	**$1,105**	**$1,145**

[1]Other costs include: treatment, recycled water, and desalination.
*Total Operating Costs does not include hydropower benefits.

Results Summary

Table 4.20 summarizes the average annual results for the Central Valley (Regions 1-21) for UPDATED CALVIN. The percent differences from OLD CALVIN are also presented. Overall, UPDATED CALVIN has lower targets and lower deliveries; UPDATED CALVIN pumps 28 percent less groundwater and delivers14 percent more surface water than OLD CALVIN. This decreased pumping is a direct effect of the new input terms for UPDATED CALVIN. With the new groundwater representation, the scarcity for UDPATED CALVIN is 10 times that of OLD CALVIN, which better represents actual water scarcity in the Central Valley. Total Delta pumping is slightly lower in UPDATED CALVIN, but Tracy pumping for UPDATED CALVIN is more than two times that of OLD CALVIN; this increase in Tracy pumping is due to the lower Banks pumping constraint in UPDATED CALVIN. For total groundwater recharge, there is a 2 percent increase for UPDATED CALVIN, primarily due to the addition of artificial recharge representation. Total Central Valley overdraft for UPDATED CALVIN is nearly three times the amount of overdraft in OLD CALVIN; this new overdraft value is comparable with CVHM total overdraft ((Faunt et al. 2009) and DWR's Bulletin 118's estimated values (DWR 2003). Total system costs are 4% less for UPDATED CALVIN than OLD CALVIN.

Table 4.20: Updated CALVIN Summary – Average Annual Results

Results	OLD CALVIN	UPDATED CALVIN	
	Annual Average (TAF/yr)	Annual Average (TAF/yr)	% Difference
Total Central Valley Agricultural Target	20,787	20,670	-1%
Total Central Valley Agricultural Delivery	20,750	20,246	-2%
Agricultural GW Pumping	8,284	5,992	-28%
Agricultural SW Delivery	12,466	14,254	+14%
Total Central Valley Agricultural Scarcity	37	424	+1046%
Total Delta Pumping	5,368	5,325	-1%
Banks Pumping	4,906	4,383	-11%
Tracy Pumping	462	942	+104%
Total GW Recharge	3,267	3,338	+2%
Total Central Valley Return Flow	3,267	2,889	-12%
Total Central Valley Artificial Recharge	0	449	+100%
Total Central Valley Overdraft	394	1,160	+194%
Total Central Valley System Costs	$1,145	$1,105	-4%

Conclusions

This update project has greatly improved several aspects of CALVIN groundwater. First, schematic improvements were made to simplify the flows in and out of each CVPM groundwater basin. And overall, Central Valley groundwater representation in CALVIN has been greatly improved.

Many of the problems associated with OLD CALVIN's groundwater representation could be attributed to the problems with CVGSM (LaBolle 2003). Models like CALVIN can help inform water management decisions for a wide range of conditions. However, conditions are constantly changing so timely updates are needed to maintain the usefulness of the model. The inputs to CALVIN need to come from a trusted source or model that represents actual, or at least reasonable water and water use conditions. C2VSIM's groundwater representation is much more explicit and reasonable than the older CVGSM. However, C2VSIM results are not always close in comparison with other groundwater models (i.e. CVHM). With different representations and results, groundwater input terms to CALVIN can be very different and would overall represent groundwater very differently. It is important to remember this when considering UPDATED CALVIN results; errors and discrepancies in the C2VSIM groundwater model also carry over into CALVIN's groundwater representation. Nonetheless, this project provides a more accurate and up-to-date representation of Central Valley groundwater in CALVIN.

CHAPTER 5

Groundwater Overdraft in California's Central Valley

This chapter discusses an application of the updated CALVIN model to three groundwater overdraft cases in California's Central Valley. Overdraft is defined as a negative change in groundwater storage from the beginning to end of the model period. The comparison of study results shows potential effects of different levels of overdraft and confirms that the model is behaving well. All three model cases use the updated CALVIN model as a base and result in feasible solutions. Increasing Delta exports and surface water use are the primary adaptations to ending overdraft (aided by artificial recharge). Greater agricultural scarcity is the second adaptation.

Background

Groundwater overdraft occurs when groundwater extraction exceeds recharge over a long period. In California, few statewide regulations currently exist on groundwater extraction and water users commonly turn to groundwater use when demands cannot be met by surface water supplies. Continued overdraft of groundwater basins gradually depletes groundwater availability and can be environmentally detrimental (i.e. subsidence, increased nitrate leaching, and water quality degradation). Despite these negative consequences, some areas continue to pump groundwater at unsustainably high rates. Using a hydro-economic optimization model like CALVIN to study overdraft shows not only the basic, physical water system effects (i.e. effects on Delta pumping and recharge), but also some economic effects. CALVIN was previously used in a case study of the Tulare Basin that examined the economic effects of different management strategies to end overdraft in that basin (Harou and Lund 2007). Similar to the Tulare Basin case study, this overdraft study examines the economic effects of different overdraft scenarios. However, the 2007 Tulare Basin study had cases based on different management options for ending overdraft, whereas the study presented here uses different groundwater models' results to represent overdraft and compare those to a case without overdraft. This approach provides insight for managing overdraft in the Central Valley and also illustrates the consequences of remaining uncertainties in groundwater availability in the Central Valley.

Case Description

Of the three overdraft cases (Table 5.1), the first case is the "Base" updated CALVIN run with overdraft largely based on C2VSIM. In the "No Overdraft" case, no overdraft is allowed; all basin ending storage values were set to the basins' initial storage values. The "Higher Overdraft" case is a CVHM-C2VSIM-based overdraft scenario. Initially, there was a CVHM-based overdraft case, but since CVHM has major differences in groundwater representation of the Sacramento Valley (discussed in Chapter 3), there would not be a feasible CALVIN result based solely on CVHM overdraft results without new calibration. Instead, a semi-CVHM overdraft case was created using the updated CALVIN overdraft for subregions 1-9 (Sacramento region) and using the typically higher CVHM overdraft for subregions 10-21 (San Joaquin and Tulare regions).

Table 5.1: Overdraft Cases Description

Case Name	Run Number	Case Description
Base	S07I14	UPDATED CALVIN with overdraft based on C2VSIM with calibration adjustments. (1.2 MAF/yr Valley-wide).
No Overdraft	S07I14a	No overdraft (initial storage = ending storage).
Higher Overdraft	S07I14b	Overdraft for subregions 1-9 are the same as UPDATED CALVIN. Greater Overdraft for subregions 10-21 is based on CVHM. (1.45 MAF/yr Valley-wide).

Table 5.2 presents the total overdraft and average annual overdraft (1921-1993) per subregion for each case. Higher Overdraft is based on CVHM calculated overdraft for the San Joaquin and Tulare regions. CVHM has slightly less overdraft than the Base case in the San Joaquin region, but has significantly more overdraft in the Tulare region. Comparing the Central Valley totals with the Base run, the No Overdraft case has 84 MAF less groundwater available for use over the 72 years and the Higher Overdraft case allows 20 MAF more groundwater to be used over the 72 years. The results from these runs are presented and discussed below.

Table 5.2: 1921 – 1993 Overdraft Cases*

Subregion	Base		No Overdraft		Higher Overdraft	
	Total (72 years)	Annual Average (TAF/yr)	Total (72 years)	Annual Average (TAF/yr)	Total (72 years)	Annual Average (TAF/yr)
1	-990	-14	0	0	-990	-14
2	0	0	0	0	0	0
3	939	13	0	0	939	13
4	220	3	0	0	220	3
5	656	9	0	0	656	9
6	-307	-4	0	0	-307	-4
7	5,330	74	0	0	5,330	74
8	7,836	109	0	0	7,836	109
9	-362	-5	0	0	-362	-5
10	3,155	44	0	0	251	3
11	592	8	0	0	289	4
12	1,737	24	0	0	-723	-10
13	9,656	134	0	0	10,756	149
14	6,831	95	0	0	9,495	132
15	2,977	41	0	0	12,555	174
16	257	4	0	0	9,435	131
17	3,561	49	0	0	9,142	127
18	0	0	0	0	20,349	283
19	13,526	188	0	0	7,256	101
20	11,937	166	0	0	6,654	92
21	16,840	234	0	0	5,611	78
Sacramento	13,323	185	0	0	13,323	185
San Joaquin	15,140	210	0	0	10,572	147
Tulare	55,930	777	0	0	80,497	1,118
Central Valley Total	84,393	1,172	0	0	104,392	1,450

*Positive values represent a depletion of storage over time and negative values represent gains to groundwater over time.

CALVIN Study Results

This section discusses the results from this study. First, the average annual scarcities and water deliveries are presented, followed by a discussion of the recharge differences. Next, the time series for storages for each region are compared in plots, showing the differences in storage over time between the cases. Then the willingness-to-pay values, scarcity costs, and operating costs are tabulated and discussed. Finally, a summary table of the average annual results with the percent differences between the results for the different cases is presented.

Water Scarcity and Deliveries

Water scarcity is defined as the amount of target water delivery not supplied by the model to meet demands. These results are shown in Table 5.3. Ending overdraft increases water shortages statewide because there is not enough available surface water to meet all demands if groundwater is not overdrafted. As expected, the No Overdraft case has nearly double the water scarcity of the Base case and the Higher Overdraft case has less scarcity than the Base case.

Table 5.3: Overdraft Study Results – Average Annual Agricultural Water Scarcities (TAF/yr)

CALVIN Delivery Link	Base	No Overdraft	Higher Overdraft
HU1-CVPM1G	1.0	1.8	0.8
HU1-CVPM1S	1.1	2.2	0.6
HU2-CVPM2G	0.0	19.5	0.0
HU2-CVPM2S	0.0	0.0	0.0
HU3-CVPM3G	0.0	0.0	0.0
HU3-CVPM3S	0.0	0.0	0.0
HU4-CVPM4G	0.0	16.5	0.0
HU4-CVPM4S	0.0	0.2	0.0
HU5-CVPM5G	0.0	0.0	0.0
HU5-CVPM5S	0.0	0.0	0.0
HU6-CVPM6G	28.5	31.3	8.0
HU6-CVPM6S	0.5	0.7	0.5
HU7-CVPM7G	0.0	11.3	0.0
HU7-CVPM7S	0.0	0.0	0.0
HU8-CVPM8G	0.0	55.0	0.0
HU8-CVPM8S	0.0	4.4	0.0
HU9-CVPM9G	12.7	41.4	0.0
HU9-CVPM9S	0.0	0.0	0.0
HU10-CVPM10G	51.4	55.9	51.4
HU10-CVPM10S	3.5	3.9	3.4
HU11-CVPM11G	0.7	9.5	0.3
HU11-CVPM11S	0.0	0.6	0.0
HU12-CVPM12G	23.4	26.1	23.3
HU12-CVPM12S	1.5	1.8	1.5
HU13-CVPM13G	74.9	141.0	74.9
HU13-CVPM13S	2.4	4.5	2.3
HU14-CVPM14G	0.0	0.0	0.0
HU14-CVPM14S	0.0	0.0	0.0
HU15-CVPM15G	0.0	65.9	0.0
HU15-CVPM15S	0.0	0.0	0.0
HU16-CVPM16G	13.3	15.1	0.4
HU16-CVPM16S	2.7	2.9	2.7
HU17-CVPM17G	34.8	36.9	35.0
HU17-CVPM17S	0.0	0.0	0.0
HU18-CVPM18G	106.0	204.0	103.3
HU18-CVPM18S	0.0	0.0	0.0
HU19-CVPM19G	0.0	0.0	0.0
HU19-CVPM19S	0.0	0.0	0.0
HU20-CVPM20G	21.9	25.9	21.6
HU20-CVPM20S	4.9	5.7	4.8
HU21-CVPM21G	38.6	47.3	36.9
HU21-CVPM21S	0.0	0.0	0.0
Sacramento	44	184	10
San Joaquin	158	243	157
Tulare	222	404	205
Central Valley Total	424	831	372

Table 5.4 compares the average annual Delta pumping for the three cases. Of the 1.2 MAF annual averaged reduction of overdraft in the No Overdraft case (compared to the Base case), approximately 0.4 MAF of that reduction becomes greater scarcity (Table 5.3) and the rest of the reduction is made up by higher Delta exports. For the system to maintain the Delta outflow requirement (discussed in Chapter 4) and have no reductions to southern California water supply, nearly 0.8 MAF/year more water is pumped from the Delta. So to account for the 1.2 MAF of water not available due to having no overdraft supplies in the No Overdraft case, there is 0.4 MAF of increased water scarcity in the Central Valley and 0.8 MAF increased Delta exports. And as expected, when comparing the Base case with the Higher Overdraft case, the increased supply from higher overdraft decreases Delta pumping and water scarcity.

Table 5.4: Overdraft Study Results – Average Annual Delta Exports (TAF/yr)

	Base	No Overdraft	Higher Overdraft
Banks Pumping	4,383	4,470	4,283
Tracy Pumping	942	1,614	726
Total Delta Pumping	5,325	6,084	5,009

Table 5.5 shows average annual groundwater pumping and surface water deliveries. The No Overdraft case significantly reduces average annual groundwater pumping and increases surface water deliveries. Even with the increased surface water use, there is still much scarcity. The Higher Overdraft case has more groundwater pumping, less surface water reliance, and less scarcity.

Table 5.5: Overdraft Study Results – Average Annual Agricultural Water Deliveries (TAF/yr)

Subregion	GW Pumping			SW Deliveries			Total Deliveries		
	Base	No Overdraft	Higher Overdraft	Base	No Overdraft	Higher Overdraft	Base	No Overdraft	Higher Overdraft
1	39	53	39	98	82	98	137	135	137
2	145	140	145	328	314	328	473	454	473
3	109	96	109	1,207	1,220	1,207	1,316	1,315	1,315
4	12	7	12	872	861	872	884	867	884
5	227	218	227	1,258	1,267	1,258	1,485	1,485	1,485
6	171	175	173	532	524	550	703	700	723
7	125	100	125	289	302	288	414	402	413
8	462	389	472	275	289	265	737	677	737
9	78	80	79	1,117	1,086	1,128	1,195	1,166	1,208
10	305	260	264	1,044	1,083	1,084	1,349	1,343	1,348
11	65	55	61	711	712	715	776	767	777
12	106	82	72	629	651	664	735	733	736
13	610	488	623	992	1,046	979	1,602	1,534	1,602
14	599	504	636	530	625	493	1,129	1,129	1,129
15	916	889	1049	912	873	779	1,828	1,762	1,828
16	24	53	144	327	297	221	351	350	365
17	213	159	242	490	543	462	703	702	704
18	793	784	1023	1,221	1,132	993	2,014	1,915	2,016
19	601	413	514	241	429	328	842	842	842
20	215	49	142	399	560	472	614	609	614
21	177	257	29	783	695	934	960	952	962
Sacramento	1,368	1,257	1,382	5,974	5,945	5,994	7,342	7,202	7,376
San Joaquin	1,086	885	1,021	3,376	3,492	3,442	4,462	4,377	4,463
Tulare	3,538	3,108	3,778	4,903	5,152	4,681	8,441	8,260	8,459
Central Valley Total	5,992	5,249	6,181	14,254	14,589	14,117	20,246	19,839	20,298

Table 5.6 shows the average annual urban water deliveries and scarcities. Similar to the results comparison between OLD CALVIN and UPDATED CALVIN, the differences in overdraft cases do not affect urban deliveries in the Central Valley. Slight differences can be seen in the deliveries in Southern California. The No Overdraft case results in a higher scarcity total in Southern California whereas the higher overdraft case results in a slightly lower total scarcity in Southern California. Since differences in urban deliveries are non-existent in the Central Valley and small for Southern California, the rest of this chapter will focus on comparisons of agricultural related aspects of the models.

Table 5.6: Overdraft Study Results – Average Annual Urban Water Deliveries and Scarcities (TAF/yr)

CALVIN Delivery Region	Delivery			Scarcity		
	Base	No Overdraft	Higher Overdraft	Base	No Overdraft	Higher Overdraft
Sacramento	1609	1608	1608	0.3	0.3	0.3
San Joaquin	1571	1571	1571	0	0.0	0.0
Tulare	1279	1279	1279	5.1	5.1	5.1
Central Valley Total	4459	4458	4458	5.4	5.4	5.4
Southern California	6648	6645	6648	192.1	194.8	191.8

<u>Recharge</u>

Table 5.7 shows the average annual return flows and artificial recharge flows to groundwater for each region. Considering just groundwater return flow, the No Overdraft case has less return flow to groundwater and the Higher Overdraft case has slightly more return flow to groundwater. The smaller return flow to groundwater in the No Overdraft case is due to overall decreased delivered water to meet the agricultural demand (hence the increased scarcity); less water delivered proportionally reduces agricultural return flows to groundwater.

The artificial recharge result shows one way that overdraft is detrimental to the overall water system. The No Overdraft case increases use of artificial recharge, an action that should be encouraged and is effective in maintaining groundwater storage overtime. However, maintaining and using artificial recharge is generally more expensive in the short term. CALVIN has a link cost for using artificial recharge. The No Overdraft case drives the system to increase use of artificial recharge capabilities since there is a shortage of water and the no overdraft condition in the groundwater basins needs to be maintained. This conjunctive use approach helps allow more groundwater to be used because it is replenished artificially when surface water is abundant. This allows scarcity to be less than total reductions in available water supply due to the no overdraft constraint (met by increased surface water use and increased Delta exports). In contrast, the Higher Overdraft case reduces use of artificial recharge since it can meet more demands through pumping (the economically cheaper option) and is not required to maintain a condition of no overdraft. Considering that these artificial recharge facilities and capabilities are assumed to be in place for all three cases, general increased use of artificial recharge should be encouraged. This agrees with the results from Harou and Lund (2007), where ending overdraft significantly increases the economic value of additional recharge capacity and when there is overdraft, less artificial recharge occurs since maintaining groundwater storage levels is not a constraint. Adding artificial recharge capacity can help lower the cost of ending overdraft. However, if there is enough available supply from (over)pumping groundwater and nothing to require users to recharge water back to the groundwater basins, it is more economical in the short term to just pump more water and return less to the ground (in real practice and in the CALVIN model). Although it may be more economical in the short term to continue over-pumping groundwater, continued overdraft of groundwater basins will eventually increase pumping costs due to higher depths to groundwater as well as environmental problems. Increased pumping lift over time is not represented in CALVIN.

Considering total recharge to groundwater (groundwater return flow + artificial recharge), the No Overdraft case has the highest recharge of the three cases. In CALVIN, this higher recharge is needed to maintain the no overdraft constraint because the solver will do what satisfies constraints and results in the smallest overall cost, driven primarily by meeting demands since shortage costs are high. CALVIN will maximize the amount of water returned to the ground so that groundwater pumping can increase to levels that fall within the no overdraft constraint.

Table 5.7: Overdraft Study Results – Recharge flows to Groundwater (TAF/yr)

Subregion	GW Return Flow			Artificial Recharge			Total Recharge to GW		
	Base	No Overdraft	Higher Overdraft	Base	No Overdraft	Higher Overdraft	Base	No Overdraft	Higher Overdraft
1	18	17	18	-	-	-	18	17	18
2	123	118	123	-	-	-	123	118	123
3	158	158	158	-	-	-	158	158	158
4	123	120	123	-	-	-	123	120	123
5	225	225	225	-	-	-	225	225	225
6	69	69	71	-	-	-	69	69	71
7	103	100	103	-	-	-	103	100	103
8	82	76	82	-	-	-	82	76	82
9	119	117	121	-	-	-	119	117	121
10	253	253	253	-	-	-	253	253	253
11	161	159	161	-	-	-	161	159	161
12	124	124	124	-	-	-	124	124	124
13	202	193	202	29	49	27	231	242	229
14	203	203	203	-	-	-	203	203	203
15	219	211	219	27	50	27	246	261	246
16	83	82	86	0	48	0	83	130	86
17	91	91	91	90	80	41	181	171	132
18	362	345	363	302	311	250	664	656	613
19	25	25	25	0	0	0	25	25	25
20	50	50	50	0	0	0	50	50	50
21	96	95	96	1	28	1	97	123	97
Sacramento	1,020	999	1,023	-	-	-	1,020	999	1,023
San Joaquin	740	729	741	29	49	27	769	778	768
Tulare	1,129	1,103	1,135	420	516	318	1,549	1,619	1,453
Total Central Valley	2,889	2,831	2,899	449	566	345	3,338	3,397	3,244

Storage

Figures 5.1 – 5.3 show the storages by Central Valley region (Sacramento, San Joaquin, and Tulare) for the three cases. All cases' storages follow similar trends that agree with seasonal variations and year types, but the no overdraft case ensures that the initial storage equals the ending storage. Comparing the Base case with the Higher Overdraft case, the Sacramento region is very similar since it has the same representation; the slight decreases in storage in the Sacramento region for the Higher Overdraft case can be attributed to some water from the north being sent to the south to supply demands.

As seen in Figure 5.2, the Higher Overdraft case actually has less overdraft in the San Joaquin region (it was called the Higher Overdraft case since overall Central Valley overdraft is higher). Figure 5.3 shows the large differences in the overdraft allowances in the Tulare region between the cases. All cases in each region have the same initial storage in the figures below.

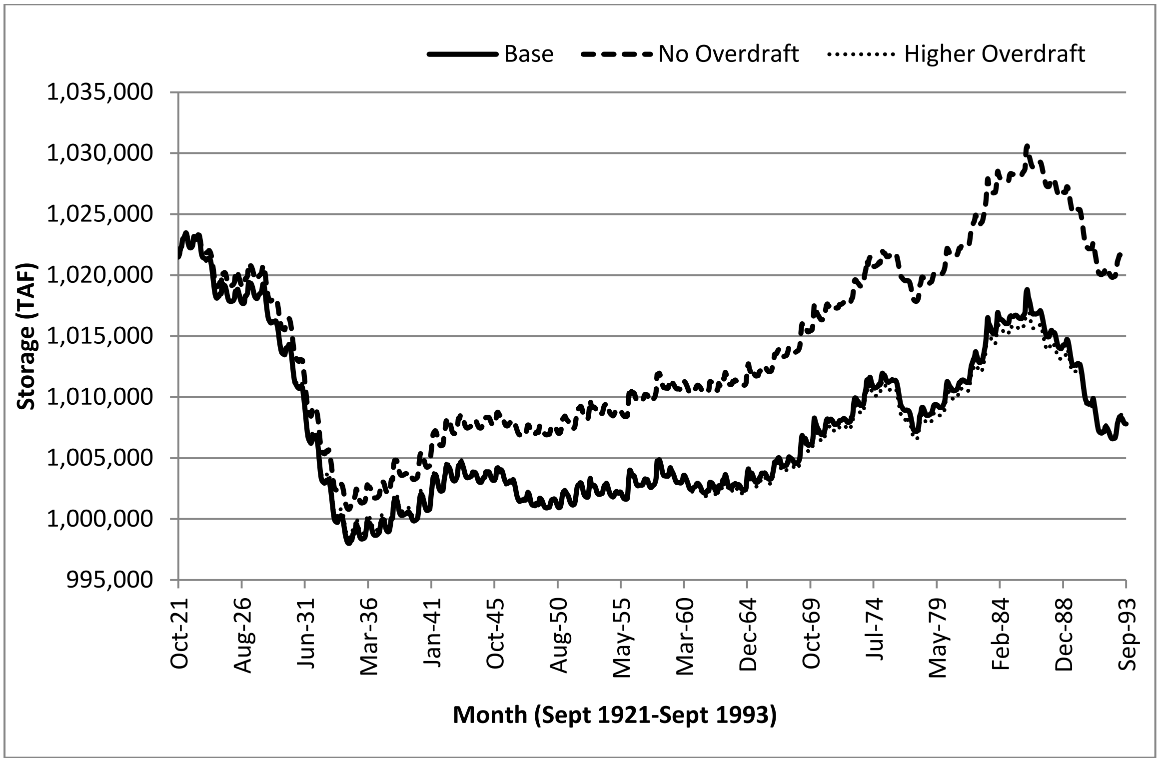


Figure 5.1: Overdraft Study Results – Sacramento Region (Basins 1-9) Storage

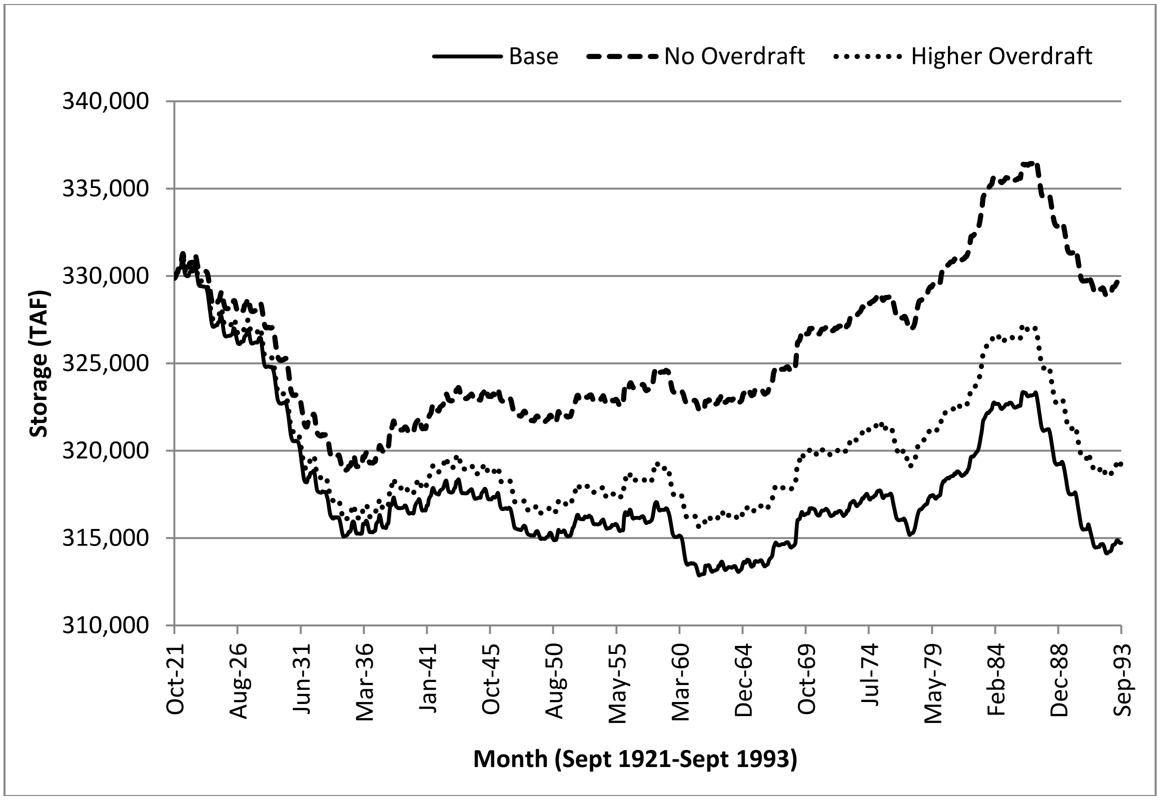


Figure 5.2: Overdraft Study Results – San Joaquin Region (Basins 10-13) Storage

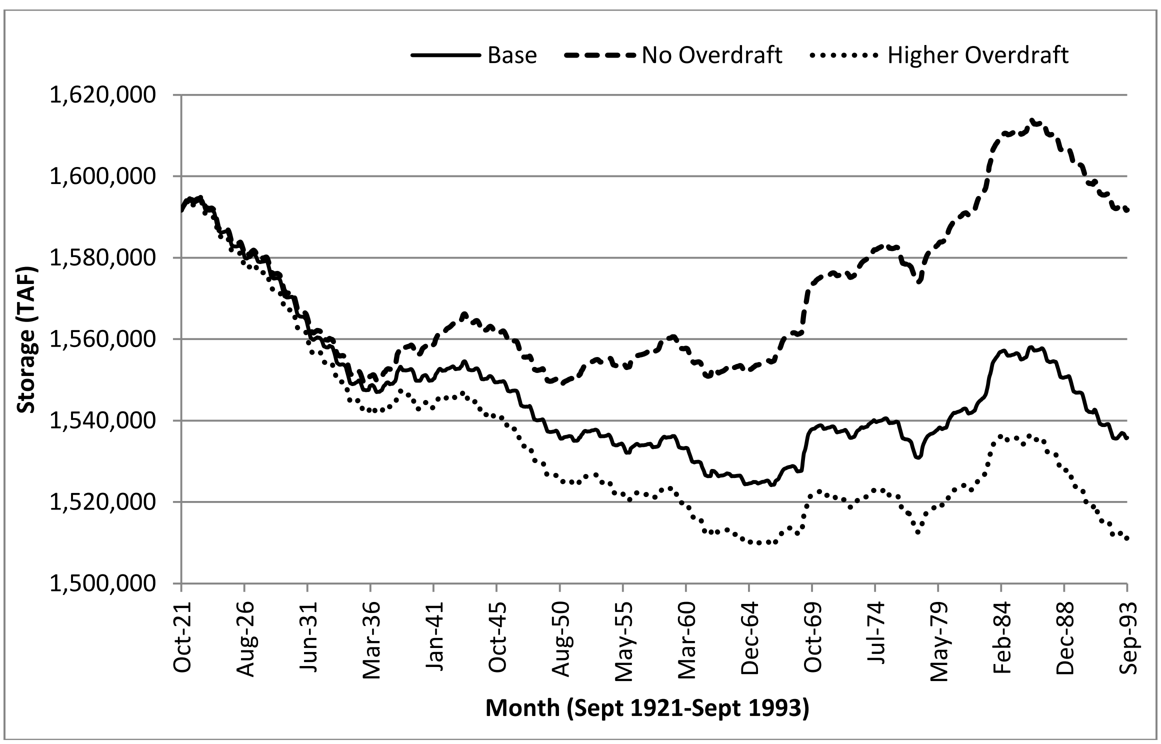


Figure 5.3: Overdraft Study Results –Tulare Region (Basins 14-21) Storage

Willingness-to-pay and Scarcity Costs

The average annual marginal willingness-to-pay (WTP) and scarcity costs are presented in Table 5.8. Marginal WTP reflects what demand areas with shortages would be willing to pay for an additional acre-foot of water; demand areas without scarcity, by definition, have no marginal WTP. Marginal WTP is estimated as the slope of the economic benefit function at the delivered water quantity. Each unit of water goes to the demand area with the highest WTP, if possible, ensuring that the highest value uses are supplied first when possible.

The No Overdraft case has a higher marginal WTP compared to the other two cases because less water is available, creating more scarcity. Comparing the two cases that allow overdraft, the Base case has a higher marginal WTP than the Higher Overdraft case since the Base case has higher scarcities with less available water, and would be willing to pay more for additional water.

Scarcity costs are directly related to the scarcity estimates (Table 5.3), but seasonal variations follow seasonal patterns of demands and availability. Overall, the No Overdraft case has the highest scarcity cost and the Higher Overdraft case has the lowest. The next section compares the Central Valley system costs, including operating costs.

Table 5.8: Overdraft Study Results – Average Annual Marginal Central Valley Agricultural Willingness-to-pay and Scarcity Costs

CALVIN Delivery Link	Base		No Overdraft		Higher Overdraft	
	Marginal WTP ($/AF)	Scarcity Cost (million US $ /yr)	Marginal WTP ($/AF)	Scarcity Cost (million US $ /yr)	Marginal WTP ($/AF)	Scarcity Cost (million US $ /yr)
HU1-CVPM1G	142	0.04	283	0.10	115	0.03
HU1-CVPM1S	68.3	0.05	126	0.09	36.3	0.03
HU2-CVPM2G	0.4	0.0	244	0.89	0.0	0.0
HU2-CVPM2S	0.0	0.0	0.0	0.0	0.0	0.0
HU3-CVPM3G	0.0	0.0	0.0	0.0	0.0	0.0
HU3-CVPM3S	0.0	0.0	0.0	0.0	0.0	0.0
HU4-CVPM4G	2.5	0.0	154	0.72	0.36	0.0
HU4-CVPM4S	22.2	0.0	137	0.01	6.44	0.0
HU5-CVPM5G	0.0	0.0	0.0	0.0	0.0	0.0
HU5-CVPM5S	0.0	0.0	0.0	0.0	0.0	0.0
HU6-CVPM6G	176	1.15	252	1.27	55.1	0.32
HU6-CVPM6S	145	0.02	238	0.03	131	0.02
HU7-CVPM7G	0.0	0.0	177	0.46	0.0	0.0
HU7-CVPM7S	0.0	0.0	0.0	0.0	0.0	0.0
HU8-CVPM8G	0.0	0.0	590	4.16	0.0	0.0
HU8-CVPM8S	8.6	0.0	628	0.34	0.54	0.0
HU9-CVPM9G	37.6	0.46	175	1.49	0.0	0.0
HU9-CVPM9S	0.0	0.0	0.00	0.0	0.0	0.0
HU10-CVPM10G	240	2.01	288	2.19	241	2.01
HU10-CVPM10S	270	0.14	339	0.15	254	0.13
HU11-CVPM11G	6.5	0.04	106	0.49	2.17	0.01
HU11-CVPM11S	0.5	0.0	117	0.03	0.0	0.00
HU12-CVPM12G	208	0.85	249	0.95	202	0.85
HU12-CVPM12S	188	0.05	262	0.06	192	0.05
HU13-CVPM13G	343	3.49	762	10.7	346	3.49
HU13-CVPM13S	363	0.11	802	0.34	356	0.11
HU14-CVPM14G	0.0	0.0	0.0	0.0	0.0	0.0
HU14-CVPM14S	0.0	0.0	0.0	0.0	0.0	0.0
HU15-CVPM15G	0.0	0.0	430	5.35	0.0	0.0
HU15-CVPM15S	0.0	0.0	0.0	0.00	0.0	0.0
HU16-CVPM16G	362	0.64	428	0.73	6.05	0.02
HU16-CVPM16S	385	0.13	467	0.14	377	0.13
HU17-CVPM17G	467	1.53	527	1.62	468	1.54
HU17-CVPM17S	0.0	0.0	0.00	0.0	0.0	0.0
HU18-CVPM18G	537	4.74	1101	14.8	501	4.62
HU18-CVPM18S	0.0	0.0	0.00	0.0	0.0	0.0
HU19-CVPM19G	0.0	0.0	0.00	0.0	0.0	0.0
HU19-CVPM19S	0.0	0.0	0.00	0.0	0.0	0.0
HU20-CVPM20G	677	1.7	836	2.0	659	1.67
HU20-CVPM20S	610	0.38	758	0.44	590	0.37
HU21-CVPM21G	669	3.03	834	3.71	632	2.90
HU21-CVPM21S	0.0	0.0	0.0	0.0	0.0	0.0
Region	Max WTP ($/AF)	Total Scarcity Cost (million US $ /yr)	Max WTP ($/AF)	Total Scarcity Cost (million US $ /yr)	Max WTP ($/AF)	Total Scarcity Cost (million US $ /yr)
Sacramento	176	2	628	10	131	0
San Joaquin	363	7	802	15	356	7
Tulare	677	12	1100	29	658	11
Central Valley	677	21	1100	53	658	18

Operating Costs

The different overdraft cases affect operating costs throughout the Central Valley. Table 5.9 shows the average annual operating costs and Central Valley system costs. The No Overdraft case has lower groundwater pumping costs than the other two cases. This is expected since there is less groundwater pumpage in the No Overdraft case (Table 5.5). The Higher Overdraft case has slightly higher groundwater pumping costs, not reflected in the table due to rounding. As expected, the No Overdraft case has higher surface water pumping costs than the Base case, and the Higher Overdraft case has less surface water pumping costs. Since there is little difference between the groundwater pumping costs of the Base case and the Higher overdraft case, the operating cost results indicate that pumping just a little more groundwater to meet demands is cheaper than using additional surface water. Artificial recharge costs are highest for the No Overdraft case and lowest for the Higher Overdraft case. Total operating costs are highest for the Base case, followed by the No Overdraft case, and then the Higher Overdraft case.

Overall, when also considering the scarcity costs, the No Overdraft case has the highest system costs. Although there are increases in the use of surface water and artificial recharge in the No Overdraft case, their capacities are unable to overcome all reductions in water availability, resulting in larger scarcities and thus larger scarcity costs. The Higher Overdraft case has the lowest system and operating costs, indicating that being able to pump more groundwater is still more economical than pumping less groundwater. If artificial recharge capacities could be increased or if there were higher costs for pumping groundwater (i.e. a tax, policy, or increased lifts represented), then pumping less and reducing overdraft might be economical. With no regulations on groundwater use and not considering the environmental and long-term effects of overdraft, CALVIN results show that it is more economically beneficial to overdraft groundwater to meet demands as best as possible, rather than pump less or end overdraft, if overdraft has no additional cost.

Comparing total Central Valley costs, the cost of ending overdraft in all Central Valley groundwater basins is at least $23 million/year, assuming that the Base case has good overdraft representation. Without economically-minded re-operation, the actual costs could be much higher. Completely ending overdraft in the Central Valley at one time is not possible, but taking steps towards having less reliance on over-pumping groundwater is. This can be done by improving efficiencies, promoting more recharge (artificial or natural), and conjunctive use, with a side-effect of increasing Delta exports unless agricultural deliveries are decreased. More discussion on viable management options for ending overdraft can be found in Harou and Lund 2007.

Table 5.9: Overdraft Study Results – Average Annual Central Valley System Costs ($millions/yr)

Costs	Base	No Overdraft	Higher Overdraft
Groundwater Pumping	361	315	361
Surface Water Pumping	426	460	416
Artificial Recharge	3	4	2
Other[1]	294	295	293
Total Operating Costs*	**$1,084**	**$1,074**	**$1,072**
Scarcity Costs	21	53	18
Total System Costs	**$1,105**	**$1,128**	**$1,090**

[1]Other costs include: treatment, recycled water, and desalination.
*Total Operating Costs does not include hydropower benefits.

Results Summary

Table 5.10 summarizes the average annual results for the entire Central Valley (Subregions 1-21) for this overdraft study and percent differences from the Base case. Overall, there is less total delivery in the No Overdraft case and more delivery in the Higher Overdraft case, with the largest factor for delivery differences being groundwater pumping. The No Overdraft case pumps 12 percent less groundwater than the base and increases surface water use by 2 percent and artificial recharge by 26 percent, but still nearly doubles scarcity. The Higher Overdraft case pumps more groundwater and uses less surface water, and has less overall scarcity. Delta pumping increases by 14% from the Base case to the No Overdraft case since there is less available groundwater in the No Overdraft case; the opposite effect happens for the Higher Overdraft case (decreased Delta pumping). More artificial recharge to groundwater occurs in the No Overdraft case to allow more use of surface water and even out water availability. The Higher Overdraft case has less artificial recharge since more groundwater is available in this case. Total system and operating costs are highest for the No Overdraft case and lowest for the Higher Overdraft case. The marginal willingness-to-pay for extra water and scarcity costs are highest for the No Overdraft case since that case has the most scarcity.

Table 5.10: Overdraft Study Summary – Average Annual Results

Result (TAF)	Base	No Overdraft		Higher Overdraft	
	Avg. Annual	Avg. Annual	% Difference	Avg. Annual	% Difference
Total Central Valley Overdraft (TAF/yr)	1,172	0	-100%	1,450	+24%
Total Central Valley Delivery (TAF/yr)	20,246	19,839	-2%	20,298	+0.3%
GW Pumping (TAF/yr)	5,992	5,249	-12%	6,181	+3%
SW Delivery (TAF/yr)	14,254	14,589	+2%	14,117	-1%
Total Central Valley Ag. Scarcity (TAF/yr)	424	831	+96%	372	-12%
Total Delta Exports (TAF/yr)	5,325	6,084	+14%	5,009	-6%
Banks Pumping (TAF/yr)	4,383	4,470	+2%	4,283	-2%
Tracy Pumping (TAF/yr)	942	1,614	+71%	726	-23%
Total GW Recharge (TAF/yr)	3,338	3,397	+2%	3,244	-3%
Return Flow (TAF/yr)	2,889	2,831	-2%	2,899	+0.3%
Artificial Recharge (TAF/yr)	449	566	+26%	345	-23%
Total System Costs (million $/yr)	1,105	1,128	+2%	1,090	-1%
Operating Costs (million $/yr)	1,084	1,074	-0.9%	1,072	-1%
Scarcity Cost (million $/yr)	21	53	+152%	18	-14%
Maximum WTP ($/AF)	677	1,011	+49%	658	-3%

Conclusions

This overdraft study is just one of the many possible applications of the updated CALVIN model. Many other overdraft cases could be explored with Updated CALVIN, but some would require additional calibration. The cases chosen for this study did not need additional calibration and show some basic comparisons between the groundwater models (CVHM and C2VSIM) and a No Overdraft case, providing some policy and operations insights.

As discussed in Chapter 3, CVHM and C2VSIM have many significant differences in representing Central Valley groundwater. The Higher Overdraft case had only differences for Regions 10-21, but these differences affect the entire system, water diversions, and scarcities. This shows how different regional representations can affect system-wide results and how important it is to pick a model with reasonable results as a base.

The No Overdraft case provides some insight into how the system and system costs would change to end overdraft. It implies that an immediate switch to completely ending overdraft would raise costs, but the results also show that improving recharge and increasing Delta exports would reduce increases in water scarcity. Additional artificial recharge evens out surface water availability, allowing for more surface water to be used and for more consistent deliveries between wet and dry years. However, unless there are direct, immediate benefits to the water users or policies that require less over-pumping or more recharge, it is unlikely that water users will take it upon themselves to pay more for a benefit that they don’t immediately see.

Along with giving useful insights for overall groundwater management and policy, this study also confirmed that Updated CALVIN is behaving as it should and that its results make some practical sense.

CHAPTER 6

Conclusions

Integrated hydro-economic modeling is useful for examining the benefits and drawbacks of existing or proposed water policies, operations, and plans. However, water conditions, regulation, demands, and estimates are constantly changing, so timely updates are needed to maintain and improve the usefulness of models. New models with new data are constantly being developed, and incorporating newer data can make hydro-economic models, like CALVIN, more useful. In an effort to make the most of available resources and include a reasonable groundwater representation in CALVIN, C2VSIM was primarily used in this groundwater update project. This project provides a more accurate and up-to-date representation of Central Valley groundwater in CALVIN, which can lead to studies investigating the economic impacts of Central Valley groundwater use and provide an additional framework for groundwater policy discussions. The CALVIN improvements from this project are summarized below.

CALVIN Improvements

Many improvements were made to the CALVIN model. These include updating and improving the model's representation of Central Valley groundwater, updating the Delta pumping constraints to better reflect actual conditions, and improving the model network and schematic to be more explicit and include some artificial recharge. These improvements are summarized in Table 6.1.

Table 6.1: Improvements to CALVIN

Central Valley
Updated agricultural demands to match current SWAP estimates
Updated existing groundwater term inputs with new, more accurate values
Added some new groundwater terms for more detailed representation of the system
Eliminated 2 MAF of calibration outflows (from the previous version of CALVIN)
Added explicit representation of artificial recharge for some regions in the Tulare Basin
Delta Pumping
Updated Banks Pumping Plant constraint
Updated Delta Export Outflow
Network and Schematic
Added artificial recharge nodes and links for some regions in the Tulare Basin
Added hidden nodes and links for groundwater pumping
Added hidden nodes and links for urban groundwater return flow

Central Valley

The updated agricultural demands based on updated SWAP reduced demands by an average of 117 TAF/year. The changes to the agricultural return flow splits, internal reuse amplitudes, applied water return flow amplitudes, external flows, pumping capacities, pumping costs, storage constraints, and urban return flow amplitudes based primarily on C2VSIM significantly changed how CALVIN models water in the Central Valley. The elimination of 2 MAF of calibration outflows strengthens CALVIN because the model now has a tighter and more explicit representation of Central Valley mass balances of water, more reasonable results, and its groundwater interaction is balanced without the additional calibration flows. The addition of explicit artificial recharge representation allows for an important recharge practice to be represented in the model. The groundwater representation in the updated CALVIN model is more explicit and accurate, making the model more useful.

Delta Pumping

Updates to Delta pumping and outflow were made based on both CALSIM II 2009 and what was previously in CALVIN. Since CALVIN is an optimization model, its Delta pumping and outflows cannot be expected to be the same as a simulation-based model like CALSIM, but incorporating aspects of CALSIM into CALVIN makes CALVIN more relatable to CALSIM and real-life applications.

Network and Schematic

The improvements made to the CALVIN network simplify the direct interactions with the Central Valley groundwater subbasins. The urban and pumping hidden nodes result in fewer direct flows going in and out of each groundwater subbasin, allowing for easier comparisons of results and mass balances.

Conclusions from CALVIN Modeling

The updated CALVIN model was used to study how a few different overdraft cases could affect model results, as well as system economics and management. Three cases were examined: the base case, no overdraft, and higher overdraft. These three cases have significantly different results, as expected. With the no overdraft case, water scarcities were highest and drove the system to increase surface water use and artificial recharge to groundwater. Overall system and operating costs were lowest for the highest overdraft scenario, suggesting that being able to pump more groundwater is the more economical option, which agrees with current, real practices.

This study shows immediately ending overdraft in the Central Valley would have high costs and that including and increasing artificial recharge capacities can benefit the overall water system. Currently, overdrafting groundwater is common, with lower costs. However, with groundwater availability decreasing, pumping costs likely increasing, and environmental effects of overdraft worsening, overdraft will be an increasing problem in the future and may have other costs associated with it not included in CALVIN. Options to mitigate overdraft include: increasing recharge use and capacities (artificial and natural), increase in water reuse, more conjunctive use, more surface water use, and decrease in water use and demands. Although there are many possible solutions, many solutions have higher immediate costs and the long-term benefits are unclear or unknown. Unless policies require water users to follow these solutions, groundwater overdraft will likely continue to be a problem in the years to come.

Limitations and Further Work

"All models are wrong, but some are useful" said George Box (1979).

This CALVIN groundwater update project has improved Central Valley groundwater representation in CALVIN. However, CALVIN is just a model and the models used for this update are just models; they can all be useful, but are not exactly accurate. These models can help draw policy implications and present likely outcomes and effects, but as can be seen in comparisons with measured data and other similar models, there is still much uncertainty in many aspects of these models, albeit probably more accuracy and certainty than most model-free analysis.

Nonetheless, to maintain usefulness, these models should be kept up to date and continue to be improved. This project focused on updating the groundwater in the Central Valley, but CALVIN is a model of California's entire water system and many more improvements can be made. To gain better understanding and insight to the Central Valley water system, the surface water side of CALVIN could use some updates to rim inflows and deliveries, particularly Valley floor accretions and depletions. Additionally, since the CALVIN network was built using software from the early 2000's, new machines are having some problems with CALVIN's network so some updates to the CALVIN software would also be very useful.

As it stands, CALVIN is a unique hydro-economic optimization model of California's water system and has a variety of applications. Using this CALVIN with updated Central Valley groundwater representation for studies related to groundwater in California could provide some useful results. There have been many CALVIN climate change studies, but none that have updated Central Valley groundwater representation. This study examined just a few overdraft scenarios, but it would be interesting to see what the updated CALVIN model would show under more overdraft cases with added climate changes. Looking more into the economic aspects of climate change adaptation or overdraft mitigation in the Central Valley could also provide some useful results. There is always more research that can be done using CALVIN.

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Appendix 1

CVHM Groundwater Term Calculations

This appendix presents some of the different approaches taken when calculating the CALVIN groundwater parameters. The parameters presented as "CVHM" (and in bold) are primarily calculations results from the Zonebudget post-processor; this was the version ultimately used to represent CVHM and the methods are described in Chapter 2. Other versions of these calculations include results from FB_details.OUT and other input files, but these were not chosen to represent CVHM since it involved using terms from different post-processors that did not result in mass balance. However, these calculations still reflect reasonable methods to calculate these terms so some descriptions and results are summarized below.

Table 2.2: CVHM Datasets (from Chapter 2)

Dataset name	Description
CVHM Historical ZB (1980-1993) "CVHM"	Based on historical CVHM run using Zonebudget post-processor; averages based on 1980-1993.
CVHM Historical (1980-2003) "CVHM Hist 1980-2003"	Based on historical CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1980-2003.
CVHM Historical (1961-2003) "CVHM Hist"	Based on historical CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1961-2003.
CVHM 2000 Land Use (1961-2003)* "CVHM 2000"	Based on an updated 2000 land use CVHM run using a combination of FB_details.OUT and Zonebudget; averages are based on 1961-2003.

*Note that this run had obvious problems in some of the Tulare Basin regions so the results from this run were ultimately not used for any formal comparison.

Agricultural Return Flow Split

Different approaches were explored to calculate this term. This was the original approach:

Fraction to SW= RUN/(RUN+DP)
Fraction to GW= DP/(RUN+DP)

Where RUN and DP are part of the Farm Balance found in FB_DETAILS.OUT.

RUN = Overland runoff out of the farm
DP = Deep percolation out of the farm

However, both RUN and DP include precipitation and applied water. CVHM does not separate precipitation out as a separate component to either runoff or deep percolation, as was previously done by the CVGSM model (Direct Runoff was runoff due to rainfall alone). So the above equation is not strictly agricultural return flows, but total return flow.

Since applied water and precipitation are outputs in the CVHM model, a ratio was used to estimate the runoff from applied water and runoff from precipitation.

Applied Water = NRD-in + SRD-in + WELLS-in

Consumptive Use = COMPOSITE EFFICIENCY (%) x Applied Water

Runoff from Applied Water = RUN x [Applied Water / (Applied Water + Precipitation)]

Deep percolation of Applied Water =
Applied Water – Consumptive Use – Runoff from Applied Water

Fraction of Agricultural Return Flow to GW =
Deep percolation of Applied Water / [Applied Water – Consumptive Use]

Fraction of Agricultural Return Flow to SW =
Runoff from Applied Water / [Applied Water – Consumptive Use]

NRD-in = Non-routed deliveries into the farm
SRD-in = Semi-routed deliveries into the farm
WELLS-in = Groundwater well pumping deliveries into the farm
COMPOSITE EFFICIENCY = see term #3 below

The results for return flow to groundwater and return flow to surface water are tabulated below. The "CVHM" set shown in bold is the dataset that was used in the final comparisons.

Table A1.1: Agricultural Return Flow Fractions to Groundwater and Surface Water

Subregion	**CVHM**		Hist CVHM (1980-2003)		Hist CVHM		CVHM 2000	
	GW	**SW**	GW	SW	GW	SW	GW	SW
1	**0.99**	**0.01**	0.65	0.35	0.65	0.35	0.64	0.36
2	**0.98**	**0.02**	0.72	0.28	0.73	0.27	0.7	0.30
3	**0.97**	**0.03**	0.75	0.25	0.76	0.24	0.75	0.25
4	**0.96**	**0.04**	0.68	0.32	0.68	0.32	0.05	0.95
5	**0.97**	**0.03**	0.71	0.29	0.72	0.28	0.63	0.37
6	**0.97**	**0.03**	0.75	0.25	0.76	0.24	0.74	0.26
7	**0.98**	**0.02**	0.69	0.31	0.70	0.30	0.67	0.33
8	**0.98**	**0.02**	0.82	0.18	0.82	0.18	0.83	0.17
9	**0.96**	**0.04**	0.79	0.21	0.80	0.20	0.82	0.18
10	**0.95**	**0.05**	0.83	0.17	0.83	0.17	0.84	0.16
11	**0.97**	**0.03**	0.76	0.24	0.78	0.22	0.77	0.23
12	**0.96**	**0.04**	0.72	0.28	0.74	0.26	0.73	0.27

13	**0.97**	**0.03**	0.84	0.16	0.85	0.15	0.86	0.14
14	**0.92**	**0.08**	0.88	0.12	0.84	0.16	0.89	0.11
15	**0.94**	**0.06**	0.92	0.08	0.91	0.09	0.9	0.10
16	**0.98**	**0.02**	0.91	0.09	0.91	0.09	0.92	0.08
17	**0.97**	**0.03**	0.86	0.14	0.87	0.13	0.87	0.13
18	**0.96**	**0.04**	0.90	0.10	0.90	0.10	0.89	0.11
19	**0.97**	**0.03**	0.93	0.07	0.93	0.07	0.92	0.08
20	**0.97**	**0.03**	0.94	0.06	0.93	0.07	0.94	0.06
21	**0.96**	**0.04**	0.93	0.07	0.92	0.08	0.93	0.07

Agricultural Reuse

This version of CVHM did not "reuse" water on a farm for repeated irrigation. 1 was used for all regions for this term, indicating no reuse.

Return Flow of Total Applied Water

Table A1.2: Return Flow Fraction of Total Applied Water

Subregion	Composite Efficiency (ETAW)		Return Flow (1-ETAW)	
	2000's	1990's	2000's	1990's
1	0.74	0.76	**0.26**	0.24
2	0.73	0.75	**0.27**	0.25
3	0.83	0.82	**0.17**	0.18
4	0.79	0.78	**0.21**	0.22
5	0.8	0.8	**0.2**	0.2
6	0.77	0.77	**0.23**	0.23
7	0.77	0.77	**0.23**	0.23
8	0.75	0.78	**0.25**	0.22
9	0.78	0.79	**0.22**	0.21
10	0.79	0.8	**0.21**	0.2
11	0.77	0.78	**0.23**	0.22
12	0.76	0.77	**0.24**	0.23
13	0.79	0.8	**0.21**	0.2
14	0.87	0.86	**0.13**	0.14
15	0.76	0.76	**0.24**	0.24
16	0.81	0.79	**0.19**	0.21
17	0.8	0.79	**0.2**	0.21
18	0.79	0.79	**0.21**	0.21
19	0.77	0.79	**0.23**	0.21
20	0.81	0.81	**0.19**	0.19
21	0.81	0.81	**0.19**	0.19

External Flows: Inter-basin Flows

Table A1.3: Average Annual Inter-basin Flow (TAF/yr)

Subregion	**CVHM**	Hist CVHM (1980-2003)	Hist CVHM	CVHM 2000
1	**-312.1**	-310.2	-314.4	-288.1

2	**44.2**	32.3	41.3	-10.0
3	**-225.8**	-218.4	-219.6	-178.8
4	**558.6**	552.3	542.1	379.6
5	**-184.9**	-171.4	-178.3	-14.1
6	**-47.2**	-55.2	-22.7	-121.6
7	**19.4**	36.0	-10.3	101.3
8	**50.3**	60.9	49.4	0.2
9	**237.7**	205.5	249.9	220.5
10	**-79.9**	-70.2	-96.9	-88.7
11	**-54.9**	-44.6	-49.7	-9.9
12	**-73.4**	-80.9	-72.4	-88.7
13	**-0.8**	-0.3	0.1	36.7
14	**85.2**	108.7	166.1	247.1
15	**621.8**	514.9	484.2	189.9
16	**-196.1**	-144.7	-169.6	-49.7
17	**-176.8**	-179.5	-153.9	-176.0
18	**-20.1**	-3.4	-33.5	-67.7
19	**212.2**	183.9	201.8	142.3
20	**-164.4**	-146.9	-173.8	140.1
21	**-292.9**	-268.7	-239.8	-364.4
SAC TOTAL	**140.1**	131.7	137.4	89.0
SJ TOTAL	**-209.0**	-196.1	-219.0	-150.6
TL TOTAL	**68.8**	64.4	81.6	61.6
TOTAL	**0.0**	0.0	0.0	0.0

External Flows: Stream Leakage

Table A1.4: Average Annual Stream Leakage (TAF/yr)

Subregion	**CVHM**	Hist CVHM (1980-2003)	Hist CVHM	CVHM 2000
1	-131.5	-121.1	-143.8	-108.5
2	-293.1	-293.3	-293.6	-373.1
3	-234.0	-228.5	-211.1	-167.7
4	-533.4	-531.6	-492.1	-250.7
5	-213.3	-216.1	-198.5	-280.8
6	13.8	32.7	33.8	31.2
7	-42.9	-41.8	-38.0	-34.1
8	84.8	91.6	94.7	84.9
9	551.8	656.0	703.6	496.9
10	38.2	53.7	65.0	46.1
11	-102.3	-102.0	-97.7	-89.2
12	20.7	33.8	39.4	31.8
13	125.3	146.1	164.0	128.4
14	5.6	5.9	5.5	5.5
15	177.6	245.7	238.3	250.9

16	35.0	36.3	33.3	41.8
17	174.8	179.4	169.5	210.9
18	106.9	113.6	103.6	142.7
19	0.0	0.0	0.0	0.0
20	19.3	19.7	18.8	18.8
21	107.2	121.8	130.4	91.8
SAC TOTAL	-797.8	-652.0	-545.0	-601.9
SJ TOTAL	81.9	131.6	170.7	117.1
TL TOTAL	626.4	722.3	699.2	762.4
TOTAL	-89.6	202.0	325.0	277.6

External Flows: Deep Percolation from Precipitation

Many different approaches were taken to calculate this term. The final calculations were based on using ratios from output terms in FB_Details.OUT and applying them to the Zonebudget output "Farm Net Recharge." The older calculations used the ratio from FB_details.OUT and applied it to FB_details.OUT's DP-out.

Applied Water = NRD-in + SRD-in + WELLS-in

Precipitation = P-in

Deep Percolation = DP-out

Deep Percolation of Precipitation = DP-out x (P-in / (P-in + NRD-in + SRD-in + WELLS-in))

Table A1.5: Average Annual Deep Percolation from Precipitation (TAF/yr)

Subregion	**CVHM**	CVHM Hist (1980-2003)	CVHM Hist	CVHM 2000
1	**440.2**	481.8	478.3	480.6
2	**631.4**	679.7	643.2	670.1
3	**613.5**	683.9	636.4	656.4
4	**260.6**	385.7	366.2	370.0
5	**690.1**	796.6	767.7	794.3
6	**556.4**	632.4	594.4	600.0
7	**278.0**	333.3	333.6	312.3
8	**546.4**	595.2	568.5	547.8
9	**263.2**	540.9	506.0	512.3
10	**158.0**	245.3	236.6	240.2
11	**180.7**	213.9	204.6	197.3
12	**137.5**	177.4	167.6	166.0
13	**350.6**	428.9	416.3	398.8
14	**100.5**	94.9	92.1	100.4
15	**177.4**	174.1	173.9	196.2
16	**106.4**	111.7	111.6	110.0
17	**159.7**	167.0	159.9	154.0
18	**217.6**	233.6	237.1	229.7
19	**93.7**	76.0	72.6	73.3

20	**62.2**	58.6	57.7	54.3
21	**79.3**	91.0	82.8	62.7
SAC TOTAL	**4279.9**	5129.6	4894.4	4943.8
SJ TOTAL	**826.8**	1065.5	1025.1	1002.3
TL TOTAL	**996.7**	1006.8	987.7	980.6
TOTAL	**6103.4**	7201.9	6907.2	6926.7

External Flows: Boundary Inflow

Table A1.6: Average Annual Boundary Inflow (TAF/yr)

Subregion	**CVHM**	CVHM Hist (1980-2003)	CVHM Hist	CVHM 2000
1	**0**	0	0	0
2	**0**	0	0	0
3	**0**	0	0	0
4	**0**	0	0	0
5	**0**	0	0	0
6	**0**	0	0	0
7	**0**	0	0	0
8	**0**	0	0	0
9	**-90.5**	-134.7	-102.9	-130.8
10	**0**	0	0	0
11	**0**	0	0	0
12	**0**	0	0	0
13	**0**	0	0	0
14	**0**	0	0	0
15	**0**	0	0	0
16	**0**	0	0	0
17	**0**	0	0	0
18	**0**	0	0	0
19	**0**	0	0	0
20	**0**	0	0	0
21	**0**	0	0	0
SAC TOTAL	**-90.5**	-134.7	-102.9	-130.8
SJ TOTAL	**0.0**	0.0	0.0	0.0
TL TOTAL	**0.0**	0.0	0.0	0.0
TOTAL	**-90.5**	-134.7	-102.9	-130.8

External Flows: Evapotranspiration / Non-recoverable losses

Some of the Agricultural Recharge terms calculated from the Farm Net Recharge terms in Zonebudget are negative. Rather than expressing negative recharge, the negative values were separated out to be the estimated ET losses from groundwater. This was the method used for the final CVHM terms. But the previous versions of the calculations took the time series of EGW-in and TGW-in from FB_Details.OUT, which are evaporation from groundwater and transpiration from groundwater to the farm. These estimated ET values are compared with the ones calculated from the Zonebudget in Table A1.7.

Table A1.7: Average Annual ET from Groundwater (TAF/yr)

Subregion	**CVHM**	CVHM Hist (1980-2003)	CVHM Hist
1	**8.0**	34.4	35.8
2	**0.0**	64.9	62.6
3	**124.5**	310.3	298.6
4	**262.2**	395.1	399.7
5	**227.8**	405.6	402.6
6	**69.3**	305.2	282.4
7	**75.8**	144.0	146.5
8	**0.7**	93.1	74.5
9	**515.5**	863.9	824.6
10	**101.4**	378.4	395.3
11	**4.3**	120.0	118.7
12	**29.2**	148.5	149.4
13	**3.6**	306.6	326.0
14	**0.0**	1.6	4.0
15	**0.0**	57.1	99.5
16	**0.0**	1.3	1.4
17	**0.0**	10.8	11.5
18	**0.0**	17.2	18.6
19	**0.0**	0.8	1.5
20	**0.0**	0.0	0.0
21	**0.0**	56.2	67.5
SAC TOTAL	**1283.7**	2616.6	2527.3
SJ TOTAL	**138.5**	953.6	989.4
TL TOTAL	**0.0**	145.0	203.8
TOTAL	**1422.2**	3715.2	3720.5

Net External Flows

Summing the respective terms from each of the datasets results in the net external flows shown in Table A1.8.

Table A1.8: Average Annual External Flows (TAF/yr)

Subregion	**CVHM**	CVHM Hist (1980-2003)	CVHM Hist	CVHM 2000
1	**6.8**	16.2	-15.7	84.0
2	**406.1**	353.8	328.4	287.0
3	**30.9**	-73.3	-92.9	309.9
4	**23.2**	11.4	16.5	498.9
5	**64.2**	3.4	-11.7	499.4
6	**453.5**	304.6	323.1	509.6
7	**186.2**	183.4	138.7	379.5
8	**685.8**	654.7	638.2	632.9

9	**446.1**	403.7	532.1	1098.9
10	**30.0**	-149.8	-190.7	197.6
11	**19.8**	-52.7	-61.5	98.2
12	**57.9**	-18.2	-14.7	109.1
13	**564.2**	268.1	254.4	563.9
14	**260.4**	207.8	259.7	353.0
15	**1117.0**	877.6	796.9	637.0
16	**-8.8**	2.0	-26.1	102.1
17	**197.9**	156.1	164.1	188.9
18	**564.3**	326.5	288.6	304.7
19	**409.7**	259.1	272.9	215.6
20	**20.9**	-68.5	-97.3	213.2
21	**-63.9**	-112.1	-94.1	-209.9
SAC TOTAL	**2302.9**	1857.9	1856.6	4300.1
SJ TOTAL	**671.8**	47.5	-12.5	968.8
TL TOTAL	**2497.5**	1648.5	1564.7	1804.6
TOTAL	**5472.2**	3553.9	3408.8	7073.5

Maximum Pumping Capacity

Some of the older calculations use the absolute maximum monthly pumping values from FB_Details.OUT. The final CVHM values used were based on “Farm Wells” from Zonebudget.

Table A1.8: Agricultural Maximum Monthly Pumping (TAF/month)

Subregion	**CVHM**	CVHM Hist (1980-2003)	CVHM Hist	CVHM 2000
1	**2.3**	2.6	2.6	2.4
2	**354.7**	149.2	157.3	84.7
3	**4.4**	55.3	77.8	42.1
4	**2.4**	4.8	11.8	0.0
5	**25.1**	6.3	72.4	3.1
6	**181.8**	142.7	183.2	96.6
7	**73.8**	19.8	39.0	0.0
8	**474.5**	217.3	249.0	116.0
9	**90.0**	131.3	269.7	16.5
10	**7.9**	81.9	81.9	104.2
11	**22.8**	53.8	100.5	74.8
12	**19.0**	59.3	71.0	74.6
13	**524.5**	261.0	327.8	292.3
14	**214.8**	236.7	485.6	338.9
15	**1066.5**	430.5	436.2	432.7
16	**32.1**	52.1	108.6	60.8
17	**275.5**	157.3	178.7	148.4
18	**570.8**	377.0	448.3	361.5

19	**471.2**	226.2	243.6	240.5
20	**162.2**	98.9	122.5	113.0
21	**113.3**	93.5	93.5	0.0

Representative depth to Groundwater (Pumping Lift)

Before it was decided that DWR 2000 average measured well data would be used to represent depth to groundwater, values were calculated based on CVHM using the following method:

Depth to Groundwater = Lift = GSE – Water Elevation

GSE = Ground surface elevation, used "cvr2_lay1_topm.txt" (from CVHM input, model_arrays folder)

Water Elevation = heads outputted in LIST file

NOTE: the head value given from MODFLOW is actually the average head, and not the effective water level. This would mean that head is actually an overestimate (this is in addition to all the other assumptions). So the calculated lift is an underestimate.

This method was based on using the well indices specified in the FMP file (a CVHM input file) that specifies, by element, where wells are located as of year 2000. For this calculation, an average of 2000 water year heads was used.

An alternative method involved using subregion indices from dwr_subregions file (CVHM input file) – to match, and then extract groundwater elevation at each element. However, this method involved sometimes using subregion elements where a well does not actually exist, or at least was not modeled in CVHM. Using the well indices file was determined to be a better representation since only elements with known, existing wells were used for the calculation.

An issue that arose was that GSE was less than Water Elevation in many elements. Elements where this occurred were excluded from the calculations.

Table A1.9: Groundwater Pumping Lift (feet)

Subregion	CVHM	CVHM 2000
1	153	154
2	43	43
3	63	63
4*	NA	NA
5	14	14
6	57	57

7	19	18
8	17	16
9	43	43
10	73	73
11	22	22
12	42	43
13	113	134
14	176	206
15	36	55
16	123	151
17	80	102
18	186	230
19	165	194
20	366	413
21	250	276

*For this region, all GSE values were less than the water elevation so no value for lift could be calculated.

Maximum Storage Capacity

The term "Storage" from the Zonebudget was used for all calculations here. Effective storage was calculated for this term to represent the absolute maximum available water. Calculation is as follows:

1. Arbitrarily set the initial storage to a very large number such that the created storage time series is never negative. Used 1×10^9.
2. Once storage values are converted from change in storage to storage, the effective storage can be calculated: Absolute Maximum storage – Absolute Minimum Storage (note that the original arbitrarily high number is subtracted out by doing this).

Table A1.10: Maximum (Effective) Storage (TAF)

Subregion	**CVHM Historical (1980-1993)**	CVHM Historical	CVHM 2000
1	**19,543**	24,969	18,984
2	**33,133**	33,133	30,105
3	**22,782**	30,291	28,094
4	**15,730**	25,993	20,348
5	**23,850**	33,887	26,713
6	**34,350**	41,230	35,657
7	**12,190**	13,308	13,030
8	**31,153**	31,153	30,177
9	**81,528**	128,968	96,095
10	**20,844**	29,718	27,502

11	**10,704**	15,972	14,237
12	**16,651**	32,495	21,168
13	**48,168**	48,168	49,794
14	**32,789**	90,541	52,038
15	**38,000**	49,214	39,397
16	**27,274**	47,732	32,371
17	**31,370**	39,890	38,811
18	**58,956**	83,700	34,740
19	**28,006**	44,875	59,136
20	**20,229**	39,587	27,953
21	**58,804**	58,804	64,187
SAC TOTAL	**274,260**	362,934	299,203
SJ TOTAL	**96,367**	126,354	112,701
TL TOTAL	**295,428**	454,344	348,633
TOTAL	**666,055**	943,631	760,537

Initial & Ending Storage Capacity

The initial storage was calculated to be the effective initial storage, the maximum amount of water available in September 2003. This was calculated: Storage in 2003-Absolute Minimum storage. The results are shown in Table 14. The initial storage values used for CALVIN here are taken directly from CALVIN model inputs.

Table A1.11: Initial Storage (TAF)

Region	**CVHM Historical (1980-1993)**	CVHM Historical	CVHM 2000
1	**16,346**	21,773	12,908
2	**19,031**	19,031	14,355
3	**10,350**	10,350	11,244
4	**8,552**	8,552	9,989
5	**16,587**	16,587	13,656
6	**11,683**	11,683	16,066
7	**10,180**	11,297	8,185
8	**12,230**	12,230	10,565
9	**18,419**	18,419	32,512
10	**11,311**	11,311	9,344
11	**4,905**	4,905	4,435
12	**3,683**	3,683	5,518
13	**33,636**	33,636	39,214
14	**32,789**	90,541	44,445
15	**22,341**	33,555	25,833
16	**27,274**	47,732	31,158
17	**24,960**	33,480	34,051

18	**58,956**	83,700	33,598
19	**28,006**	44,875	59,136
20	**20,229**	39,587	27,953
21	**58,699**	58,699	64,187
SAC TOTAL	**123,377**	129,922	129,481
SJ TOTAL	**53,536**	53,536	58,510
TL TOTAL	**273,254**	432,170	320,361
TOTAL	**450,167**	615,627	508,353

Overdraft scenarios were not examined when initially calculating groundwater terms so the CVHM dataset ending storages were just set to the initial storages (no change in storage).

Appendix 2

Table A2.1 shows the summary calculation for pumping lift cost. The first column presents the DWR 2000 averaged well data. The Technical Note by Buck 2012 (below) describes how the pumping lift depths were determined. Column 2 shows drawdown values used in the previous version of CALVIN (Appendix J). Column 3 is the Pumping Head, which is estimated by summing the drawdown and the pumping lift. Column 4 shows the change in lift values that were used in the previous version of CALVIN, which are used to determine Total Dynamic Head in Column 5. Column 6 is the estimated pumping cost in year 2000 dollars ($.20af/ft). The 2000 costs are then hit with a multiplier (x1.296) to reflect 2008 costs (last column in the table).

Table A2.1: Estimated Agricultural Pumping Costs

Subregion	Estimated Pumping Lift (ft)*	Drawdown (ft)	Pumping Head (ft)	Change in Lift (ft)	Total Dynamic Head (ft)	Pumping Cost, 2000$ ($.20af/ft)	Pumping Cost, 2008$ ($/AF)
1	71	20	91	0	91	$ 18.20	$ 23.59
2	40	20	60	1	61	$ 12.20	$ 15.82
3	27	20	47	-1	46	$ 9.20	$ 11.93
4	16	20	36	0	36	$ 7.20	$ 9.33
5	27	20	47	-1	46	$ 9.20	$ 11.93
6	25	20	45	1	46	$ 9.20	$ 11.93
7	40	30	70	19	89	$ 17.80	$ 23.07
8	90	30	120	3	123	$ 24.60	$ 31.89
9	24	20	44	2	46	$ 9.20	$ 11.93
10	17	20	37	-2	35	$ 7.00	$ 9.07
11	47	30	77	-2	75	$ 15.00	$ 19.45
12	68	30	98	-2	96	$ 19.20	$ 24.89
13	75	30	105	-5	100	$ 20.00	$ 25.93
14	235	30	265	2	267	$ 53.40	$ 69.22
15	93	30	123	-7	116	$ 23.20	$ 30.08
16	57	30	87	-11	76	$ 15.20	$ 19.70
17	34	30	64	-2	62	$ 12.40	$ 16.07
18	80	30	110	-4	106	$ 21.20	$ 27.48
19	139	30	169	4	173	$ 34.60	$ 44.85
20	298	30	328	-4	324	$ 64.80	$ 84.00
21	191	30	221	8	229	$ 45.80	$ 59.37

* Averaged DWR 2000 well data

Technical Note:

Pumping Lift from DWR Well Data

By: Christina R. Buck
September 20, 2011
Updated October 10, 2011

Introduction

An estimated pumping lift for each CVPM region is required for calculating pumping costs in CALVIN. Recent efforts to update the representation of groundwater in CALVIN have explored using the Central Valley Hydrologic Model (CVHM), developed by the United States Geological Survey (USGS), and the California Central Valley Simulation (C2VSIM) model, developed by the Department of Water Resources (DWR), to improve required terms. For estimating pumping lift in CALVIN, it was decided that using measured data of groundwater heads would be best.

The pumping lift is the length (often in feet) that water must be pumped from the water surface in the well to ground surface elevation. DWR monitors water levels throughout the Central Valley typically twice per year, once in the spring and then in the fall. This data provides a snapshot of the head in wells at the time of measurement. This is usually close to the start and end of the irrigation season. A variety of well types make up their monitoring network, including irrigation, domestic, stock, monitoring, industrial, observation, recreation wells and some that are no longer in use. Data from this monitoring effort is available online from the Water Data Library (http://www.water.ca.gov/waterdatalibrary/).

Method

In CALVIN, one number is used to represent typical pumping lifts in irrigation wells in each sub-region. Therefore, water level data was obtained (by Aaron King, UC Davis Center for Watershed Sciences, Graduate Student) from contacts at DWR. The full data set includes wells in CVPM regions 2 thru 21 from years 1990-2011. Data for CVPM region 1 was obtained separately. The year 2000 was chosen to establish a representative pumping lift.

Data was filtered by year (2000). Measurements were tagged as Spring or Fall measurements based on a cutoff of July (July and earlier being a spring measurement, August and later being a fall measurement). This allowed for calculating the average 2000 spring measurement and fall measurement independently. DWR data includes a number of columns: ground surface elevation, RPWS, GSWS, WSE, etc. Ground Surface Water Surface (GSWS) is the measured distance from the ground surface to the water level in the well. This was the data used to calculate a representative pumping lift.

There are a variety of well types in DWR's monitoring network. Wells in the categories of irrigation, irrigation and domestic, stock, unused irrigation wells, observation, and undetermined were used in the calculation. This served to focus mainly on irrigation related wells while still including enough categories to maintain a good sample size. The distribution of wells with measurements taken in 2000 that were used for the calculation is shown in Figure A2.

Measured water levels indicate the piezometric head in the well and are dependent on the screened intervals of the well. This should be distinguished from the "depth to groundwater" which can refer to the distance below ground surface to the water table. Piezometric head in the wells can be higher or lower than the water table depending on the well screening and aquifer dynamics. For this effort, we want the average pumping lift for irrigation wells in each region, so averaging the GSWS measurements in each region to obtain a representative lift for that area assumes that the sample of measured wells is generally representative of wells in that region.

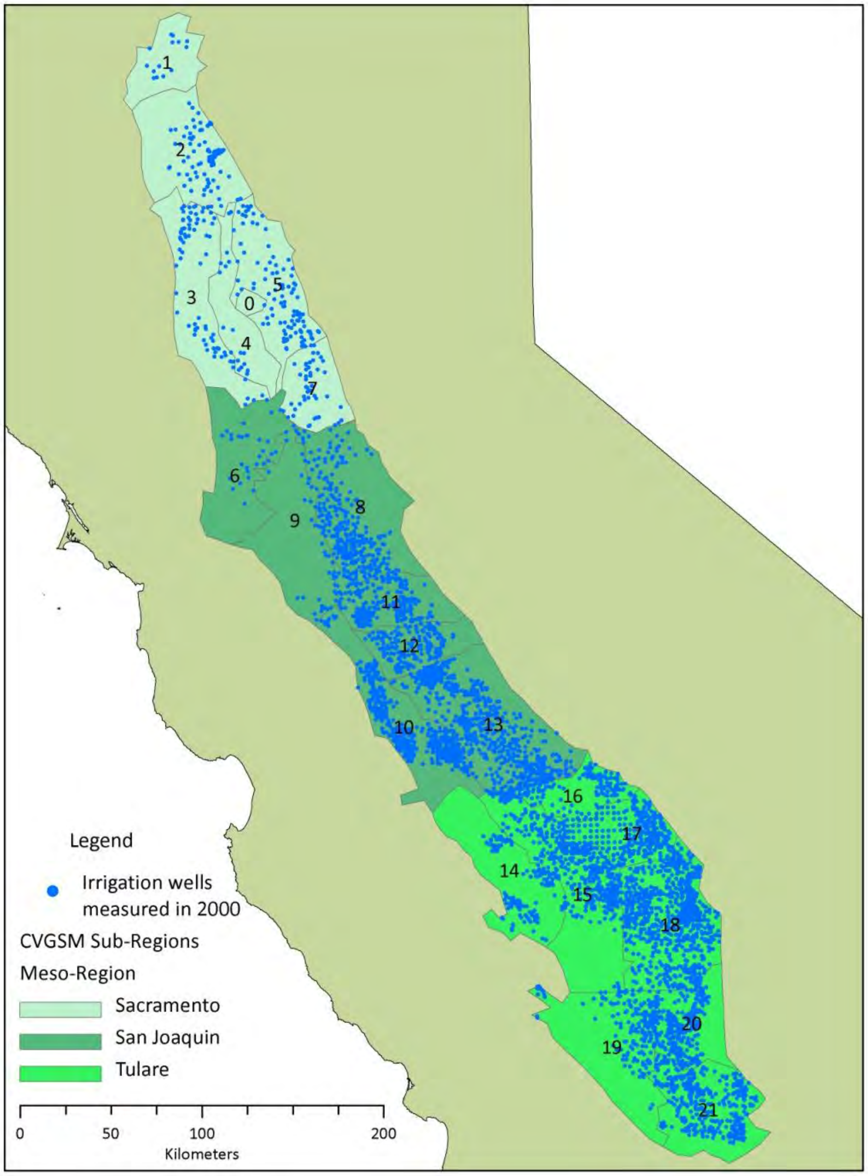


Figure A2: Distribution of wells measured in 2000 used for the estimate of pumping lift (courtesy of Aaron King)

<u>Results</u>

Table A1 presents averaged measurements taken any time during year 2000, average of fall and spring measurements, and the total number of measurements used for the year 2000 average (Count).

Table A1.2: Average GSWS (feet) for measurements taken in 2000, Fall 2000, Spring 2000 and the total count of measurements used for the Year 2000 average

CVPM region	GSWS (ft)			
	Year 2000	*Fall 2000*	*Spring 2000*	*Count**
1	71	70	73	31
2	40	45	38	529
3	27	33	23	258
4	16	19	13	221
5	27	29	26	294
6	25	26	23	151
7	40	39	42	210
8	90	99	84	589
9	24	27	22	104
10	17	77	16	439
11	47	45	48	319
12	68	#DIV/0!	68	177
13	75	#DIV/0!	75	641
14	235	245	150	136
15	93	140	92	377
16	57	#DIV/0!	57	145
17	34	#DIV/0!	34	271
18	80	#DIV/0!	80	857
19	139	#DIV/0!	139	179
20	298	178	298	282
21	191	#DIV/0!	191	379

*Measurement count for Year 2000

Cells that have #DIV/0! indicate that no data was available during that time or for that area. Spring values tend to be less than fall indicating that water levels in the spring and early summer are closer to the ground surface than by the end of irrigation season. This is due to winter recharge that "refills" the groundwater basin and summer extraction that draws water levels down. In some places where irrigation serves as a major source of recharge, fall levels can be higher than spring levels (example, region 20).

In reality, pumping lift is dynamic and changes between years and within a year. For the purposes of CALVIN, which uses a single number for all time and for each region, Year 2000 values were used because they approximate the overall average of available measured data for groundwater head in wells.

Appendix 3

CALVIN Schematic & Network Improvements

Updates to the CALVIN schematic were made to better accommodate components related to groundwater for the agricultural and urban sectors and to facilitate the calibration process. Hidden nodes and nodes for artificial recharge have been added to the PRMNetBuilder network. The following hidden nodes were added:

- Return flow of applied water to surface water from agricultural areas (HSD)
- Return flow of applied water to groundwater for urban areas (HGU)
- Infiltration of surface diversions allocated for spreading-Artificial Recharge (HAR)
- Pumping to all demand areas (HGP)

The added hidden nodes link to physical downstream and upstream nodes and carry amplitude functions that can represent losses. Hidden nodes for pumping (HGP) link groundwater to demand areas and have amplitudes of 1. It is assumed that pumps are located close to the demand areas so that no losses occur.

Hidden nodes for return flow (HGD and HGU) to groundwater for agricultural and urban areas link demand areas to groundwater and have a return flow amplitude representative of fraction of applied water that is returned to the ground. Artificial recharge nodes (HAR) consists of upstream and downstream links such that upstream links to surface water diversions allocated for spreading and carry amplitude that reflect fractions of diverted water that is lost to evaporation and the downstream link is artificial recharge flow to the groundwater basin. Hidden node for return flow to surface water (HSD) for agricultural and urban areas link demand areas to surface water and have return flow amplitude representative of fraction of applied water that is returned to surface water.

Figures A3.1 and A3.2 below show the updated, detailed schematic for agricultural and urban sectors, respectively.

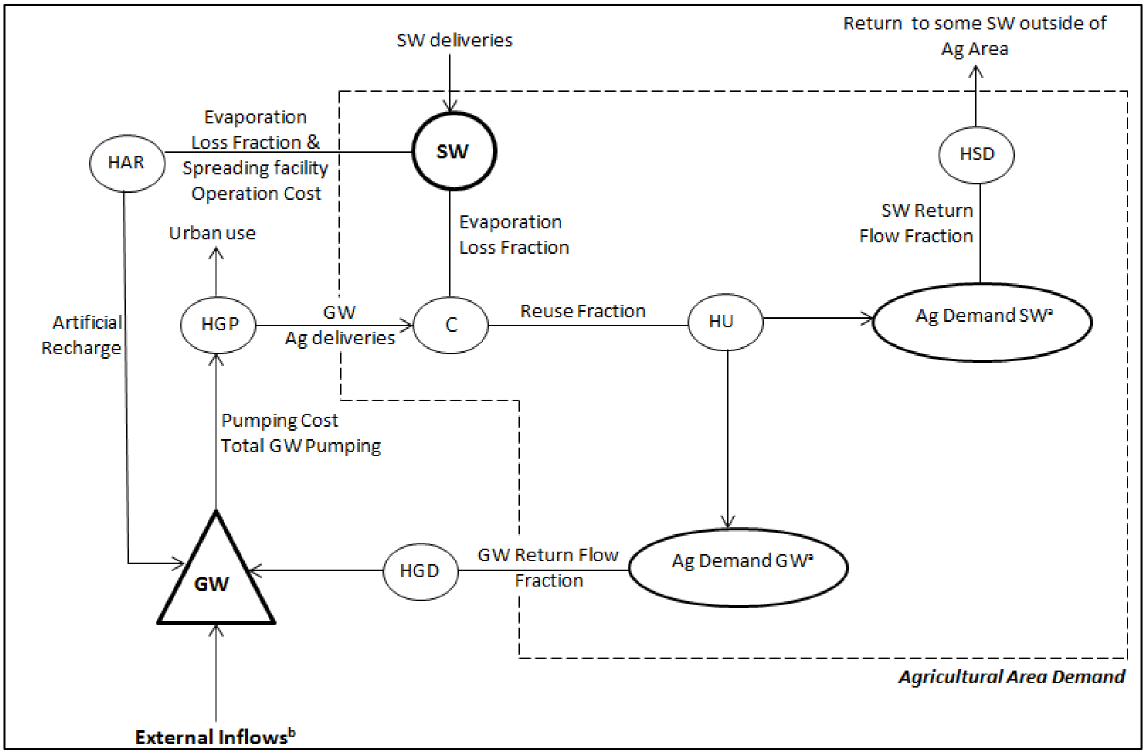


Figure A3.1: Updated CALVIN Schematic for Agricultural Sector

Notes: a) Ag Demand GW represents the non-consumptive use portion of irrigation water that deep percolates to groundwater, and Ag Demand SW represents the portion that returns to surface water systems as tailwater.
b) External Inflows represent net monthly time series inflows to groundwater from Streams, Lakes, Deep Percolation of Precipitation, Diversion losses, Boundary Inflows, Interbasin Inflows, Subsidence and Tile Drain Outflows

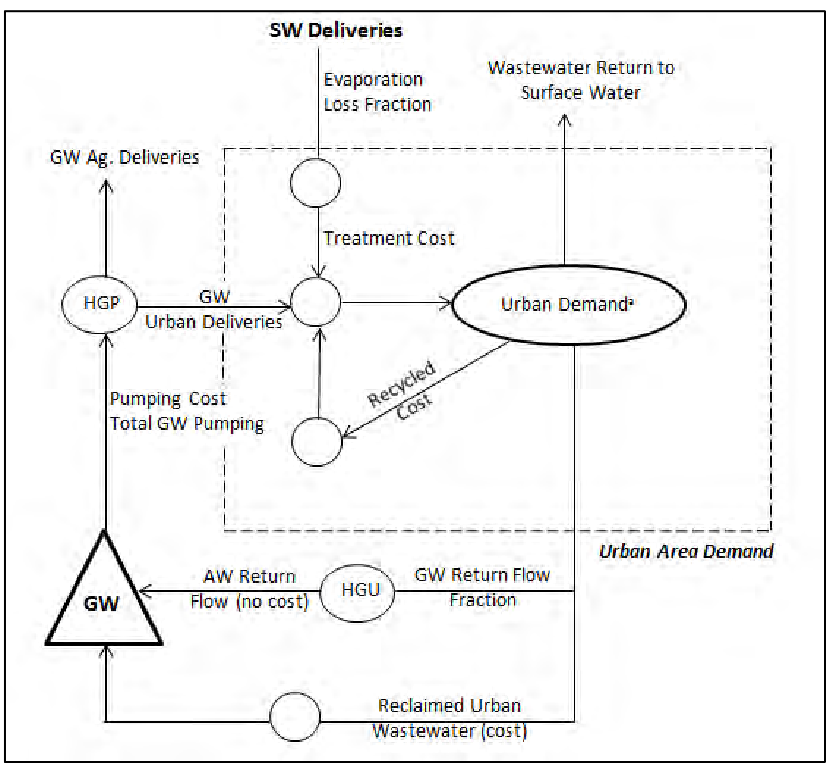


Figure A3.2: Updated CALVIN Schematic for Urban Sector

Notes: a) Urban Demands is represented in CALVIN as Int: CVPM, represent urban demands for water for indoor use and Ext: CVPM is demand for outdoor use, following Bartolomeo (2011).

Appendix 4

C2VSIM Streamflow Adjustments

Differences in streamflow exchange before and after 1951 could be due to the change in aquifer levels and changes in the interactions between surface-groundwater. There are changes in direction and magnitude of flow between groundwater basins and rivers over time so streams that may have been gaining streams before 1951 could have reversed to being losing stream after 1951 or vice versa. Another possibility is that less water goes from groundwater to streams after this time as a result of groundwater depletion and thus smaller stream-aquifer hydraulic connectivity. If the historical time series of streamflows were used, there would likely be a million acre-feet per year of water that may not be accounted for correctly in the Central Valley, which would result in some exaggerated availability of surface water or groundwater.

Because the possible inflated availability, streamflow exchanges before 1951 were adjusted using the annual average difference for subregions above 50 TAF/yr. Adjusted subregions are 2, 4, 5, 6, 9, 11, 13, 15, 18, 19 and 21. In order to maintain mass balance of water available within the subregions, the difference between historical and adjusted stream inflows were accounted for in the depletion areas of respective subregions or as depletions or accretions to major streams in these subregions. Table A4.1 shows monthly flows added or subtracted in the subregion depletion study areas: (-) add to depletion area and (+) subtract from depletion area. Details on depletion areas and how they are used in CALVIN are in the Appendix I (Draper et al. 2000). Table A4.1 also shows depletion and accretion areas and streams corresponding to subregions, as well as nodes per CALVIN network. Depletion and Accretion areas are listed in Appendix I and checked in CALVIN Schematic; stream information is as modeled in C2VSIM - version R356.

Table A4.1: Adjusted monthly flows to depletion and accretion areas in the Central Valley due to changes in historical streamflow exchanges before 1951

Subregion	Depletion Area or Stream	Nodes in CALVIN network	Adjusted monthly inflows (TAF/month)
2	10	D76a - DA10 Depletion	11.9
4	15	D66 - DA15 Depletion	5.8
5	69	D37 - DA69 Depletion	4.9
6	65	C20 - DA65 Depletion	9.3
9	55	D509 - D55 Depletion and Accretion	10.3
11	San Joaquin River to Tuolumne to Stanislaus	D688 - Depletion	6.4
13	Merced River	D643 - Depletion Upper Merced River	0.2
		D647 - Depletion Lower	0.3

		Merced River	
	Chowchilla River	D634 - Depletion Chowchilla River	0.4
	Fresno River	D624 - Depletion Fresno River	1.4
	San Joaquin River	D605 - Depletion San Joaquin River	1.9
15	Kings River	C53 - Depletion Kings River	19.5
18	Kaweah River	C89 - Accretion Kaweah River	0.1
	Tule River	C57 - Accretion Tule River	4.5
19 and 21	Kern River	C97 - Depletion Kern River	18.2

Table A4.2 shows annual average Net External Inflows calculated to be used in CALVIN based on C2VSIM in column 3. The 2nd column shows the adjusted values actually used in CALVIN. Columns 4 and 5 show comparisons of average yearly flows under this term from CVHM and CVGSM.

Table A4.2: Annual Average Net External Inflows in the Central Valley

Subregion	Net External Inflows to Groundwater (TAF/yr)			
	C2VSIM		CVHM	CVGSM
	w/ Adjustments to Streamflow Exchange	w/out Adjustment to Streamflow Exchange		
1	28	28	6.8	-96
2	235	177	406.1	189
3	-9	-9	30.9	77
4	-68	-96	23.2	227
5	91	67	64.2	6
6	225	180	453.5	302
7	168	168	186.2	242
8	402	402	685.8	686
9	134	85	446.1	-118
10	72	72	30.0	262
11	29	-1	19.8	303
12	49	49	57.9	129
13	365	344	564.2	781
14	278	278	260.4	267
15	688	594	1117.0	1130
16	51	51	-8.8	273
17	96	96	197.9	309
18	241	263	564.3	402
19	424	368	409.7	121
20	101	101	20.9	194
21	322	290	-63.9	322
Sacramento Total	**1206**	**1002**	2497.5	**1515**

San Joaquin Total	**515**	**464**	671.8	**1474**
Tulare Total	**2201**	**2041**	2302.9	**3017**
Central Valley Total	**3922**	**3507**	5472.2	**6006**

Appendix 5

C2VSIM Surface Water Recoverable and Non-recoverable Losses

Table A5.1shows the C2VSIM surface water recoverable (primarily diversion) and non-recoverable (evaporation and transpiration) losses and how they correspond to CALVIN nodes and links. The 5th column shows the previous version of CALVIN's Recoverable and Non-recoverable loss amplitudes. Column 6 shows the new values used. If a parentheses ( ) is shown, that indicates that amplitude was adjusted to the value inside of the parentheses during the calibration process.

Table A5.1: Surface Water Recoverable & Non-Recoverable Loss Amplitudes

C2VSIM Surface Water Diversion Source Node	Subregion	Fraction Non-Recoverable Losses	Land Use	Old CALVIN RL & NRL Amplitude	New CALVIN RL & NRL Amplitude	Diversion Description & CALVIN Nodes & Links for Fraction Update
			Subregion 1			
Import	1	0.01	Ag			Whiskeytown and Shasta imports for SR1 Ag
		0.01		**0.97**	**0.96**	**HSU1SR3_C3**
Import	1	0.01	M&I			Whiskeytown and Shasta imports for SR1 M&I
206	1	0.01	M&I			Sacramento River to Bella Vista Conduit SR1 M&I
206	1	0.01	M&I			Sacramento River Keswick to Red Bluff SR1 M&I
		0.03		**1**	**0.88 (1)**	**T41_Ext: Redding & T41_Int: Redding**
206	1	0.02	Ag			Sacramento River to Bella Vista Conduit SR1 Ag
	1	**0.02**		**0.97**	**0.95**	**HSU1D5_C3**
216	1	0.02	Ag			Sacramento River Keswick to Red Bluff SR1 Ag
212	1	0.02	Ag			Cow Creek riparian diversions to SR1 Ag
221	1	0.02	Ag			Battle Creek riparian diversions to SR1 Ag
Import	1	0.02	Ag			Cottonwood Creek riparian diversions to SR1 Ag
	1	**0.08**		**0.97**	**0.52**	**HSU1D74_C3**
			Subregion 2			
234	2	0.02	Ag			Antelope Creek diversions to Los Molinos MWC SR2 Ag
245	2	0.02	Ag			Mill Creek to Los Molinos MWC SR2 Ag
258	2	0.02	Ag			Deer Creek to Los Molinos MWC SR2 Ag

231	2	0.02	Ag			Sacramento River diversions to Corning Canal SR2 Ag
Import	2	0.02	Ag			Clear Creek riparian diversions to SR2 Ag
		0.1		**0.93**	**0.47 (0.88)**	**HSU2D77_C6**
242	2	0.02	Ag			Elder Creek riparian diversions SR2 Ag
253	2	0.02	Ag			Thomas Creek riparian to SR2 Ag
262	2	0.02	Ag			Sacramento River to SR2 Ag
	2	**0.06**		**0.93**	**0.64 (0.88)**	**HSU2C1_C6**
231	2	0.02	Ag			Sacramento River diversions to the Tehama Colusa Canal to SR2 Ag
	2	**0.02**		**0.93**	**0.95**	**HSU2C11_C6**
264	2	0.02	Ag			Stony Creek to North Canal SR2 Ag
Import	2	0.02	Ag			Stony Creek to South Canal from Black Butte Reservoir SR2 Ag
		0.04		**0.93**	**0.88**	**HSU2C9_C6**
Subregion 3						
264	3	0.02	Ag			Stony Creek to Tehama Colusa Canal and SR3 Ag
231	3	0.02	Ag			Sacramento River diversions to the Tehama Colusa Canal to SR3 Ag
		0.04		**0.95**	**0.9**	**HSU3C11_C302**
264	3	0.02	Ag			Stony Creek to Glenn-Colusa Canal and SR3 Ag
261	3	0.02	Ag			Sacramento River to Glenn Colusa Canal to SR3 Ag
261	3	0.02	Refuge			Sacramento River to Glenn Colusa Canal to SR3 Refuge (Ag)
		0.06		**0.95**	**0.85**	**HSU3C13_C302**
282	3	0.02	Ag			Sacramento River to SR3 Ag
		0.02		**0.95**	**0.88**	**HSU3D66_C303**
327	3	0.02	Ag			Colusa Basin Drain to SR3 Ag
324	3	0.02	Refuge			Colusa Basin Drain to SR3 Ag
		0.04		**0.95**	**0.76 (0.88)**	**HSU3C305_C303**
Subregion 4						
331	4	0.02	Ag			Sacramento River to SR4 Ag
		0.02		**0.97**	**0.88**	**HSU4D30_C14**
IN CALVIN: Butte Creek and Little Chico Creek --> SURPLUS DELTA OUTFLOW OR TO NORTH BAY AQUEDUCT TO URBAN NAPA-SOLANO						
285	4	0.02	Ag			Butte Creek to RD 1004 SR4 Ag
284	5	0.02	Ag			Butte Creek at Parrott-Phelan Dam to SR5 Ag

286	5	0.02	Ag			Butte Creek at Durham Mutual Dam to SR5 Ag
287	5	0.02	Ag			Butte Creek at Adams and Gorrill Dams to SR5 Ag
291	5	0.02	Refuge			Butte Creek to Sutter & Butte Duck Clubs to SR5 Ag
Import	5	0.02	Ag			Little Chico Creek to SR4 Ag
292	4	0.02	Ag			Butte Slough to SR4 Ag
Subregion 5: URBAN in CALVIN receives only GW supplies, Yuba receives both GW and SW supplies & Palermo Canal serves Ag						
Import	5	0.02	Ag			Tarr Ditch SR5 Ag (55% is used inside the model area)
		0.02		**0.96**	**0.88**	**HSU5C35_C26**
Import	5	0.02	Ag			Miocene and Wilenor Canals SR5 Ag
Import	5	0.02	Ag			Oroville-Wyandotte ID through Forbestown Ditch SR5 Ag
347	5	0.02	Ag			Feather River to SR5 Ag (replaced by Thermalito)
347	5	0.02	Ag			Feather River to SR5 Ag
Import	5	0.02	Ag			Bangor Canal SR5 Ag (Miners Ranch Canal)
		0.08		**0.96**	**0.52 (0.88)**	**HSU5C77_C26**
Import	5	0.02	M&I			Feather River to Thermalito ID SR5 M&I
352	5	0.01	M&I			Feather River to Yuba City SR5 M&I
Import	5	0.02	M&I			Palermo Canal from Oroville Dam SR5 M&I
351	5	0.01	M&I			Yuba River to SR5 M&I
		0.06		**1**	**0.82 (1)**	**T61_Ext: Yuba and T61_Int: Yuba**
Import	5	0.02	Ag			Thermalito Afterbay to SR5 Ag
358	5	0.02	Ag			Bear River to Camp Far West ID North Side SR5 Ag
		0.04		**0.96**	**0.76 (0.88)**	**HSU5C80_C26**
351	5	0.02	Ag			Yuba River to SR5 Ag
				0.96	**0.88**	**HSU5C83_C26**
Subregion 6						
329	6	0.02	Ag			Knights Landing Ridge Cut diversions (Baseflow) SR3 Ag
371	6	0.02	Ag			Sacramento R Rt Bk btwn Knights Landing & Sacramento to SR6 Ag
		0.04		**0.93**	**0.76 (0.88)**	**HSU6C314_C17**
381	6	0.01	M&I			Sacramento River to West Sacramento SR6 M&I
400	6	0.02	M&I			Putah South Canal SR6 M&I
413	6	0.02	M&I			Delta to North Bay Aqueduct to SR6 M&I

		0.05		**1**	**0.84 (1)**	**T14_ERes: Napa-Solano, T14_Ind: Napa-Solano and T14_IRes: Napa-Solano**
Import	6	0.02	Ag			Cache Creek to SR6 Ag
				0.93	**0.88**	**HSU6C16_C17**
398	6	0.02	Ag			Yolo Bypass to SR6 Ag
400	6	0.02	Ag			Putah South Canal SR6 Ag
404	6	0.02	Ag			Putah Creek riparian diversions SR6 Ag
413	6	0.02	Ag			Delta to North Bay Aqueduct to SR6 Ag
		0.08		**0.93**	**0.59 (0.88)**	**HSU6C21_C17**
Subregion 7						
364	7	0.02	Ag			Feather River to SR7 Ag
				0.93	**0.88**	**HSU7D42_C34**
358	7	0.02	Ag			Bear River to Camp Far West ID South Side SR7 Ag
358	7	0.02	Ag			Bear River to South Sutter WD SR7 Ag
Import	7	0.02	Ag			Bear River Canal to South Sutter WD SR7 Ag
		0.06		**0.93**	**0.64 (0.88)**	**HSU7C33_C34**
372	7	0.02	Ag			Sacramento R Lt Bank btwn Knights Landing & Sacramento to SR7 Ag
				0.93	**0.88**	**HSU7C67_C34 (Include diversions from Butte Creek & Little Chico)**
Subreigon 8						
Import	7	0.01	M&I			Folsom Lake to SR7 M&I
377	7	0.01	M&I			American R to Carmichael WD SR7 M&I
378	7	0.01	M&I			American R LB to City of Sacramento SR7 M&I
381	8	0.01	M&I			Sacramento River Left Bank to City of Sacramento SR8 M&I
375	8	0.01	M&I			Folsom South Canal to SR8 M&I
		0.05		**1**	**0.76 (1)**	**T4_Ext: Sacramento and T4_Int: Sacramento**
375	8	0.01	M&I			Folsom South Canal to SR8 M&I
				1	**0.94 (1)**	**T43_Ext: CVPM8 and T43_Int:CVPM8**
Import	7	0.02	Ag			American River to North Fork and Natomas Ditches to SR7 Ag*
375	8	0.02	Ag			Folsom South Canal to SR8 Ag
		0.04		**0.92**	**0.76 (0.88)**	**HSU8C173_C36**
193	8	0.02	Ag			Cosumnes R riparian to SR8 Ag
				0.92	**0.88**	**HSU8C37_C36**
Import	8	0.02	Ag			Mokelumne R to SR8 AgS

195	8	0.02	Ag			Mokelumne R to SR8 Ag
		0.04		**0.92**	**0.76 (0.88)**	**HSU8D98_C36**
165	8	0.02	Ag			Calaveras R to SR8 Ag*
*In CALVIN Calaveras diversions are not allocated for SR8 (Calaveras_SR-New Hogan Lake_etc).						
Central San Joaquin ID from Stanislaus River diversion to CVPM 8 in CALVIN but not in C2VSIM (_C43_HSU8C43_C36_CVPM8 Ag)						
Subregion 9						
418	9	0.02	Ag			Delta to SR9 Ag
				1	**0.88 (0.93)**	**HSU9D507_C68**
Import	9	0.02	Ag			Delta Mendota Canal to Subregion 9 Ag
				1	**0.93**	**HSU9D521_C68 and HSU9D515_C68**
Subregion 10						
145	10	0.03	Ag			San Joaquin R riparian (Fremont Ford to Vernalis) SR10 Ag
				0.9	**0.82**	**HSU10C10_C84**
Import	10	0.02	Ag			Delta Mendota Canal to Subregion 10 Ag
Import	10	0.02	Refuge			Delta-Mendota Canal to SR10 Refuges (Ag)
				0.9	**0.93**	**HSU10C30_C84**
Import	10	0.02	Ag			Mendota Pool to SR10 Ag
Import	10	0.02	Refuge			Mendota Pool to SR10 Refuges (Ag)
				0.9	**0.82**	**HSU10D731_C84**
Import	10	0.02	Ag			O'Neill Forebay to SR10 Ag
Import	10	0.02	Refuge			O'Neill Forebay to SR10 Refuges (Ag)
				0.9	**0.88**	**HSUD803_C84 (IN CALVIN as CA Aqueduct, Harvey Bank Pumping Station, should confirm this)**
Import	10	0.02	Ag			San Luis Canal to SR10 Ag
Import	10	0.02	Refuge			San Luis Canal to SR10 Refuges (Ag)
				0.9	**0.93**	**HSU10C85_C84**
Subregion 11						
147	11	0.03	Ag			Stanislaus R to South San Joaquin Canal to SR11 Ag
147	11	0.03	Ag			Stanislaus R to Oakdale Canal to SR11 Ag
		0.06		**0.8**	**0.64 (0.82)**	**HSU11D16_C172**
147	11	0.01	M&I			Stanislaus R to South San Joaquin Canal to SR11 M&I
147	11	0.01	M&I			Stanislaus R to Oakdale Canal to SR11 M&I
152	11	0.01	M&I			Stanislaus R riparian to SR11 M&I
Import	11	0.01	M&I			Modesto Canal to SR11 M&I
142	11	0.01	M&I			Tuolumne R RB riparian to SR11 M&I

		0.05		1	0.7 (1)	**T45_Ext:CVPM11 and T45_Int:CVPM11**
152	11	0.03	Ag			Stanislaus R riparian to SR11 Ag
				0.88	**0.82**	**HSU11D672_C172**
Import	11	0.03	Ag			Modesto Canal to SR11 Ag
				0.88	**0.82**	**HSU11D662_C172**
142	11	0.03	Ag			Tuolumne R RB riparian to SR11 Ag
				0.88	**0.82**	**HSU11D664_C172**
145	11	0.03	Ag			San Joaquin R riparian (Fremont Ford to Vernalis) SR11 Ag
				0.88	**0.82**	**HSU11D689_C172**
Subregion 12						
142	12	0.03	Ag			Tuolumne R LB riparian to SR12 Ag
				0.9	**0.82**	**HSU12D664_C45**
142	12	0.01	M&I			Tuolumne R LB riparian to SR12 M&I
123	12	0.01	M&I			Merced R Right Bank riparian to SR12 M&I
117	12	0.01	M&I			Merced R to Merced ID Northside Canal to SR12 M&I
Import	12	0.01	M&I			Turlock Canal to SR12 M&I
		0.04		**1**	**0.76 (1)**	**T66_Ext:CVPM12 & T66_Int:CVPM12**
Import	12	0.03	Ag			Turlock Canal to SR12 Ag
				0.9	**0.82**	**HSU12D662_C45**
117	12	0.03	Ag			Merced R to Merced ID Northside Canal to SR12 Ag
				0.9	**0.82**	**HSU12D645_C45**
123	12	0.03	Ag			Merced R Right Bank riparian to SR12 Ag
				0.9	**0.82**	**HSU12D649_C45**
134	12	0.03	Ag			San Joaquin R riparian (Fremont Ford to Vernalis) SR12 Ag
				0.9	**0.82**	**HSU12D699_C45**
Subregion 13						
			AG	**0.9**	**0.94**	**HSU13D606_C46**
123	13	0.03	Ag			Merced R Left Bank riparian to SR12 Ag
				0.9	**0.82**	**HSU13D649_C46**
117	13	0.03	Ag			Merced R to Merced ID Main Canal to SR12 Ag
				0.9	**0.82**	**HSU13D645_C46**
Import	13	0.03	Ag			Madera Canal to Chowchilla WD SR13 Ag
Import	13	0.03	Ag			Madera Canal to Madera ID SR13 Ag
Import	13	0.02	Ag			Madera Canal to SR13 Ag
		0.05		**0.9**	**0.75(0.88)**	**HSU13C72_C46**
84	13	0.03	Ag			Chowchilla R riparian

						SR13 Ag
				0.9	**0.82**	**HSU13D634_C46**
74	13	0.03	Ag			Fresno R riparian SR13 Ag
				0.9	**0.82**	**HSU13D624_C46**
60	13	0.03	Ag			San Joaquin R riparian (Friant to Gravelly Ford) SR13 Ag
115	13	0.03	Ag			San Joaquin R riparian (Fremont Ford to Vernalis) SR13 Ag
				0.9	**0.82**	**HSU13D694_C46**
Import	13	0.02	Ag			Delta-Mendota Canal to SR13 Ag
Import	13	0.02	Ag			Mendota Pool to SR13 Ag
		0.04		**0.9**	**0.75(0.88)**	**HSU13D731_C46**
Subregion 14						
Import	14	0.02	Ag			Mendota Pool to SR14 Ag
				0.9	**0.82**	**HSU14D608_C91**
Import	14	0.02	Ag			San Luis Canal to SR14 Ag
Import	14	0.02	Refuge			San Luis Canal to SR14 Refuges (Ag)
				0.9	**0.93**	**HSU14C92_C91**
Import	14	0.01	M&I			San Luis Canal to SR14 M&I
				1	**0.94**	**D750_Ext:CVPM14**
Import	14	0	Seepag e			San Luis Canal Seepage Losses SR14
Subregion 15						
28	15	0.04	Ag			Kings R Main Stem to SR15 Ag
43	15	0.04	Ag			Kings R North Fork to SR15 Ag
37	15	0.04	Ag			Kings R South Fork to SR15 Ag
52	15	0.04	Ag			Kings R Fresno Slough to SR15 Ag
				0.84	**0.8**	**HSU15C52_C90**
Import	15	0.02	Ag			Mendota Pool to SR15 Ag
Import	15	0.02	Refuge			Mendota Pool to SR15 Refuges (Ag)
				0.84	**0.82**	**HSU15D608_C90**
Import	15	0.02	Ag			San Luis Canal to SR15 Ag
Import	15	0.02	Refuge			San Luis Canal to SR15 Refuges (Ag)
Import	15	0.02	Ag			Friant-Kern Canal to SR15 Ag
				0.84	**0.93**	**HSU15C49_C90**
Subregion 16						
60	16	0.03	Ag			San Joaquin R riparian (Friant to Gravelly Ford) SR16 Ag
				0.8	**0.82**	**HSU16D606_C50**
24	16	0.03	Ag			Kings R to Fresno ID SR16 Ag

				0.8	**0.85**	**HSU16C53_C50**
Import	16	0.02	Ag			Friant-Kern Canal to SR16 Ag
				0.8	**0.93**	**HSU16C49_C50**
60	16	0.01	M&I			San Joaquin R riparian (Friant to Gravelly Ford) SR16 M&I
Import	16	0.01	M&I			Friant-Kern Canal to SR16 M&I
		0.02		**1**	**0.88 (1)**	**T24_Ext: City of Fresno and T24_Int: City of Fresno**
Subregion 17						
25	17	0.04	Ag			Kings R to Consolidated ID SR17 Ag
25	17	0.04	Ag			Kings R to Alta ID SR17 Ag
				0.9	**0.8 (0.88)**	**HSU17C53_C55**
Import	17	0.02	Ag			Friant-Kern Canal to SR17 Ag
				0.9	**0.93**	**HSU17C76_C55**
Import	17	0	Seepag e			Friant-Kern Canal to SR17 Seepage Loss
Subregion 18						
420	18	0.03	Ag			Kaweah R Partition A to SR18 Ag
422	18	0.03	Ag			Kaweah R Partition B to SR18 Ag
422	18	0.03	Ag			Kaweah R Partition C to SR18 Ag
420	18	0.03	Ag			Kaweah R Partition D to SR18 Ag
426	18	0.03	Ag			Kaweah R to Corcoran ID SR18 Ag
				0.9	**0.83**	**HSU18C56_C60**
18	18	0.03	Ag			Tule R riparian to SR18 Ag
				0.9	**0.83**	**HSU18C58_C60**
Import	18	0.02	Ag			Friant-Kern Canal to SR18 Ag
				0.9	**0.93**	**HSU18C688_C60**
Import	18	0.01	M&I			Friant-Kern Canal to SR18 M&I
				1	**0.94 (1)**	**C688_T51 (New supply for 2100 from FKC to CVPM18)**
Subregion 19						
7	19	0.01	Ag			Kern R to SR19 Ag
				0.9	**0.92**	**HSU19C73_C100**
Import	19	0.02	Ag			California Aqueduct to SR19 Ag
Import	19	0.02	Refuge			California Aqueduct to SR19 Refuges (Ag)
				0.9	**0.93**	**HSU19D847_C100 and HSU19D850_C100**
Import	19	0.02	Ag			Friant-Kern Canal to SR19 Ag
Import	19	0.02	Refuge			Friant-Kern Canal to SR19 Refuges (Ag)
				0.9	**0.93**	**HSU19C62_C100**

Import	19	0.02	Refuge			Cross-Valley Canal to SR19 Refuges (Ag)
				0.9	**0.93**	**HSU19C74_C100**
Subregion 20						
2	20	0.03	Ag			Kern R to SR20 Ag
				0.9	**0.84**	**HSU20C65_C63**
Import	20	0.02	Ag			Friant-Kern Canal to SR20 Ag
				0.9	**0.93**	**HSU20C64_C63**
Import	20	0.02	Ag			Cross-Valley Canal to SR20 Ag
				0.9	**0.93**	**HSU20C74_C63**
2	20	0.01	M&I			Kern R to SR20 M&I
Import	20	0.01	M&I			Friant-Kern Canal to SR20 M&I
		0.02		**1**	**0.88 (1)**	**T53_Int:CVPM20 and T53_Ext:CVPM20**
Subregion 21						
2	21	0.02	Ag			Kern R to SR21A Ag
3	21	0.02	Ag			Kern River to Subregion 21B Ag
4	21	0.02	Ag			Kern River to Subregion 21C Ag
				0.8	**0.9**	**HSU21C65_C66**
Import	21	0.02	Ag			California Aqueduct to SR21 Ag
Import	21	0.02	Ag			Friant-Kern Canal to SR21 Ag
				0.8	**0.93**	**HSU21C689_C66**
Import	21	0.02	Ag			Cross-Valley Canal to SR21 Ag
				0.8	**0.93**	**HSU21C74_C66**
Import	21	0.01	M&I			California Aqueduct to SR21 M&I
				1	**0.94 (1)**	**T28_Int:Bakersfield and T28_Ext:Bakersfield**

DEPARTMENT OF WATER RESOURCES
NORTHERN REGION OFFICE
2440 MAIN STREET
RED BLUFF, CA 96080-2356

February 3, 2015

Glenn County Board of Supervisors
525 West Sycamore Street, Suite B1
Willows, California 95988

Glenn County Water Advisory Committee
Post Office Box 351
Willows, California 95988

Dear Supervisors and Committee members:

The purpose of this letter is to provide land subsidence results from the Global Positioning System (GPS) surveys performed in Glenn County. GPS surveys were performed to monitor changes in ground surface elevation to detect subsidence throughout the county and ultimately the entire Sacramento River Valley. The enclosed comparison showed two areas of the county exhibiting land subsidence.

The Glenn County subsidence network was installed and initially monitored in 2004. It consisted of 58 stations; about half were existing survey monuments, and the other half were installed as part of this project. Initial GPS surveying took place during March and April 2004. The network was resurveyed in spring 2008 as part of a larger Sacramento Valley GPS subsidence project.

The two surveys did not follow the same observation schedule and monitoring plan, and therefore, direct comparison was not possible at some locations within the county. By performing data analysis and review, the Northern Region Office of the Department of Water Resources (DWR) was able to develop the enclosed map showing the land surface change along the defined paths, or vectors, between the years of 2004 and 2008. The data analysis and review performed to complete the map included identifying and using similar vectors, where available, from both years. It also included using auto leveled monuments, where necessary, to be able to include the monuments that were relocated between the survey years. This was performed only when there was a direct relationship between the points in order to preserve the accuracy of the survey data.

Using the best methodologies available at the time, the GPS vertical accuracy, or threshold, for this monitoring effort was estimated to be 0.164 feet or approximately 2 inches. Any changes that show greater than the defined threshold are considered statistically significant and indicate possible ground movement.

In general, the analysis did not show that the county experienced widespread ground movement during this four-year time frame. However, two areas determined from the analysis indicate ground movement. The first area, to the south and east of Hamilton City, did exhibit a change in ground surface elevation that is statistically significant. The monument designated “WILD” on the enclosed figure showed an average change of 0.38 feet or about 4.5 inches when compared to the nearest monuments to the west. This monument is on the eastern edge of the Glenn County network and additional surveying would need to be performed comparing 2008 to current levels in a larger area of Glenn and Butte counties to determine if this is an ongoing concern or just an anomaly.

The second area is near Sunset Avenue and County Road E to the southwest of Orland. This area showed a change just below the level of being statistically significant at 0.125 feet or about 1.5 inches. This may have indicated an area of concern and warrant additional surveying to determine whether this is an onset of land subsidence or not.

Ideally, the entire Sacramento Valley GPS Subsidence Monitoring Network should be resurveyed and compared to the valley wide 2008 survey to determine changes caused by the increased groundwater pumping and the persistent drought impacts. It is possible to check small areas without resurveying the entire network as mentioned above. DWR will further investigate the opportunities to work with the Sacramento Valley counties to resurvey the Sacramento Valley GPS Subsidence Monitoring Network. As an intermediate step, DWR may resurvey the two local areas that showed subsidence in 2008 to investigate any additional land elevation changes.

A formal presentation of the results will be provided by DWR to the Glenn County Water Advisory Committee at a future date.

If you have any questions or need additional information, please contact me at (530) 528-7403, or Roy Hull, Engineering Geologist, at (530) 529-7337.

Sincerely,

Bill Ehorn, Chief
Groundwater and Geologic Investigations

Enclosure

ec: (See attached list.)

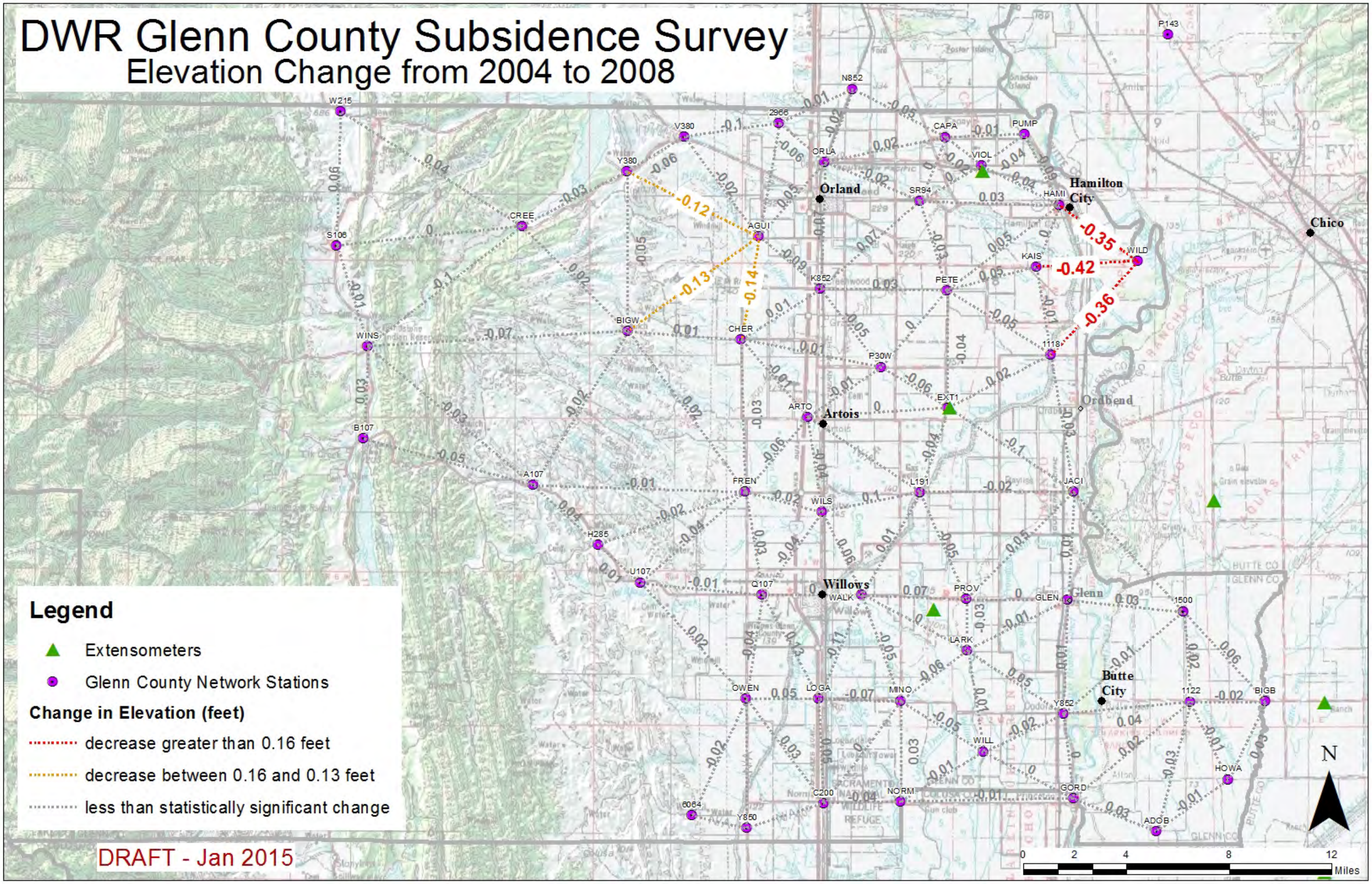
Ms. Lisa Hunter, Glenn County
Water Resources Coordinator
LHunter@countyofglenn.net

Mr. Paul Gosselin, Butte County
Director, Water and Resource Conservation
PGosselin@buttecounty.net

Ms. Mary Fahey, Colusa County
Water Resources Coordinator
mfahey@countyofcolusa.com

Mr. Gary Antone, Tehama County
Tehama County Public Works Director
gantone@tcpw.ca.gov

Mr. Ryan Teubert, Tehama County
Tehama County Flood Control & Water Resource Manager
rteubert@tcpw.ca.gov


DWR Glenn County Subsidence Survey
Elevation Change from 2004 to 2008
Legend
Extensometers
Glenn County Network Stations
Change in Elevation (feet)
decrease greater than 0.16 feet
decrease between 0.16 and 0.13 feet
less than statistically significant change
DRAFT - Jan 2015
Orland
Hamilton City
Chico
Artois
Ordbend
Willows
Glenn
Butte City
-0.35
-0.42
-0.36
-0.12
-0.13
-0.14
N
0 2 4 8 12
Miles

california water impact network

CALIFORNIA SPORTFISHING PROTECTION ALLIANCE CSPA * Since 1983 *

AQUALLIANCE
DEFENDING NORTHERN CALIFORNIA WATERS

Testimony on Water Availability Analysis for Trinity, Sacramento, and San Joaquin River Basins Tributary to the Bay-Delta Estuary

Submitted by
Tim Stroshane
Senior Research Associate
California Water Impact Network (C-WIN)

and on behalf of
California Sportfishing Protection Alliance
and AquAlliance

October 26, 2012

for

Workshop #3
Analytical Tools for Evaluating the Water Supply,
Hydrodynamic, and Hydropower Effects of the Bay-Delta Plan
November 13 and 14, 2012

Th State Water Resources Control Board called for workshops to receive information from and discuss with participating parties the scientific and technical bases for considerin potential changes to th 200 Water Qualit Control Pla for th Sa Francisco/Sacramento-San Joaqui Delt Estuar for Phas II o th Board's comprehensive review o thi plan.

According to th State Board's public notic for thes workshops, th prompts for Workshop 3 testimony are:

1. Wha type o analyses shoul b completed to estimate th water supply, hydrodynamic, an hydropower effects o potential change to th Bay-Delta Plan?

2. What analytical tools should be used to evaluate these effects? What are the advantages, disadvantages an limitation o thes tools?

Water Availability Analysis

Workshop 3 Testimony, Bay Delta Plan
Submitted by California Water Impact Network,
California Sportfishing Protection Alliance, and AquAlliance

Th California Water Impac Network, th California Sportfishin Protection Alliance, and AquAlliance (hereinafter, C-WIN) are please to submi thi testimony to th State Water Resources Control Board. Thi testimony addresses th close linkage between th Board's publi trust responsibilities on behalf of the State of California, its water quality control planning function, and its duty to regulate water rights i California. Water quality control planning efforts to date have led th Board to conside proportional tributar contribution neede to mee Delt inflow objectives from th Sacramento an Sa Joaqui River Basins to improve water qualit an protect all beneficial uses, including fish and wildlife, in the Delta. The State Water Resources Control Board has authority over water rights i the Basins that would enable it to reallocate water usage and ensure complianc wit th Board's new instream flow objectives.

Water availability analysis i a importan method for modeling how th Board would implemen ne flow objectives. Ou testimony illustrates th us o planning-level water availability analysis for th Trinity River (muc o whose flows are diverted to the Central Valley watershed o the Bay-Delt Estuary) and th majo tributarie of th Sacramento an Sa Joaqui River Basins We incorporate into th analysis the Basins hydrologic variability, instream flow requirements based o th Board's 201 publi trus Delt flow determinations, an then operate publicly available water rights dat an prioritie o the divertable flows tha remain i th system. We fin that unde publi trus protective flow determinations, th promised water represented i water rights claim far exceed flow condition available to thes claim i mos years.

We recommend for th Bay-Delta Plan's implementatio program tha th State Water Resources Control Board draw on its new flow determinations to increase th season durin which rivers in th Bay-Delta Estuary's Central Valley watershed are fully appropriated, an pus bac th water rights priorit date o which Term 9 curtailment are now based Ou water availability analysis suggest distinc parameters for both actions.

Finally, we conclude tha the Board shoul us th Bay-Delta Plan process to tighten u its regulation of surplus water usage and export by the State Water Project and Central Valley Project to avoid permanently damagin Sacramento Valley groundwater resources. Th Board's Delta flow determinations, couple wit comprehensive enforcement of water rights priorities ca hel to protect bot groundwater an surface water resources i th Sacramento Valley over th lon term.

Government's Public Trust Responsibility

Governments have permanen fiduciary responsibility an obligation to protect th publi trust. In *National Audubo Societ v. Superio Court* (1983) 33 Cal 3d 419, 441, the court held tha "the public trus i more tha a affirmatio o state power to us publi property for public purposes It i a affirmatio o th dut o th state to protect th people's commo heritag o streams, lakes, marshland an tidelands surrendering that right o protection only i rare cases when abandonmen o tha right i consistent wit th purpose o th trust." The ac of appropriating water i a acquisitio of property right from th waters of th state, a ac tha i therefore subject to regulation under the state's public trust responsibilities.

Th State Water Resources Control Board has invoked its public trust responsibilities i regulating the waters of California and now acknowledges that the public trust is one of its ongoing regulatory responsibilities. It mos publicly prominent instanc cam i Water Rights Decisio 163 (D-1631) i 1994 I D-1631 the Board balance th need of th City o Los Angele for water supply from th tributarie o Mon Lake with th lake's own need for water to sustai it ecosystem. It required Lo Angele to make releases from eac o it tributarie tha would sustai riparia ecosystems an hel restore fis population to th tributaries by prescribing lake level targets in a specifie tim period (State Water Resources Control Board 1994 Th Board has als adopted regulations governing how i treats th publi trus i matters o th appropriation o water in California. (State Water Resources Control Board 2011b Articl 14 Standard Permit Terms and Conditions)

Th trial court in *Unite State v Stat Wate Resource Contro Board* (1986 18 Cal.App.3d 82 determined that th State Water Resources Control Board ha th authority to modif an appropriative water right permi once i had been issued an tha i could reduce th U Bureau of Reclamation's Central Valley Project permit to gain complianc from th Bureau. Bu th tria court held new fish and wildlife objectives the Board had approved i Water Rights Decisio 1485 (D-1485 i 1978 to be invalid becaus th Board failed to identif th *source* of its authority. Justice John Racanelli, the author o the subsequent appellate court decision cited above, stated that the source o the Board's authority to issue and enforce new fish and wildlife objectives such as those containe i Water Rights Decisio 148 (D-1485) was th Publi Trust Doctrine:

> ...th state as trustee o th publi trust retains supervisory control o th state's waters such tha n part ha vested right to appropriate water i manne harmfu to th interests protected by th publi trust. (18 Cal.App.3d 82 149)

Stevens (2005 summarize th present range o coverage tha America an California law gives the public trust doctrine:

1. I applie to al navigable streams.
2. I applies to ecologica preservation.
3. I applies to wetland areas.
4. I applie underground (citin the Waiahole decisio from Hawai'i).
5. I applies to artificially enlarged waters.
6. I applie to wil animals including fish.[1]

The Public Trust and Paper Water

I th next few years, th State Water Resources Control Board i expected to make several crucial decisions on California' water future. These decision include:

---

[1] The California Constitution also provides an absolute right to fish among the fundamental declared rights it accords all California citizens. Article I, Section 25 states:

> ARTICLE 1 DECLARATION OF RIGHTS
>
> Section 25. The people shall have the right to fish upon and from the public lands of the State and in the waters thereof, excepting upon lands set aside for fish hatcheries, and no land owned by the State shall ever be sold or transferred without reserving in the people the absolute right to fish thereupon; and no law shall ever be passed making it a crime for the people to enter upon the public lands within this State for the purpose of fishing in any water containing fish that have been planted therein by the State; provided, that the legislature may by statute, provide for the season when and the conditions under which the different species of fish may be taken.

In combination with California Fish and Game Code Section 5937, which provides that owners of dams must preserve fish populations downstream in "good condition", preservation of this right logically should be construed as an important aspect of the public trust responsibilities of government. It retains meaning as a right only when there exist sufficient fish to catch sustainably.

- Determining how to provide sufficient flows from th Sacramento an San Joaqui River's majo tributarie to th Bay-Delta Estuary.
- Updatin it 200 Bay-Delta Water Qualit Control Pla to includ thos ne Sacramento and Sa Joaquin River flow and South Delta salinity objectives.
- Deciding whether to extend the water rights *permits* of th California State Water Project and the federal Central Valley Project, or instead *license* the a levels tha represent reasonable and public trust protective water usage.
- Decidin whether and/or how to permi "nort Delt diversion"—a diversion that is now more familiarly known a th Peripheral Tunnels Project.
- Decidin whether and/or how to permi ne reservoirs on th San Joaqui River an i the southwestern Sacramento Valley (and/o to raise existing dam to increase storage elsewhere) that would be added to the storage capacities o the Central Valley Project and the State Water Project.

As a regulatory agency, th State Water Resources Control Board i no known for makin and holding to courageous o visionary decision that protect beneficial use o water throughout California. Thei record o delay an incrementalism ha contributed to th poo condition o the Bay Delt Estuar an the great rivers o it watershed, th great Sacramento an Sa Joaqui Rivers.

Th State Water Resources Control Board ha authorit to make bol decision an hol to them. (Cahill 2008)

Th State Water Resources Control Board will nee to balance protection o the public trust with othe competin beneficia use o water reliant on th Delta Th Board ha already determined the flows that fish and other aquatic species need (State Water Resources Control Board 2010: 114-123 I completin an implementin th Bay-Delta Plan th Board's next step i to evaluate th feasibility o measures neede to protect public trus resources fully. (California Supreme Court 1983 Kibe 2011 6 Thes steps wil nee to include determination of flow needs o publi trust resources, water rights reallocation, flow modification benefit-cos analysis, an habitat restoration. I th process. key question mus b answered:

1. How doe th State Water Resources Control Board intend to prioritiz water us i terms o coequa goals o publi trus balancing How doe it long-established water rights priorit system fi into thi polic framework?

2. Wha does water supply reliability mea in an ari state where we have granted rights to far more water tha actually exists? Shoul water supply reliability b conditione upo specifi requirements to maximiz reclamation, reuse, conservation an development of alternative local sources of water?

3. I the standard by which we measure water supply reliability th same for junio an senior appropriators? Do use o water tha require vast publi subsidie have th same priorit as use tha don't require subsidy o publi funds Are use tha internalize adverse impact equa i priorit to use that externalize them?

4. Shoul the worth o water be confine only to it economi value i use O doe water supply reliability apply to both publi trus resource need as well a consumptive use (i.e. i legislation neede for better protection o public resources through water rights)?

5. Are statutory requirements to protect water qualit an listed specie equivalent to water supply reliability for lawns o surplus subsidized, and non-food crops? Are food crops more

importan tha non-food commoditie when i come to allocatin water? Doe healt and safety take precedence over certain agricultural uses o water?

6. Does efficient use o water have higher priority over wasteful and inefficient use? Is protection of th Bay-Delta Estuar as a “nationa treasure” and on o th world’s great estuarie more valuable to societ tha irrigating impaired soils tha by thei nature when irrigated, discharge prodigious quantities o salt and toxic wastes back to ou waterways and aquifers?

Answers to thes question are central to resolving California’s water problems.

Th California Legislature consolidated the State o California’s water rights and water quality control responsibilities i th State Water Resources Control Board i 1967 Sinc tha time the Board has considerable authority to grapple with these questions and arrive a answers and solution from them Th Board ha authority to:

- Plan for water quality control.
- Receive, condition, and approve ne water rights application a permits.
- Regulate an licens water rights permit specifyin th poin o diversion, diversion flows, plac of use, and purpose of use for water.
- Investigate pre-1914 an riparia water rights to determine whether suc claim to divert an us water are legal, includin follow-up enforcement against illegal use when determined (discussed below).
- Investigate and enforce th state’s prohibition of waste and unreasonable use and wasteful an unreasonable metho o diversion o water unde the California Constitution, Articl X Sectio 2.
- Protect th publi trust. A a agency o the state, th Board i charged with ensurin the state o California carries out its fiduciary responsibility to protect air, running water, the sea an th seashore, “thes thing that are commo to all,” a stated originally i Roman law (the Institutes of Justinian).

California’s constitutio promises water rights only up to what i reasonable use N on has a right in California to us water unreasonably, no even th federal government. (California Constitution, Articl X Sectio 2 Th Public Trust Doctrin provides tha n on ha vested right to appropriate water i manne harmfu to the interests protected by the publi trust. (*National Audubo Societ v Superio Court* 3 Cal.3d 419 189 Cal.Rptr 346 65 P.2d 709 An the dictionary definition o usufructuary rights, o which both riparian and appropriative water rights are examples, indicates tha fundamenta principl of usufruc i that i connotes only right to *use* resource like water, no to waste or use it unreasonably. Th State Water Resources Control Board, in taking u al of the key questions we outline above, will be deciding whether and how California’s abundan legal authoritie apply to th Bay-Delta Estuary’s Central Valley watershed.

The Public Trust and Proportional Delta Inflows

I mid-2009 the State Water Resources Control Board updated it review of th Water Qualit Control Plan which it Water Right Decisio 1641 (D-1641 implements Th Board took the positio tha to change its water qualit an flow criteria it neede more scientifi information about flows reasonably needed to protect fish and wildlife beneficial uses (State Water Resources Control Board, 2009 17) It impetu to conside makin change a tha tim include pronounced fisherie declines amon bot ope water resident an migratory fish an th still-unfolding impact o climate chang an it impact o th Bay-Delta estuarin system (State Water

Resources Control Board, 2009 9) The California Departmen o Fis an Game sought to buil a salmo survival model to assis th Board's nee for additiona information. (California Departmen of Fish an Gam 2010)

Later in 2009, the California Legislature directed the State Water Resources Control Board to prepare a report on Delta flow criteria tha would "develop ne flow criteria for th Delta ecosystem necessar to protect publi trus resources" and i so doin "use th bes available scientific information." Th Legislature directed th Board to gather th information a par o an "informational proceeding" rather tha through a evidentiary hearing An th Legislature charged the Board wit includin volume, qualit an timing o water necessar for th Delta ecosystem unde different conditions (California Water Code: Section 85086(c)).

Th Board produced it Delt flow criteria report after takin detaile testimony o th best available scienc for key fis specie an ecosystems. Th report identified a set o broad flow regimes for upstream tributarie providing inflow to th Bay-Delta Estuar tha fis nee to survive and recover. They represent the Board's consideration of the best available fishery and hydrologic scienc it considered during 201 addressing the question: what flows do fis need? Th Board confirm thi when i stated i footnote, "...the flow criteria developed i thi proceeding are intended to halt population decline and increase populations o certain species," and acknowledged that, "Recent Delta flows are insufficien to suppor native Delt fishe for today's habitats….Flow an physical habita interact i many ways, bu they are no interchangeable." (State Water Resources Control Board 2010: 5, 120)

Th Board states tha th flow criteria "mus b considered" i context:

- Th flow criteria do not conside any balancing of public trust resource protection with publi interest needs for water.
- Th State Water Board doe no intend tha th criteria shoul supersed requirements for health and safety such a th nee to manag water for floo control.
- There i sufficien scientifi information to suppor increased flows to protect publi trust resources; ***while there i uncertainty regarding specific numeric criteria, scientific certainty is no the standar fo agency decision making.*** (State Water Resources Control Board 2010 4; emphasi added)

Th Board's flow determinations are:

- 75 percent o unimpaired Delt outflow from Januar through June.
- 75 percent o unimpaired Sacramento River inflow from November through June.
- 60 percent o unimpaired Sa Joaquin River inflow from February through June.
- Increased fall Delt outflow i wet an above normal years.
- Fall puls flows o th Sacramento an San Joaqui Rivers to stimulate migrating fish.
- Flow criteria i the Delt interior to hel protect fis from mortalit in th central and souther Delt cause by operations o th state an federal water export pumps.

I essence thes flow determinations represent th Board's answer to th question "what flows do fis nee i th Central Valley watershed an th Bay-Delta Estuary?" Th State Water Resources Control Board's 201 Delta flow criteria report acknowledged that protective Delta outflows start with protective tributary inflows to the Delta. The Board's Delta inflow criteria rely on a percentage o unimpaired flow measure, which enable th flow criteria o th Sacramento and Sa Joaqui rivers to more closely mimi thei natural hydrographs tha now occurs.

For th Sa Joaqui River, the State Water Resources Control Board approved its determination that 6 percent o unimpaired flow from February through Jun for th river basi would protect juvenile Chinook salmo durin thei pea emigration period For th Sacramento River, th Board adopted th criterion of 7 percent of unimpaired flow from November through June. (Thi is becaus numerous run o migratory salmon use th Sacramento River Basi for more o the year.) Thes constrained period would als benefi th rearing perio o juvenile salmo i the basin's majo tributarie upstream. Th Board als adopted i tha report (2010) a fall seaso Delt inflow criterion callin for an average flow of 3,600 cubi feet pe secon for 10 days sometim durin late October.

Nearly al scientist testifying to th Board i March 201 agreed tha mimickin th natural hydrograph (i shap i no i magnitud an volume of flow) is necessar to improve conditions for native fish species, and to counter invasive species in the Delta. Existing Board water quality and flow objectives intended to protect fis and wildlife beneficial uses i the south Delta are not working, as shown in abundant evidence presented to the Board at its hearings for the Delta Flow Criteria report. Th Board include muc o tha dat i its report. (State Water Resources Control Board 2010 C-WIN provide brie evaluation o th Vernalis Adaptive Managemen Pla to supplemen thi record o failure i Appendi to thi testimony.

I August 2010, the State Water Board approved these currently nonbinding Delta inflow determinations for th Sacramento an Sa Joaqui rivers. (State Water Resources Control Board 2010 114-123 Th State Water Resources Control Board observed tha using suc flow criteria would mea tha "to achieve th attributes o natural hydrograph, th criteria are advanced as a percentage o unimpaired flow o 14-day average, *to b achieve on proportiona basi fro the tributaries t th Sa Joaquin River.* (State Water Resources Control Board, 2010 120, emphasi added Th Board makes a importan poin tha mimickin natural hydrograph an improving prospects for specie recovery depend o achieving proportional flow allocation from al the majo tributaries. Proportional tributar contribution would b neede to implemen th Board's broader Delta inflow criteria. The Board will need to answer key questions including: what should those proportions be how shoul responsibility for the b assigned an who wil b responsible for providing them And when wil th uppe Sa Joaqui River b include by th Board i making these determinations? (Right now, th Board excludes th uppe San Joaqui River from it Bay-Delt Estuar plannin deliberations. C-WIN evaluates th Board's stanc i Appendix B.)

Th question for the Board i how to d proportional flows *legally* Proportional tributary contribution from Delt inflow are not new. I 1992 th California Departmen o Fish and Game proposed metho to identif tributar contributions to Delt inflows base o the pro rata share of unimpaired runof eac tributary generates to the Delta, a identified i th California Departmen o Water Resource's Bulleti 12 eac year (California Departmen o Fis and Game 1992) Othe allocatio method coul b devised a well, suc a on base o reservoir storage on these sam tributaries Th State Water Board in its Draft Water Right Decision 163 presented suc method bu which excluded contribution from th San Joaqui River above Mendot Pool (State Water Resources Control Board, 1992: Tables I and V).

Proportional tributar contribution neede to fulfil Delt inflow determinations from th Trinity River, and th majo tributarie o th Sacramento an Sa Joaqui River Basins wil require changes to th water rights o majo water users i thes Basins Th State Water Resources Control Board ha authorit over water rights to reallocate water usag an ensure complianc wit the Board's Delta inflow objectives.

Paper Water Means Boundary Disputes and Clouded Titles

Property i often legally conceived a a bundl o rights representing “investment-backed expectations” of a future stream o benefit accruin to it owner, usually i th form o money. Water rights are a form o property, conveying to thei owners rights to us water from stream. Unlike real property i land however, we have situation i which far more i rights to us water have bee granted by th state o claimed by right holder tha Nature and reality actually provide.

California’s moder water cod an it body o water rights cas law i th result o more tha a hundred an sixt years o legislatio an legal precedent. Riparia water rights are th most paramount rights, followed by pre-1914 appropriative rights and, lastly, post-191 appropriative rights, a determined by th seniorit requirements of first-in-time-and-use.

Bu despite thi accumulated legal tradition, human promises o water exceed Nature’s provisions. A shorthan descriptio o thi conditio i “pape water.” Th pape water problem i th area of water and rivers in California has close analogies in concepts like “clouded title,” and “boundary dispute” for piece o real property (say, house o plo o land that ha more tha on owner claimin th same piec o portio of ground. Typically, boundary disputes are resolved by on or more disputant engaging th service o surveyor to establis where the boundar i actually located. From there, the owners have common se o facts o which they may agree to resolve their boundary dispute.

“Clouded title ha relevance here a well. cloude title mean th ownership o a titl in water ha som defect or potential defect arisin from competin clai for th sam source o water.

On of th earliest recognitions o th problem o pape water i California occurred over a century ago and helps illustrate the clouded condition of paper water. I 1900, Frank Soulé, professor of civil engineerin a th University of California, was retained by th U Departmen o Agriculture’s Offic o Irrigation Investigations to study water rights claim i th Sa Joaqui River basin. Soulé found that th San Joaquin River’s average winter an sprin months flows were approximately 5,00 to 6,00 cubi feet per second I drie late summe an fall months flows coul get a low as 150 cubi feet pe second Soulé researched water rights claim to al tributarie of th San Joaqui River watershed to see how they matched u wit flows i th river. Actual flows from the 1895-190 perio averaged abou 2.02 millio acre-feet, according to state records. (State Water Resources Board 1951: Table 62) He visited the recorders’ offices for Stanislaus, Merced, and Fresno counties and itemized 31 claim to San Joaqui River waters totaling 36,571,471 miner inche of flow (there are 5 miner inche to cubi foot pe second) Thi converts to 731,42 cubi feet pe second Stretched ou over year (Soul di no specif th season for which th claim were made), thi translated into a annual clai o water rights o 529. millio acre-feet o water, over 260 times greater than average flow o th Sa Joaquin River i that period For a eight-month irrigation seaso o abou 24 days, suc flows would amoun to 356. millio acre-feet, nearly 180 time greater tha San Joaqui River flows. These Soul contended, were th “definite claims,” ones tha ha well-defined diversion points and amounts claimed Si separate individuals claime “all th water flowing i th Sa Joaqui River,” definite claim i exaggerated. His summar for th San Joaqui di no includ claim to the Fresno and Chowchilla rivers, which are much smaller watersheds, bu th grandiosity continue there. O the Fresno River, some 670,79 miner’s inches were the subjec o 5 claim (abou 13,41 cubi feet per secon o 9. millio acre-feet year), an o th Chowchilla jus 1 claim aggregated to 31,00 cubi feet pe secon (or abou 22.5 millio acre-feet annually). (Soul 1901 222 232)

Clouded titles in water have been allowed to fester since before Professor Soulé began studying the problem i 1900 Failure by th State o California to quiet title to water sinc assumin authority for appropriative water rights in 191 contributes untold expectations for benefit streams tha fuel controversy i California water resources plannin an development ever since.

C-WIN i no lon contemporary voice o th problem o pape water. I September 2008, State Water Resources Control Board staf informed th Delt Vision Blu Ribbo Task Force abou water rights, use, and flows in the Delta watershed. It stated in part:

- Th "total face value o th approximately 6,300 active water right permits and licenses withi th Delt manage by th State Water Board, includin th already assigned portio of state filings i approximately 24 millio AFA [acre-feet annually]." Ou organizations note tha thi 245 millio acre-feet o face value i water rights was permitted by th Board an it predecessors i th Central Valley watershed (including import from watersheds like that of the Trinity River). (State Water Resources Control Board 2008)

- Face value "does not includ pre-1914 an riparia water rights." Riparia water rights, in th absenc of som form o watershed adjudication are usually unquantifie but nonetheless require real, wet water. (State Water Resources Control Board 2008 And,

- Tha "the total face value o th unassigne portio o state filing for consumptive use (excluding state filings for the beneficial us of power) within the Delta watershed is approximately 6 millio [acre-feet annually]." Thes are claim th State ha file to reserve water for further expansion of the State Water Project. (State Water Resources Control Board 2008 se als Appendi C.)

Othe matters exacerbate th pape water problem:

- Th SWRCB doe no know how muc water i actually use (an by whom) sinc state law has yet to require full accounting o either surface o ground water use.

- Th SWRCB doe no know th extent o paramount riparia o senior pre-1914 water rights either.

- Climate chang i likely to alter th timin an reduce th volume o runof into California's ri dam an overall state and federal water systems. (Knowles an Cayan 2002 I i also likely to decrease natural groundwater recharge as well, which would further reduce runoff volumes where river reaches benefi from groundwater inflows.

- Increased col water pool an groundwater suppor from gaining streams wil b needed to maintai water temperatures below ri dam according to estimates by the SWRCB and Departmen o Fis and Game o the increased inflow an outflow necessary to protect rivers an the Delta publi trus resources. (California Departmen o Fis and Game 2010: 51 Table 5)

Given these constraints, the obligation to achieve a public trust balancing o water supply reliability wit fis an ecosystem survival canno rest o maintenance o existing levels o supply from either Delt exports o th ri dams on al majo Central Valley tributarie i th Delt watershed. The State Water Resources Control Board mus us it water rights authorit i th service o meetin these water quality challenges on behalf of public trust resources.

Th Delt Watermaster acknowledges the problem o pape water i recent report on th State Water Resources Control Board's role in the Delta Stewardship Council's Delta Plan process (Wilson 2011) He expresses concern however, that "the face value o water rights i not a sufficient measure o water tha ca b use to determine the over-allocation o water in th [Delta watershed.” He cites four mai reasons for hi concern:

- Th face value o many water rights are for nonconsumptive uses suc a hydropower.
  - **C-WI Response:** A muc a possible water availability analysis should factor out water rights claims tha are primarily devoted to nonconsumptive use and hydropower generation i particular. C-WIN’s analysis factors ou all single-purpose hydropower generation water rights claims whether pre- o post-1914 Where multipl purpos o us claim includ hydropower generation, we assum these rights are stil primarily consumptive use claims especially when irrigation i one of th othe purpose o us for which claim are made Hydropower generation is considered incidenta to the other consumptive uses.

- Th face value represents maximu possibl water diversion, which i far greater than what is actually used;
  - **C-WI Response:** We agree that face value often represents maximu possibl diversion (and/o storage amount) We also agree tha i may b far greater than what i actually use i many cases Bu C-WIN’s review of water right claim shows tha som rivers’ claim far exceed maximu unimpaired flows an even reservoir capacit o tha river. (Th Trinity River i goo example o this. Thi is les a criticis o face value tha a acknowledgement o pape water by th Delta Watermaster. No doe i justif continuatio o the practice by the State Water Resources Control Board. Since th maximu possibl flow (an use ca occur only relatively rarely i California’s hydrology, C-WIN suggest that thi extra increment o claim b eliminated becaus i wil occur i th future wit even les frequency tha now occurs Reliable rights are only meaningfu when they ca b exercised with relative frequency.

- Permit/license terms, suc a thos for protection o instream uses furthe reduce below th face value th amoun o water tha ca b diverted;
  - **C-WI Response:** Th State Water Resources Control Board needs to continue having som standard method for quantifyin the value of water rights a property. Thi i th only way that increments o titl to water a property can be described and titles cleared or quieted in the event of dispute. Moreover, quantified water rights are the only way to conduc reality-based water resources plannin and development. Thi extends to employing standard metho for quantifyin and measurin instream flows tha benefi publi trus resources. I th Board an Delta Watermaster are to enforce instream flows, they mus quantif instream flow commitment an ensure tha they are fulfilled *prior* to th exercise o permitted or licensed water rights claims.

- Water, when applied i typically no consume u to the ful face value an th same water (return flow) i often use multipl time as i runs downstream.
  - **C-WIN Response:** Whil C-WIN acknowledges th reality of return flow i diversion o water for consumptive irrigation uses there i n consistently available dat that measures th volume an occurrence o return flow to rivers. Som estimates, both recent (California Departmen o Water Resources 2005 water balance for Sacramento an Sa Joaqui River Basins an historical (Wiel 1928 259) pu return flow at between 6 an 6 percent o originally diverted volumes. O course th reality o return flow, however, means tha river flow ca decrease by a muc as third o diversion quantitie eac tim i i applied the more frequently water is diverted to consumptive use th sooner surface flows are depleted i the immediate

> river reach downstream. Return flows d no reach th river from which they were diverted instantaneously. Onc diverted there occur a tim la between the diversion and its application, and when water actually returns to the river, and even then i may only reach the river i small increments, dependin o th surface return flow and/or subsurface transmissivity gettin bac to th river. Meanwhile, th diverted water i gon from th river, thereby depletin it flow unti som later time and lower location I return flow i truly importan to determining water availability and avoiding boundary disputes and clouded water titles, then California need to invest i getting dat from eac watershed tha quantifie th volume, timing, and duration o return flow, instead o ignorin it. (State Water Resources Control Board 1983 9-10)

C-WIN's methodolog recognizes eac o thes facets o "face value" or face amoun of water rights. Unfortunately, th Delt Watermaster's remarks d no clarif whatever els i i tha face value quantities i water rights are suppose to positively describe. I the quantities i water rights are no relevant to face value, the o what basi ca separable, stable an reliable rights to water use b analyzed an judged Th Watermaster acknowledges that "while actua water us may b only a fraction o th face value of water rights, th state's water supplie have been over-allocated in many areas."[2] (Delt Watermaster 2011b 5 C-WIN shows in thi testimony tha i i possibl to use th "data" of water rights i combinatio wit dat o flows an diversions to generate consistent an meaningfu picture of th problem o overallocation o water supplie an rights i th San Joaquin River Basin. Our water availability analysis illustrates the usefulness o having *some idea* of th magnitud o th pape water problem a compared wit having *n idea* Al o California needs better dat o al facets o th problem o pape water.

Tables 1 and 2 provide static (snapshot) views of total water rights in the Trinity, San Joaquin River an Sacramento River Basins Total water rights reported i thes two table are for consumptive uses Hydropower generation water rights have bee excluded from this analysis.

I Table 1, average annua unimpaired flow for th San Joaqui River Basi is abou 6. millio acre-feet compared wit 32. millio acre-feet o consumptive water rights claims. The ratio of total claim to average unimpaired flow for the Sa Joaqui Basi i 5. acre-feet o consumptive use claim to every acre-foot o unimpaired flow i the Basin About 4 percent o total consumptive water claim are by riparia an pre-1914 claimants while 5 percent i by post-191 claimants (tha is permit an licenses) regulated by th State Water Resources Control Board.

Specifically o th majo tributarie of th San Joaqui River Basin th ratio o total consumptive us claim to unimpaired flow ranges from abou 5. o th Stanislau to 6. acre-feet o claim to every unimpaired acre-foot o flow o th Sa Joaqui River (includin valley floo an uppe watershed claims).

I Table 2, average annua unimpaired flow i th Sacramento Valley (essentially, average Sacramento River inflow to th Delta i abou 21.6 million acre-feet. Consumptive water rights claim are estimated a abou 120. millio acre-feet. Th ratio o total consumptive us claim to averge unimpaired flow i th Sacramento River Basi is abou 5. acre-feet o claim pe acre-foot of unimpaired flow. Ratios o claim to unimpaired flow to range from 2. o th Yuba River to 6.8 o the Trinity River.

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[2] The Delta Watermaster suggests that for the Delta the process for determination of fully appropriated streams from the Water Code Sections 1205 through 1207 be used (p. 5).

Water Availability Analysis

Workshop 3 Testimony, Bay Delta Plan
Submitted by California Water Impact Network,
California Sportfishing Protection Alliance, and AquAlliance

Table 1
Consumptive (Irrigation) Water Right Summar fo San Joaquin River Basin

Flow and Consumptive Wate Rights	Thousand of Acre-Feet				
	Stanislaus River	Tuolumne River	Merced River	San Joaquin	Basin Total
Average Annual Unimpaired Flow	957	1,851	956	1,728	6,181
Total Consumptive Water Right Claims	5,318	11,015	5,495	10,828	32,656
Ratio of Total Claims to Unimpaired Flow	5.56	5.95	5.75	6.27	5.28
Total Riparia & Pre-1914 Claims	1,401	8,185	4,525	2,014	16,125
Ratio of Riparian & Pre-1914 Claims to Unimpaired Flow	1.46	4.42	4.73	1.17	2.61
Total Post-1914 Claims	3,917	2,831	970	8,814	16,532
Ratio of Post-1914 Claims to Unimpaired Flow	4.09	1.53	1.01	5.10	2.67

Sources: State Water Resources Control Board (e-WRIMS); Publi Record Act responses from various public water and irrigation districts; California Water Impac Network Sum of major tributaries unimpaired flow does no equal Valley total due to omission of othe watersheds from the table.

Table 2
Consumptive (Irrigation) Wate Right Summar for Trinity and Sacramento River Basins

Flow and Consumptive Wate Rights	Thousands of Acre-Feet				
	Trinity River	Feather River	Yuba River	American River	Sacramento Valley Total
Average Annual Unimpaired Flow	1,283	4,370	2,287	2,621	21,619
Total Consumptive Water Right Claims	8,725	15,717	5,093	9,847	120,571
Ratio of Total Claims to Unimpaired Flow	6.80	3.60	2.23	3.76	5.58
Total Riparian & Pre-1914 Claims	134	3,855	92	286	47,883
Ratio of Riparia & Pre-1914 Claims to Unimpaired Flow	0.10	0.88	0.04	0.11	2.21
Total Post-1914 Claims	8,591	11,863	3,596	9,561	72,688
Ratio of Post-1914 Claims to Unimpaired Flow	6.70	2.71	1.57	3.65	3.36

Sources: California Departmen o Water Resources, 2007; State Water Resource Control Board (e-WRIMS); Public Record Act responses from various public water and irrigation districts; California Water Impac Network. Sum of major tributaries' unimpaired flow does no equal Valley total due to omissio o othe watersheds from the table Trinity River i include becaus large portion of its runoff is exported to th Sacramento River via federal Central Valley Project facilities.

O basin-wide basis riparia an pre-1914 water claim accoun for about 4 percent o total consumptive us claim o 120. millio acre-feet, and post-191 claims (permits and licenses in th Sacramento River Basi amoun to abou 6 percent o total consumptive us claims.

Th largest water claim o Sacramento River Basi tributarie belon to the Feather River an the America River. Th mainstem Sacramento (which i incorporated into th total for th Valley) include th Pi an McCloud rivers an numerous smal creeks tha enter i from th eas and west. C-WIN estimate that th largest componen o pre-1914 water rights claim i hel by th Glenn-Colusa Irrigation District. This Distric claim 2 millio acre-feet i rights to divert directly from th Sacramento, a well a anothe 1 millio acre-feet i rights from west sid creeks.

O the Trinity River, th U Bureau o Reclamation i significan claiman o post-1914 water rights, an given th smal amoun o riparia an pre-1914 water rights claims on th Trinity, the Bureau's Trinity River rights are reliable, a conditione an limited by th Trinity River Record of Decision (U Departmen o the Interior 2000 Th Trinity's ratio o total consumptive claim to average unimpaired flow i 6. acre-feet o claim to every acre-foot o unimpaired flow.

There i another, more dynamic approach tha we als includ i thi testimony to characterize excess claim to water us relative to flows. Thi planning-level analysis o water availability incorporates into th model hydrologic variability, instream flow requirements an publicly available water rights priorities o th divertable flows tha remain i the system.

Applying Water Availability Analysis

I Tables 3 an 3 an accompanying charts we present results o applying bot diversion ca (derived from th State Board's 2010 Delt flow determinations) and th water rights priorit system in th manne that th State Water Resources Control Board i legally authorize to proceed. Th unimpaired flow hydrology for thi analysis was obtaine from th California Departmen of Water Resources (2007) Thi analysis proceeds from th basic water rights premises that:

1) Instream flows needed to mee water qualit and flow objectives have top priority.
2) When applying water rights, riparia rights are paramount, followed by—
3) Pre-1914 water rights clai water base o seniorit date, followed by—
4) Any water lef over i provided to junior water rights holders i order o priorit date (whether pre-1914 rights o post-1914 permits and licenses).

Detaile mode results, water rights, an flow dat employed i th analysis are found i Appendi D. Assumption embedde i the metho are itemized in Appendi o thi report.

To apply th water rights priorit system i th context of providing ne Delt inflows from the majo tributaries C-WIN's analysis build i range o flows from th 10^{th} through 90^{th} percentiles of th 82-year unimpaired flow hydrology available from th California Departmen of Water Resources (2007). 25^{th} 50^{th} (median) an 75^{th} percentile (quartile) flows are also considered. C-WIN's analysis summarize total regulated perio unimpaired flow, th Delt inflow contribution an calculates "diversion cap." (Se Appendice D.1, D.2, an E.)

Water rights priorities are then assigned to allocate the diversion cap flows for the regulation perio to paramount riparia an senior water right holder first. Detaile table of ou model results are provided i Appendix D.1 for th Trinity an th majo Sacramento an Sa Joaqui River Basi tributaries O th majo tributaries there are generally few significant water rights holders an relatively smal bloc of riparians may b known an allocated flows prio to pre-1914

Table 3A
Summar o Wate Availabilit Analysis Results Incorporating Water Right Claims for Major Tributarie of th San Joaquin Rive Basin

River/ Instream Flow Objective	Annual Total		
	Riparians and Senior Pre-191 Righ Holders	**Majo Water Righ Claimants**	**Other Junior Majo Claimants**
Stanislaus	**Various including Tuolumne Utilitie District**	**Oakdale & South San Joaquin Irrigation Districts**	**US Bureau o Reclamation**
40% Diversion Cap	2 TAF i al percentile flows.	19 to 75 TAF in al percentile flows.	81 to 250 TAF i th 50th to 90th percentile flows.
Tuolumne	**Various including Tuolumne Utilitie District**	**Turloc Irrigation District, Modesto Irrigation District**	**Cit County o San Francisco**
40% Diversion Cap	2 TAF across al percentile flows.	40 to 1,66 TAF across all percentile flows.	95 TAF in only the 90th percentile flows.
Merced	**Various including Gallo interests**	**Merce Irrigation District**	**Not applicable**
40% Diversion Cap	218 to 283 TAF across all percentile flows.	to 59 TAF from 40t to 90th percentile flows, abou 14% of all claims.	Not applicable
San Joaquin	**Below Friant Dam, and along Fresno Slough**	**San Joaquin Rive Exchange Contractors**	**US Bureau o Reclamation**
40% Diversion Cap	172 TAF in all percentile flows.	24 to 81 TAF in al percentile flows.	89 to 413 TAF i 75th to 90th percentile flows.

Sources: California Departmen o Water Resources, 2007 State Water Resources Control Board, 2010, 2012 other primary an secondar sources compile by th California Water Impact Network. Se Appendi for details of data an supportin mode results.

right holders Pre-1914 water right claim tend to comprise th majority, o in mos case exceed th unimpaired flows i mos (an i som cases all decil flows reported i th analysis.

Table 3B
Summar of Wate Availabilit Analysis Result Incorporating Wate Rights Claims fo the Trinity Rive and th Majo Tributaries o the Sacramento River Basin

River/ Instream Flow Objective	**Annual Total**		
	Riparians and Senior Pre-1914 Right Holders	**Major Wate Righ Claimants**	**Other Junior Major Claimants**
Trinity	**Various smal claimants**	**US Bureau of Reclamation**	**No applicable**
25% Diversion Cap	13 TAF i al percentile flows.	7 to 454 TAF across all percentile flows.	Not applicable.
Sacramento River above Feather River Confluence	**Various including Anderson-Cottonwood ID and Glenn Colus ID**	**Earl Post-191 to early 1927 claimants**	**CVP and Feather River Project Filings fro 1927 throug 1961**
25% Diversion Cap	2,094 to 5,98 TAF ranging across al percentile flows.	0 TAF across range of all percentile flows.	0 TAF across range of all percentile flows.
Feather River	**Western Canal W and Joint Wate Districts, adjudication decrees**	**South Feather and Thermalito 1920 Rights**	**DWR 1927, 1951, and 1956 Claims**
25% Diversion Cap	72 to 1,97 TAF ranging across all percentile flows.	4 to 3 TAF from 20th to 90th percentile flows.	7 to 23 TAF i all percentile flows.
Yuba River	**Various including Nevad ID, Cit of Nevad City**	**Nevada ID and Yub C WD 1920 Rights**	**Yuba County Water Agency 1927 Claims**
25% Diversion Cap	25 to 1,00 TAF ranging across all percentile flows.	1 to 1 TAF only a 25th to 80th percentile flows.	2 to 8 TAF amon 50th to 80th percentile flows.
Bear River	**Various including Nevad ID**	**Camp Fa West and Nevad ID Claims**	**Sout Sutte Water District Claims**
25% Diversion Cap	2 to 9 TAF ranging across all percentile flows.	1 to 5 TAF across all percentile flows.	4 to 9 TAF from 50th to 90th percentile flows.
American River	**Various including San Juan Wate District Nevad ID and Cit of Sacramento Post-1914 Claims**	**Georgetown Divide PUD and Place County Water Agency**	**U Bureau of Reclamation**
25% Diversion Cap	29 to 1,00 TAF ranging across all percentile flows.	8 to 18 TAF from 50th from all percentile flows.	9 to 13 TAF i all percentile flows.

Sources: Californi Departmen o Water Resources 2007 State Water Resources Contro Board 201 and 2012 other primar and secondar sources compiled by the California Water Impact Network. Se Appendix for detail o data and supportin model results.

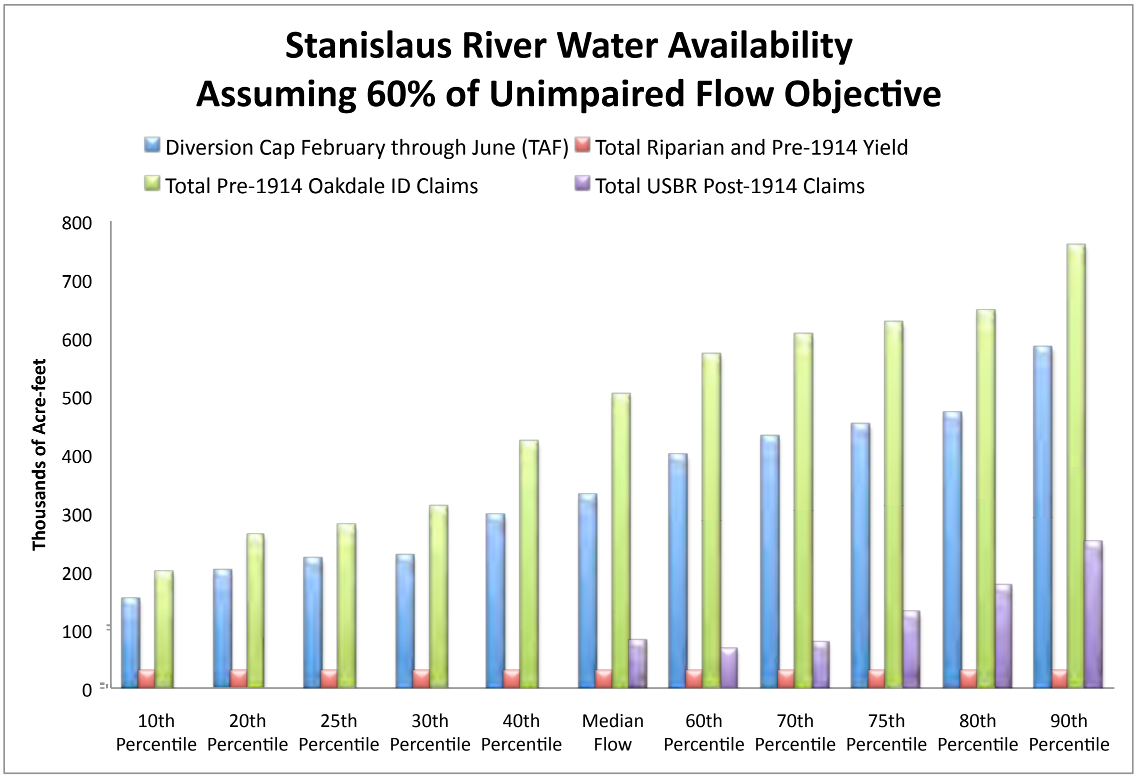
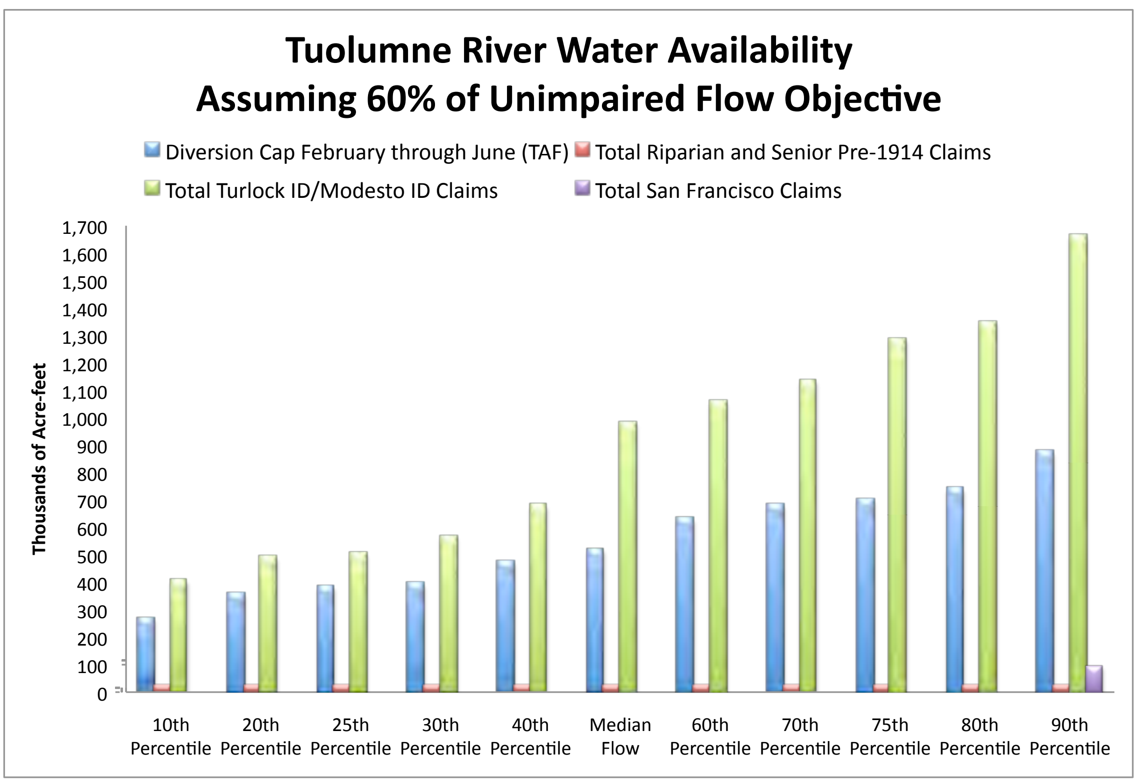


Figure 1, above. Figure 2, below.



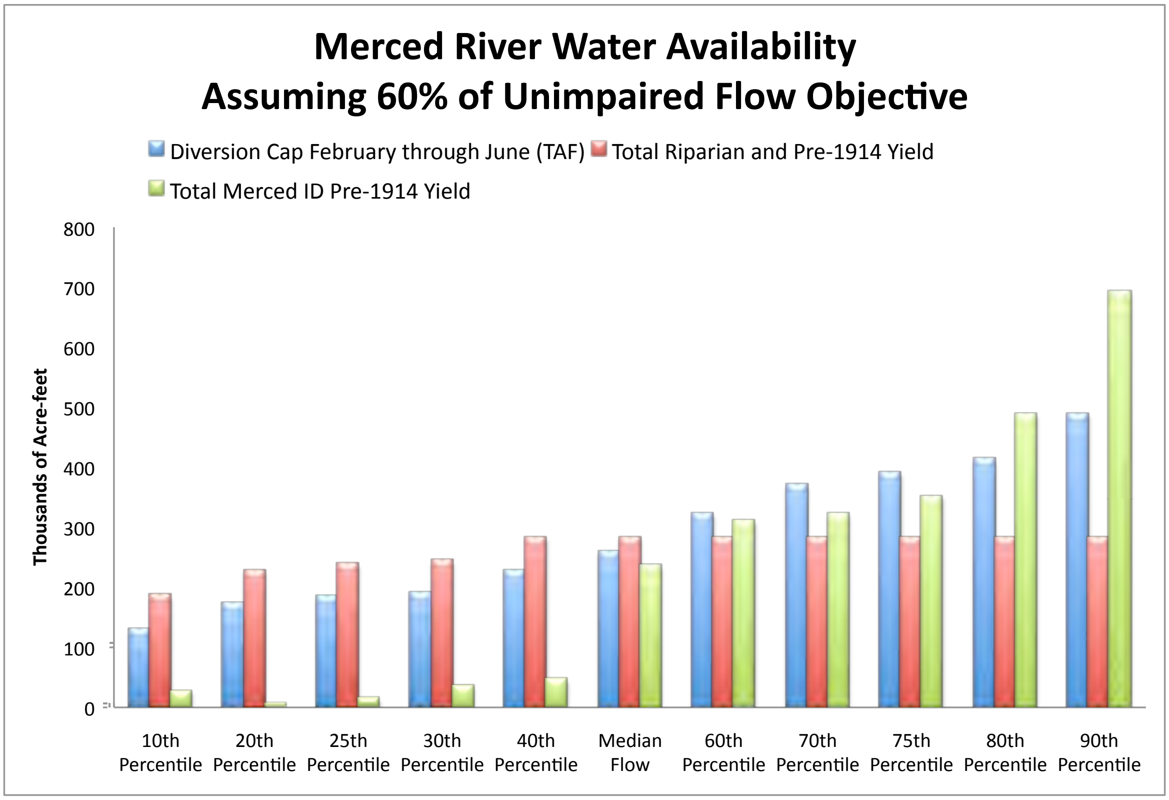
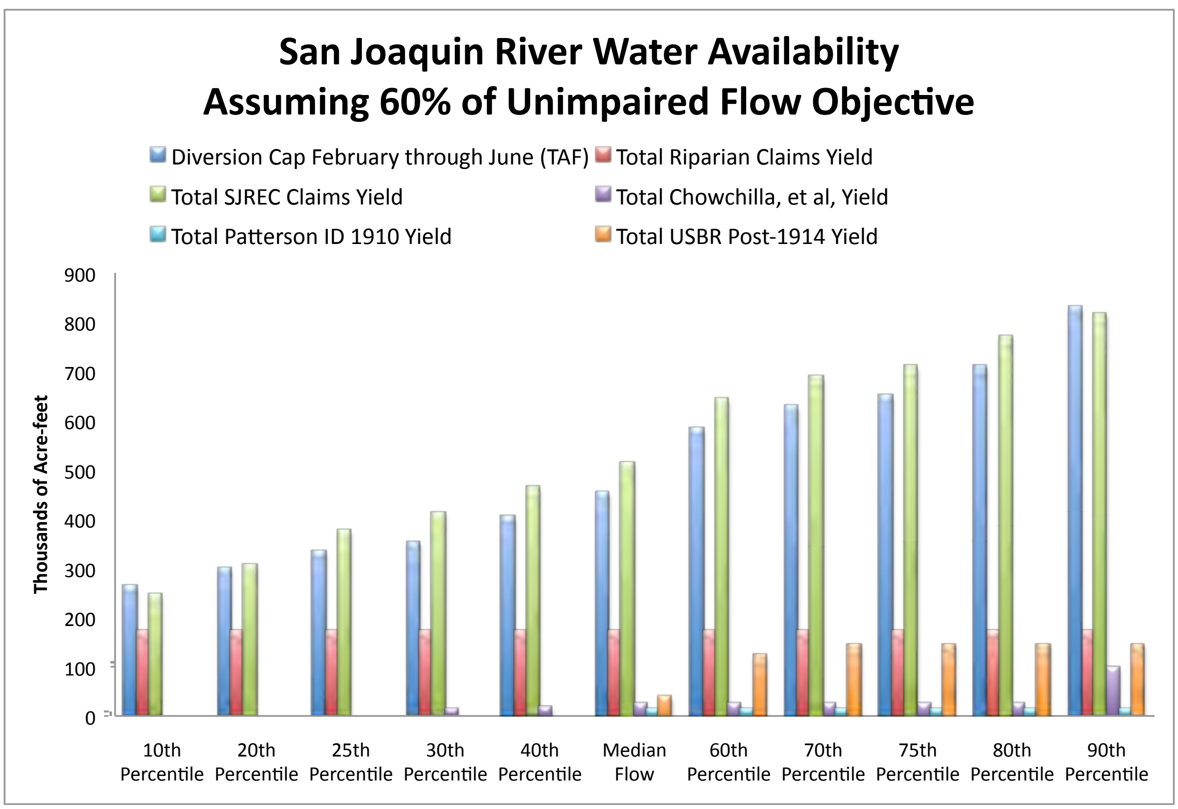


Figure 3, above. Figure 4, below.



Stanislaus River (Figure 1)

Implications: Under strict application of bot th 40 percent diversion ca and th water rights priorit system i th Stanislau River watershed, the U Bureau o Reclamation's water rights for Ne Melone Reservoir yield only small fraction o Bureau claim in actua supplies.

Tuolumne River (Figure 2)

Implications: Unde strict application o both the 4 percent diversion ca an the water rights priorit system, th City an County o San Francisco would have reliable rights to water only i the wettest 10 percent of flows.

Merced River (Figure 3)

Implications: Under stric application o the water rights priorit system to th 4 percent diversion cap, Merced Irrigation District' pre-1914 water rights exceed it post-191 claims significantly, bu are junio to large amoun of riparia an senio pre-1914 right holders.

San Joaquin River (Figure 4)

Implications Only th small riparia allocation alon th uppe San Joaqui River would have fully reliable flows. Th Exchange Contractors would have full claim o flows abou 30 percent of th tim (a th 70^{th} percentile flows an above). Th Bureau o Reclamation would not receive allocations except in the wettest 30 percent of years at all and would receive its full allocation no more tha abou 1 percent o th time.

Trinity River (Figure 5)

Implications: Riparia an pre-1914 water right holder o thi river system are few. Th Bureau's post-191 water rights to develop Trinity Reservoir an Lewiston Dam, and th hydropower complex linked to Keswick Da alon Clear Creek are the dominan water rights o th Trinity River. A noted i Table 2 however, th consumptive us rights alon appear to b quite excessive relative to Trinity River's unimpaired flow hydrology.[3]

Sacramento River Above Feather River Confluence (Figure 6)

Implications Becaus o large pre-1914 water rights claims by Glenn-Colusa Irrigation District alon th Sacramento River, n water would b available to th U Bureau o Reclamation, except from Trinity River exports. Stric applicatio o thi pattern of water rights claim would dramatically reduce water available for export from th Sacramento River Basin and potentially undermin the Sa Joaqui River Exchange Contract.

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[3] Our analysis applies to the Trinity the Board's 75 percent of unimpaired flow determination for November through June. This flow determination exceeds those of the 2000 Trinity Restoration Record of Decision. (U Department of the Interior 2000)

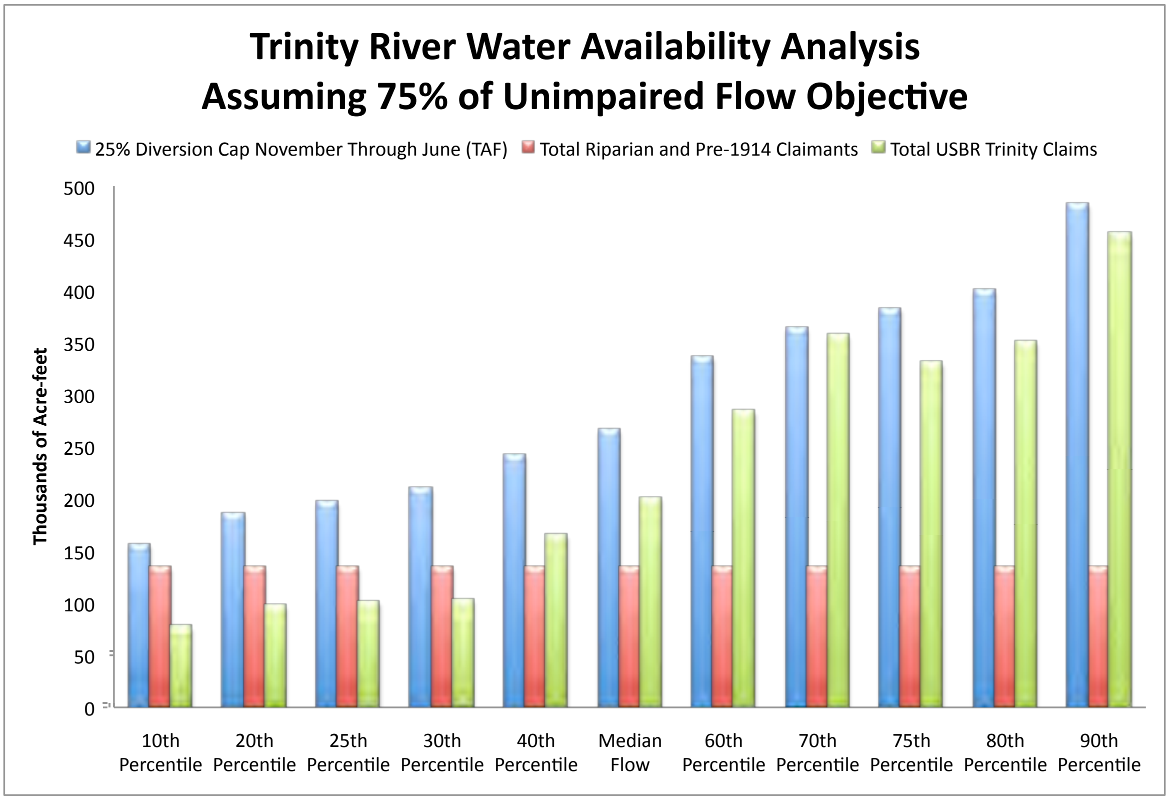
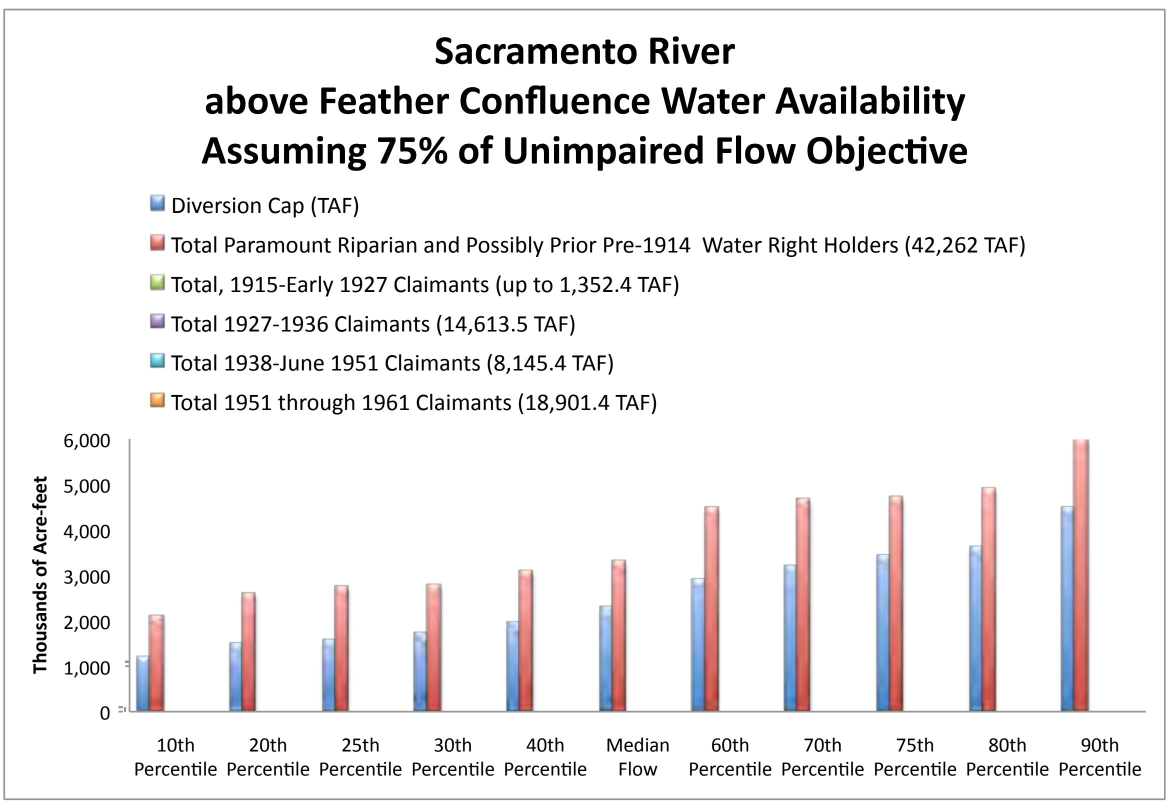


Figure 5, above. Figure 6, below.



Feather River (Figure 7)

Implications Th Department o Water Resources' 1927 1951 an 195 water rights claim for th Feather River Project (now th State Water Project) would receive almos n water unde 25 percent diversion cap scenario. I drier years, even at relaxed diversion ca scenarios, DWR would receive only very smal amounts Thi i due to senio pre-1914 water rights claimant suc a the Joint Water Districts[4] and Western Canal Water District, whose rights predate th cultivation of rice i the Butte County region, and were adjudicated i 1923 DWR's claim amoun to abou 10.4 millio acre-feet (MAF o th Feather River alon for consumptive uses.

Yuba River (Figure 8)

Implications Nevada Irrigation District and Yuba County Water District, through thei pre-1914 claim an 1920 water rights claims would have senio claim to Yuba River flows. Full operation of thes claims would nearly eliminate Yuba County Water Agenc diversions unde 2 percent diversion cap scenario.

Bear River (Figure 9)

Implications Becaus o senio water rights claim by Nevada Irrigation District an Camp Far West Irrigation District, South Sutter Water District would see its supplies reduced significantly relative to it claime rights unde 2 percent diversion ca scenario.

American River (Figure 10)

Implications: Th U Bureau o Reclamation's Central Valley Project facilities alon the American River would receive very littl water supplie from operation o th water rights priorit system unde 2 percent diversion cap despite having claime u to 5.3 millio acre-feet.

Discussion

Assumin tha th State Water Board adopt th 7 percent unimpaired flow determination for the upstream tributarie o th Sacramento River Basin, th 6 percent o unimpaired flow determination for the Sa Joaqui River Basin and tha the water rights priorit system is applied it become evident tha several significan water rights claimants tha are junio i priorit contribute dramatically to th problem o pape water: They have been promised water far in excess o flow condition available to the in mos years.

Table summarize th majo water rights claimant whose title to water i th Central Valley watershed tributaries should be considered clouded, whose property "boundaries" are in dispute.

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[4] The Joint Water Districts include Butte Water District, Biggs-West Gridley Water District, Richvale Irrigation District, and Sutter Extension Water District, the successors to pre-1914 water rights accumulated by the Sutter Butte Canal Company.

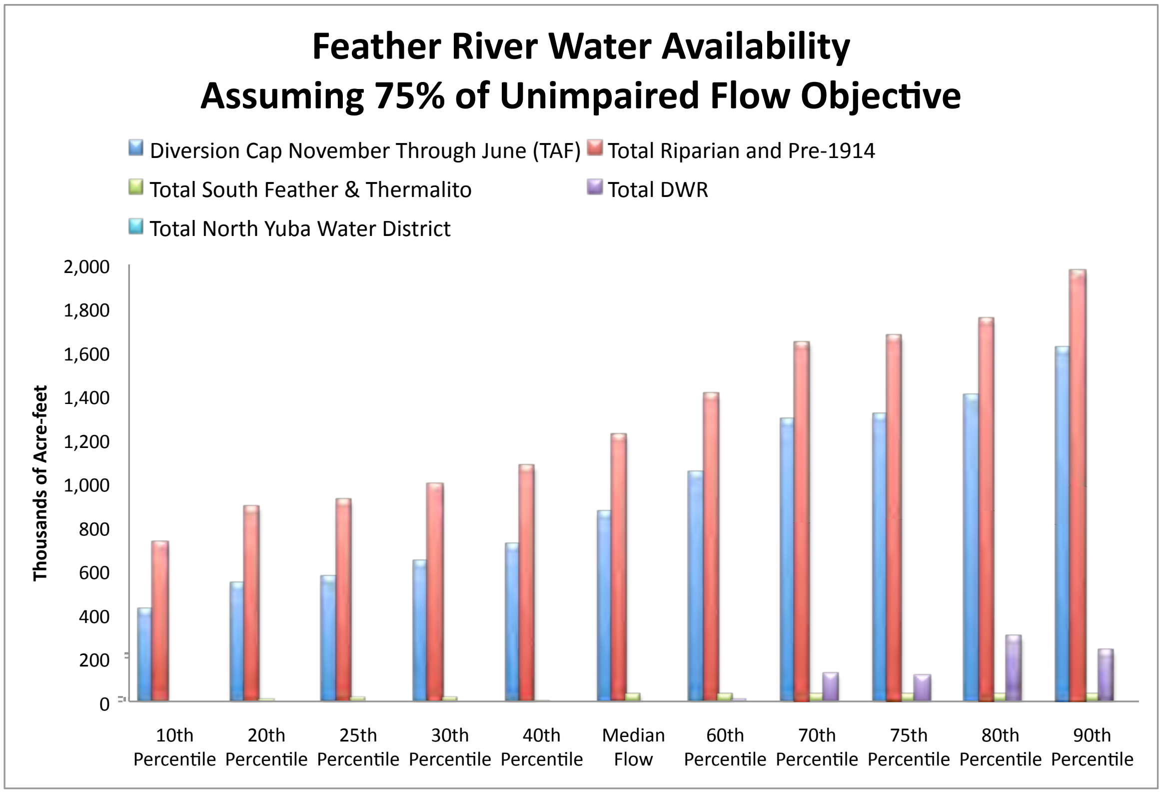
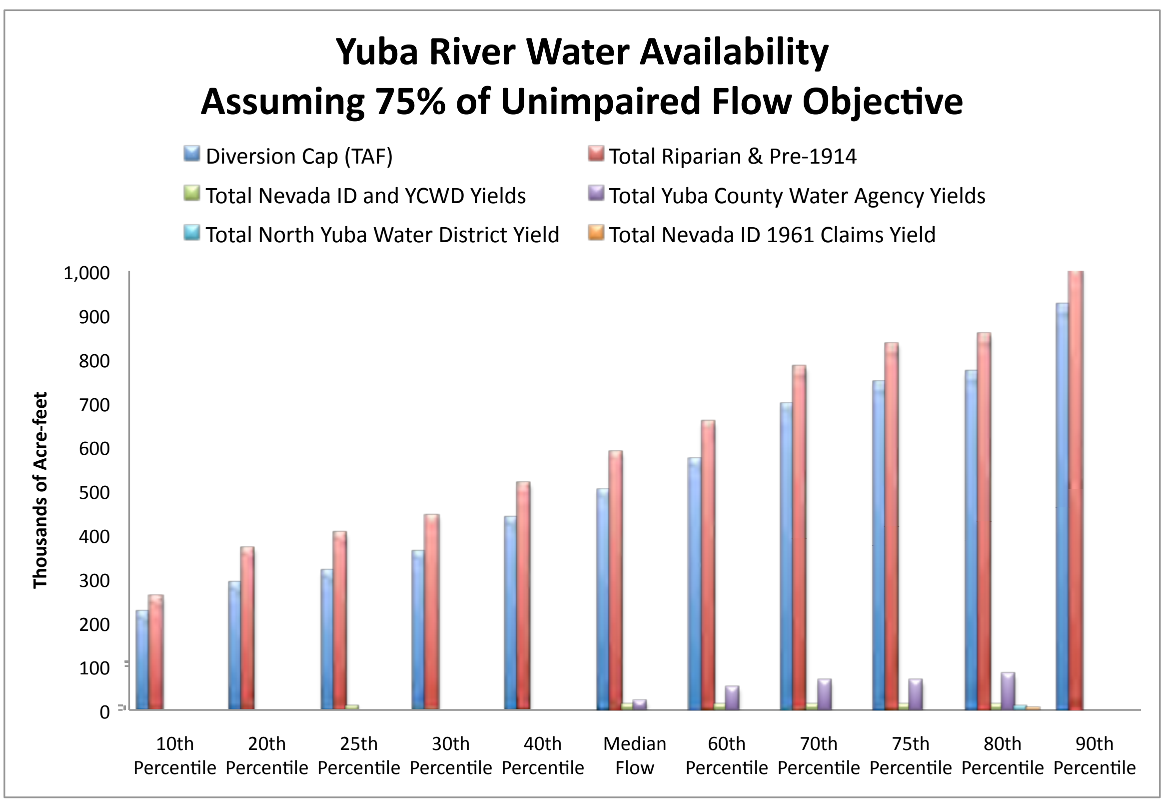


Figure 7, above. Figure 8, below.



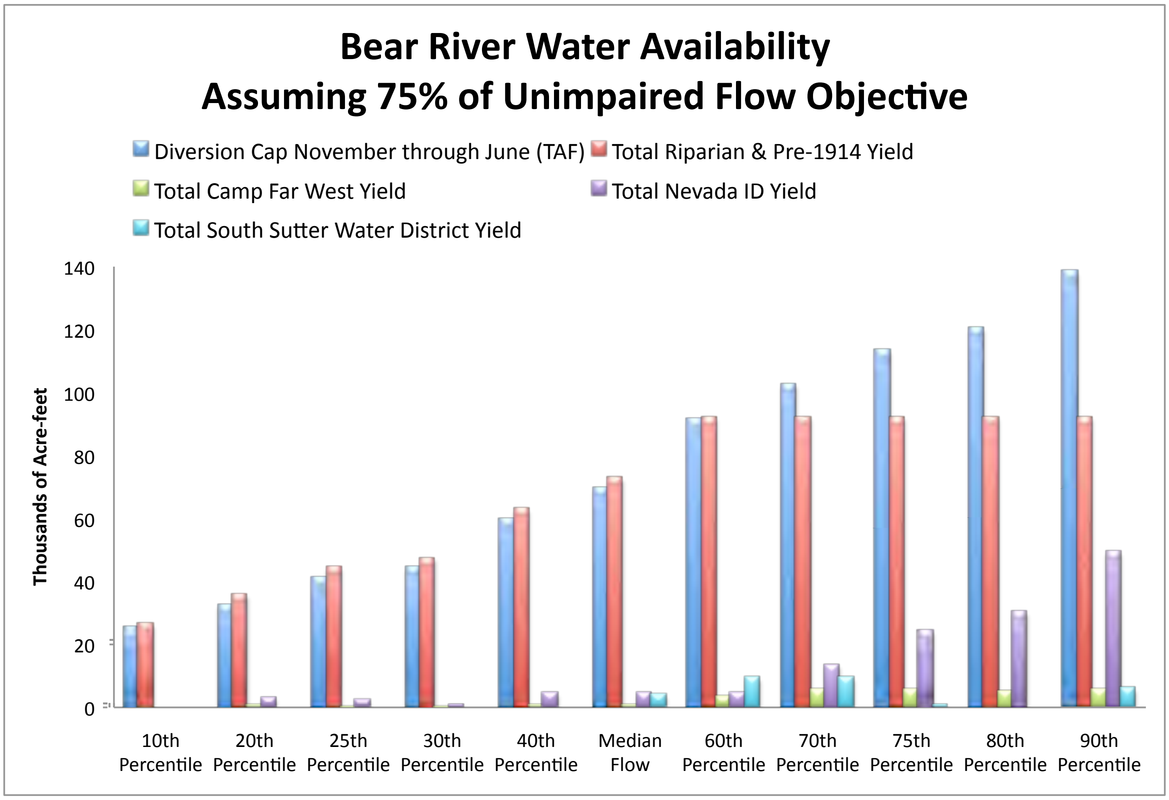


Figure 9, above. Figure 10, below.

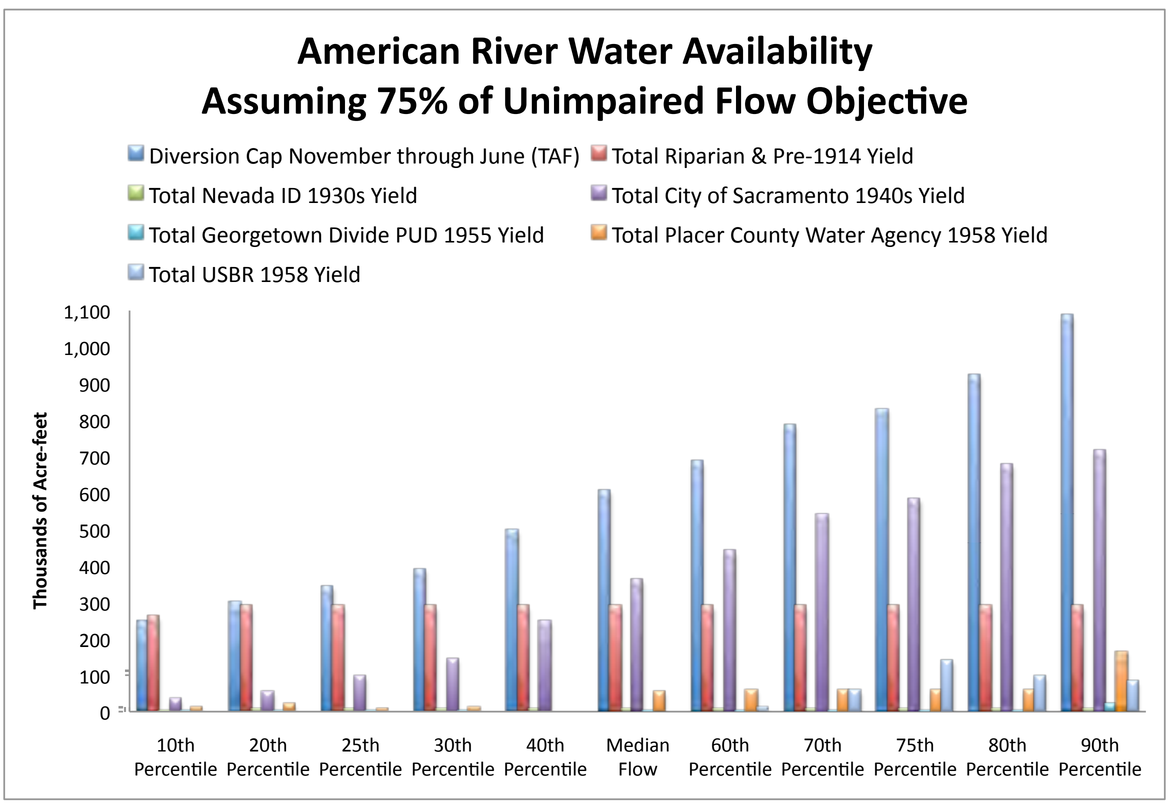


Table 4
Summary o Watershed Consumptive Water Rights Claimants
b Reliability (Based on Legal Priority) of Claims

Watershed	Claimants with Highly Reliable Rights	Claimants wit Potentially Clouded Title to Water
Stanislaus River	Various claimant covered by Stanislau River decree o 1929; Oakdale ID, South San Joaquin ID	US Bureau of Reclamation (New Melones)
Tuolumne River	Tuolumne Utilities District, Turlock Irrigation District, Modesto Irrigation District	City and County of San Francisco (190 through 1911 rights)
Merced River	Gallo, various riparian an pre-1914 parties to early Merced River decrees	Merced Irrigation Distric (post-191 rights)
San Joaquin River	Paramount riparian claimants, San Joaqui River Exchange Contractors, Chowcilla WD, Tranquillity & James IDs, Patterson ID	US Bureau of Reclamation (post-191 rights)
Trinity River	Various small riparian and pre-1914 claimants U Bureau of Reclamation	US Bureau of Reclamation (ha overstated water claim compared with actual basin hydrology)
Sacramento River (including west and east creeks, Pit and McCloud Rivers)	Various small riparian and pre-1914 claimants claimants amon adjudicated watersheds in Pit River region, Anderson-Cottonwood Irrigation District, Glenn-Colusa Irrigation District	US Bureau of Reclamation (Shasta Lake)
Feather River	Uppe watershed adjudicated claimants, Joint Water Districts, Western Canal WD	California Departmen o Water Resources (Lake Oroville)
Yuba River	Browns Valley ID, Nevada ID, Yuba County WD	Yuba County Water Agency (192 rights), Nevada ID (1930s rights), and North Yuba Water District (1958 rights)
Bear River	Nevada ID, Camp Far West ID	South Sutter Water District (195 and 1981 rights)
America River	City of Folsom, San Jua WD, Georgetown Divide PUD, El Dorado ID, Nevada ID, Placer County Water Agency, City of Sacramento	US Bureau of Reclamation (Folsom Lake), Foresthill PUD

Sources: California Departmen o Water Resources; State Water Resources Control Board; California Water Impact Network.

By adoptin it public trust Delt inflow determinations as flow objectives i the Bay-Delta Pla for each majo tributary, an applying water rights priorities—i that order—the State Water Resources Control Board ca us it authorit to eliminate pape water (water claim tha do not have basi i water rights law) in th Bay-Delta Estuary's Central Valley watershed. Th California Constitution reminds u that no on i California ha right to us o divert water wastefully or unreasonably. The state's publi trust responsibility requires protection of th waters of th state for the benefit of all beneficial users, not just water rights holders. The state's water quality control plannin obligations carry ou thi responsibility. I als help th state meet its publi trust obligations as well. Th doctrine o prio appropriation requires that senio water right holders be served before junior water right holders. Th water quality control planning process and the water rights priorit system o th major tributarie o th Sacramento an San Joaqui River Basins shoul b use a tools for eliminatin pape water—that is for quietin water titles an endin trespasses an boundar disputes tha compromise public trus resources—from th Bay-Delta Estuary's Central Valley watershed.

Paths for Aligning Water Rights with All Other Beneficial Uses and River Flows

We se three primary path by which th State Water Resources Control Board ca alig water rights with all other beneficial uses and river flows:

- Water qualit control plan implementation,
- Fully-appropriated streams declaration an Term 91 and
- Court adjudication.

Water Qualit Contro Pla Implementation. Th State Water Resources Control Board has approved a Delt inflow determination for th Sa Joaqui River a Vernalis o 6 percent of unimpaired flow durin th February through June period For th Sacramento the Board approved 75 percent o unimpaired flow determination for th November through Jun period I doin so th Board would implicitly place a ca o total diversions for eac major tributar o 4 percent of unimpaired flow for th Sa Joaqui River an 2 percent o unimpaired flow for th Sacramento River Basin Thes objectives would result i instream flows tha are substantially greater i most years tha current instream flow requirements now provide. I ou water availability analysis, we als apply th Sacramento River Basi 7 percent objective rather tha th Trinity Record of Decisio flow objectives to th water availability analysis for th Trinity River. (U Department of the Interior 2000: 12)

Key water rights holder i thes basin possess riparia an pre-1914 water rights tha exist prio to the regulatory powers of the State Water Resources Control Board. On the question of implementin water quality control plan an adherin to state water rights law, th issu has arisen of the Board's jurisdiction over those water rights that the Board did not originally consent to.

Attorney Ti O'Laughlin, representing th Sa Joaquin River Group Authority (SJRGA), ha asked the State Water Resources Control Board to "identify the legal theory or approach it will use a the implementation proceeding i order to obtai th necessar flows to mee th additiona flow requirements identified" i th Board's flow studies Withou tha legal theor o approach, O'Laughlin argues, th State Water Resources Control Board wil b unabl to complete economi or othe impact analysis in it Substitute Environmental Documen o the Sa Joaqui River Flow and Sout Delta salinit objectives. He further contended i February 201 tha th Board is operating according to *some* kind of theory since it

> blatantly **suggest** tha additiona flows wil com from th Stanislaus Tuolumne, an Merced Rivers. [State Water Resources Control Board 2011c, pp. 78 81, and 85-89 Thi foreshadowing demonstrates tha the SWRCB no only believes that, regardless o the Vernalis flow alternative eventually adopted, i will be abl to obtain flow from all th tributaries bu tha i intends to do so Tha approach, however, completely ignores th existence o th water right priorit system. (See e.g. *Pleasan Valle Canal Compan v Borror* (1998 6 Cal.App.4th 742, 770; *Cit of*

> *Barstow v Mojave Wate Agency* (2000) 23 Cal. 4th 1224, 1243; see also *E Dorad Irrigation Distric v State Wate Resource Contro Board* (2006) 14 Cal. App.4th 937 961) A the SJRGA ha pointed out to th SWRCB o numerous occasions any approach to allocatin responsibility for ne Vernalis flow requirements mus incorporate th water rights priorit system. That said, th SJRGA recognizes tha strict applicatio o th water right priorit system does not produce straightforward results suc that th water required to mee th selected Vernalis flow alternative would come from particula waterway o tributary, o tha suc water would roughly be divided equally o proportionally amon suc waterways an tributaries. (O'Laughlin 2011a 1-2 emphasi i original)

O'Laughlin, o behal o SJRGA, assert tha th Board ha n jurisdictio to regulate pre-1914 appropriative water rights or riparian rights, regardless of any legal theory the Board intends to use i th implementatio phase I responsibility for ne Vernalis flow requirements i determined solely base o th water rights priorit system, writes O'Laughlin, "junior water right holder will b required to reduce o completely ceas thei water us before senior appropriators wil be required to reduce theirs" as required in California's doctrine of prior appropriation. (O'Laughlin 2011a)

He wrote to th Board subsequently i Jun 201 abou it jurisdictio i th Bay-Delta proceedings. There h stated, "I now appear tha th [Substitute Environmental Document is being prepared solely on the basis of percentage of natural flow, without regard to the nature or priorit of th water rights affected, an wil therefore b the subjec o immediate litigation." (He is here apparently referring to th Board's proposed us of percentage of unimpaired flow a the basi for limitin diversions.) O'Laughlin als reiterated i thi letter to the Board tha it

> doe no have jurisdictio over pre-1914 appropriative water rights for any reason, includin the implementatio o water qualit objectives adopted pursuan to th State Water Resources Control Board's authorit unde Porter-Cologne. Given th prevalence o pre-1914 appropriative rights held in the Sa Joaquin River Basin, and the scope of the percentage of natural flow tha th [Board] i considering i i almos certai tha there wil b time and conditions where th [Board] wil no b abl to implement a percentage of natural flow. I is arbitrary and capricious for the [Board] to continue to consider percentage of natural flow as on o its objectives without knowing how often, i ever, it will be able to require such percentages b met. (O'Laughlin 2011b)

O'Laughlin argues tha th Board's flow objective results may no b achievable if for example, flow i 100 cfs an th Board applie 6 percent instream flow criterion to thi waterway while pre-1914 water right holder may clai 80 percent o th flow i the stream. I tha case th Board, contends O'Laughlin, "would not be able to obtain the full 60 percent flow it desired." O'Laughlin contends tha thi no only renders th Delt flow criterion infeasible, it mean tha evaluation of criterion alternatives unde th California Environmental Qualit Act i the Substitute Environmental Documen wil als b infeasible an th SE thus inadequate.

O course, contrary to th Racanelli decision O'Laughlin elevates th water rights priorit system to paramount statu i California water an environmental law. I i plai from a review o state water case law that water rights priorities while important, are not paramount considerations when the Board takes u th protection of beneficia uses o water. A Justice Racanelli stated, water qualit control plannin mus concern itsel wit the regulation o *beneficia uses* no water rights strictly speaking. Beneficial uses include, and g well beyond, water rights and their relative priorities. (Se sidebar, pag 26. The Racanelli decisio mad clea tha th State Water Resources Control Board ha authorit to implemen it water qualit control plan by regulating al beneficia uses Adjusting quantities i water rights i within its authority.

Moreover, the Board retains authorit to regulate pre-1914 water rights under its constitutional authority to prohibit waste and unreasonable use of water. Th Legislature provided i the California Water Code key section that d no limit the Board's authority to investigate rivers an streams in the service of the state's constitutional provisions (emphase added).

> **Beneficial Uses Served in the Bay-Delta Water Quality Control Plan:**
> - **Municipal and Domestic Supply**
> - **Industrial Service Supply**
> - **Industrial Process Supply**
> - **Agricultural Supply**
> - **Ground Water Recharge**
> - **Navigation**
> - **Water Contact Recreation**
> - **Non-Contact Water Recreation**
> - **Shellfish Harvesting**
> - **Commercial and Sport Fishing**
> - **Warm Freshwater Habitat**
> - **Cold Freshwater Habitat**
> - **Migration of Aquatic Organisms**
> - **Spawning, Reproduction, and/or Early Development**
> - **Estuarine Habitat**
> - **Wildlife Habitat**
> - **Rare, Threatened, or Endangered Species**
>
> **Source: State Water Resources Control Board 2006: 8-9.**

275. *The departmen and boar shal tak all appropriat proceeding or actions* before executive, legislative, or judicial agencies *t prevent waste, unreasonable use unreasonabl metho of use o unreasonabl metho o diversio o water i this state*.

...

1050. Thi division i hereby declared to be i furtherance o the policy contained i Section 2 of Articl o th California Constitution and i al respects for th welfare an benefit o the peopl of th state, for th improvement o their prosperity an their living conditions, and *the boar an the departmen shal b regarde a performin governmenta function in carrying ou the provision of thi division*.

1051 Th board for th purpose o thi division may:

(a *Investigat al streams strea systems portion o strea systems, lakes o othe bodie of water*.

(b Take testimony i regard to th rights to water o th us o water thereon o therein.

(c *Ascertai whether o no water heretofor file upo o attempte t b appropriate is appropriate unde th laws o thi State*.

...

1052. (a) Th *diversio o us o water subjec t thi division other tha a authorize i this divisio i trespass*.

(b Civil liabilit may b administratively impose by the board pursuan to Sectio 105 for a trespass a define i thi sectio i a amoun no to exceed five hundred dollar ($500 for each day in which the trespass occurs.

(c Th Attorney General, upo request of th board, shall institute in th superior court in and for any county wherein the diversion or use is threatened, is occurring, or has occurred appropriate actio for the issuanc o injunctive relief a may b warranted by way of temporary restraining order, preliminary injunction o permanen injunction.

(d) Any perso o entit committin trespass a defined i thi sectio may be liable for a su no to exceed five hundred dollar ($500 for eac day i which th trespass occurs The Attorney General, upo request o th board, shal petition th superio cour to impose assess an recover any sums pursuan to thi subdivision. I determining th appropriate amount, the cour shal take into consideration al relevant circumstances, including bu no limited to, the

extent o har cause by th violation th nature and persistence of th violation th length of time over which th violatio occurs an th corrective action i any, taken by th violator.
(e Al fund recovered pursuan to thi sectio shal b deposited i th Water Rights Fund established pursuant to Section 1550.
(f) Th remedies prescribed i thi sectio are cumulative an no alternative.
...
1825. It i the intent o the Legislature that *th stat should tak vigorou actio* to enforce the terms an condition o permit licenses certifications, an registrations to appropriate water, to enforce state board orders and decisions, and *to preven th unlawful diversio o water.*
...
2501 Th board may determine, in th proceedings provided for i this chapter, al rights to water o a stream system whether base upo appropriation, riparian right, o other basi of right.

Nothin in thes section o th Water Code prevents th Board from investigating pre-1914 water rights an eliminatin illegal diversions shoul they b found. Water Code Sectio 275, appear to extend thi authorit o th Board to determining whether any water us i wasteful or unreasonable, o any metho of use o metho o diversion is wasteful o unreasonable.

Thes section provided authorit for th Board to investigate pre-1914 an riparia water rights in the Delta recently. I these investigations, the Board has issued water rights orders that in a least on instance adjusted the rights o a riparian water right holder. (Wilson 2012 Mr. O'Laughlin is surely aware o thi authority. O behal o th Sa Joaqui River Group Authority, his comment on the Board's 2008-201 strategic work pla helpe initiate th Delt water rights investigations in 2008 H cited California Water Code Section 182 to support the San Joaquin River Group Authority's recommendation tha th Board investigate Delt riparia an pre-1914 water rights. (San Joaquin River Group Authority 2008 64)

Whe the Board moves to adjus diversion amounts i th Delta's majo tributaries. Th Board should apply a diversion cap during the regulated period applicable to each tributary (including the Uppe Sa Joaqui River; se Appendix B an the allocate diversions according to water rights priority. C-WIN analyzes operation o th water rights priority system i the following river profiles.

Our testimony analyzes water availability usin water rights prioritie a way of identifyin the legal metho for allocatin responsibility for Delt inflows tha are fully protective o publi trust resources in the Delta.

Th Board announced i two notice (dated February 13 2009 an Apri 1, 2011, th latter containing revisions to the earlier Notice) its intent to revise the Bay Delta Water Quality Control Plan of 2006. This plan traces its lineage to the 199 Bay Delta Water Quality Control Plan an the Bay-Delta Accord. The Sa Joaqui River flow an Sout Delta salinit objective process i likely to b step i th right direction away from thes failed plans Th well-documented failures o this misguide loyalty include:

- Anadromous fishery decline throughout th Central Valley watershed o th Delt estuary.
- Declines o pelagi (open water) aquati ecosystem regimes throughout th Delta
- Continued listin o endangered species includin salmon steelhead, Delt smelt, longfi smelt, Sacramento splittail an green sturgeon.
- Chronic violation from 200 through 200 o sout Delta salinit objectives i bot the Bay-Delta Water Qualit Control Pla an Water Rights Decision 164 tha are intended to protect agricultural beneficial uses i this part of th Delta.

- Historic record Delt pumpe exports between 200 an 2006 peakin a nearly 6. million acre-feet. (More recently, 2011 exports reached 6. millio acre-feet.)

From th two NOPs, i appear th Board prepares to incorporate flow objectives for majo tributaries o the Sa Joaqui River: th Stanislaus, th Tuolumne, an th Merced rivers. I appear to u the Board intends to require fair share flow contribution from eac o thes importan rivers to flows o th mainstem Sa Joaqui a inflow to th Delt as measured at Vernalis. Our organizations welcome thi prospect i concept, an suppor th Board's efforts toward thi goal despite legal, ecological, and engineering challenges ahead.

Th 198 Delt Water Cases decisio (als name a th "Racanelli decision" for it author, presiding Justic Joh Racanelli o th Third Distric Court o Appeal i California) bears review because it defines the Board's water quality planning duties for the Delta and its watershed. (California Appeal Court, Third Distric 1986 Whe i come to th Board's role i undertakin its duty to fulfill its water quality planning function, the Racanelli court stated:

> I its *water quality* role of setting th level of water qualit protection, th Board's task is no to protect water rights, bu to protect 'beneficial uses.' Th Board is obligated to adopt water quality control plan consistent with the overall statewide interest in water quality [citation to California Water Code §13240] which wil ensure 'th reasonable protection o *beneficial uses* (§13241 emphasi added) It legislated mission is to protect th 'qualit o al th waters of th state...for us an enjoyment by th people o the state." (13000 1st para., emphasi added. (California Appeal Court, Third Distric 1986: 178)

Thus protection of beneficia uses mus b the Board's paramount goal i thi process. Beneficial use make u "al competing demand for water" which mus receive Board attention durin publi trus balancin an analysis. Water rights are amon th Board's implementatio tools for achieving the protection of beneficial uses in California's Central Valley watershed and Delta estuary, not strictly end i themselves i thi context.

Justice Racanelli wrote that the State Water Resources Control Board has a dual role o regulating both water quality and adjudicating water rights. The Racanelli court stated:

> I performing it dual role, includin development o water qualit objectives, th Board is directed to conside not only the availability o unappropriated water...but also *al* competin demand for water in determining what is a reasonable level o water qualit protection. (California Appeal Court, Third Distric 1986: 179-180)

Th Delt Water Cases came abou becaus th Board construe it scop for water qualit planning too narrowly, focusing o th major stakeholders i th Delta th Bureau, th Departmen o Water Resources, and their respective contractors. The Board erred in doing so, the Racanelli court stated.

> ...th Board mus conside 'past, present, an probable future beneficia use o water'...as well as 'water quality conditions that could reasonably be achieved through the coordinated control of *all* factors which affect water qualit i the area' Unfortunately, th Board neglected to do so. (California Appeal Court, Third Distric 1986: 180)

Tha was 2 years ago A we wil indicate below, C-WIN i deeply concerne tha th Board may still neglect significant, realistic alternatives that will be essential to fulfilling its water quality plannin role for solving problems i th Bay-Delta estuar an th larger Central Valley watershed.

Fortunately, the Board can avoid such neglect. Justice Racanelli wrote that the Board "need only take *th large view of th water resources* i arriving a reasonable estimate o all water uses an activity well withi it water rights functio to determine th availability of unappropriated water." An h added "We think a simila *globa perspective* is essential to fulfill th Board's water qualit plannin obligations." (California Appeals Court, Third Distric 1986 emphasi added Justice Racanelli stated later that th Board compromised its role i previous water quality control plan when i define it scope for action too narrowly "in terms o enforceable water rights. I fact," the judg wrote, "th Board's water qualit obligations are no so limited."

> ...i order to fulfill adequately it water qualit plannin obligations, we believe th Board cannot ignore other actions which could be taken to achieve Delta water quality, suc as remedial action to curtail excess diversions and pollutio by othe water users (California Appeal Court, Third District 1986 182)

Th Board's "paramount duty" remains to "provide 'reasonable protection' to beneficia uses considerin al th demand mad upo th water." Finally, Justic Racanelli concludes abou the Board's water quality planning powers:

> Thus we d no believe tha difficult in enforcement justifie bypass o th legislative imperative to establis water qualit objectives which i the judgmen of th Board wil ensure reasonable protection of beneficia uses (California Appeals Court, Third Distric 1986 182)

C-WIN believes that credible water qualit control pla for th Bay Delt estuar must take what Racanelli deeme th "global perspective" i order to redress th ecologica collaps an cumulative salinizatio an pollutio resulting from th Board's water qualit plannin efforts to date. The 199 Bay-Delta Accord's water qualit control planning pendulu swung too far i favor o water right holders and water contractors, and their respective beneficial uses. The Board's duty now i to credibly balance all o the beneficial uses o water i the estuary so that public trust resources are protected, an so tha reasonable use an method o diversion of water are employed by al water users.

I addition to th water qualit planning obligations that Justice Racanelli eloquently addressed, recent state legislation provides additional authority to the State Water Resources Control Board. Usin this adde authority, the Board ca better protect water quality an beneficial use i the Bay-Delta Estuar an the Central Valley watershed. We point to two ne laws enacted i 2009.

Th State Water Resources Control Board ha already fulfille it obligation under California Water Code Sectio 85086(c) and (e to prepare public trust assessmen of th Bay-Delta flow criteria neede to protect fish and wildlife beneficia uses. Whil no "balancing analysis required under publi trust doctrine, the Board's *Delt Flow Criteria Report* provides valuable scientific analysis and finding tha mus b used to hel th Board fulfil it water qualit plannin responsibilities and achieve protective publi trust resource outcomes i th Bay-Delta estuary. Th report employed the best available science in arriving a its findings. (State Water Resources Control Board 2010b)

Th sam legislative package als change th California Water Code to recognize th nee to reduce reliance on the Delta as a source of water for California:

> 85021 Th polic o the State o California i to reduce reliance o th Delta i meetin California's future water supply need through statewide strategy o investing i improved regional supplies, conservation, and water use efficiency. Each region that depends on water from th Delt watershed shal improve it regional self-reliance for water through investment

i water us efficiency, water recycling, advanced water technologies, local and regional water supply projects, an improved regional coordination o loca an regional water supply efforts.[5]

Thes new laws provide the Board with additional legal and political tools aiding the protection of al beneficial uses, particularly fish and wildlife beneficial uses whose protection has been neglected for decades.

The Water Code's Fully Appropriated Stream Provision an Term 91. The Board will nee to revise it 199 water rights order concerning fully appropriated streams, an revisit it applicatio of Term 9 curtailmen o post-197 water rights permittees. Ou water availability analysis help show where key seasona an priority thresholds may occu unde th Board's ne Delt inflow objectives.

California's Water Code implicitly acknowledges th potential for over-appropriation to occu and provides a process by which th State Water Resources Control Board may take steps to avoid or prevent excessive water promises. Th Board can declare streams to b fully-appropriated on a mont by mont basi i every watershed of California under Section 120 through 1207 Its statutory languag is reproduced i Appendi F to thi testimony.

Sectio 1205(b) provides tha a declaration tha stream system i fully appropriated shal contain findin tha th supply o water i the stream system i fully applied to beneficia use where the Board find tha previous water rights decision have determined tha n water remains available for appropriation. According to Sectio 1206(a once stream system i declared fully appropriated by th Board, th Board shall not accep for filing any applicatio for permit to appropriate water from th stream system describe i the declaration, an may cancel an applicatio pendin o that date. Section 1206(b states tha th th Board may provide for exceptions to applicatio filing unde specified conditions which may limi th purpos of use th instantaneou rate o diversion, th seaso o diversion o th amoun o water diverted annually.

Past State Water Resources Control Boards have declared fully-appropriated streams in California. (State Water Resources Control Board 1989 1991 an 1998 Th Board's mos recent 1998 declaration include majo reaches o al tributarie to th Sacramento an San Joaquin River Basins as fully appropriated, including the Trinity River. (State Water Resources Control Board 1998 Exhibi A)

Th Board ha also designated as fully appropriated some rivers an streams tha are adjudicated o have reaches designated for protection unde state and federal wild and sceni river legislation. Major portion o th Trinity, Middle Fork o th Feather, the Tuolumne, an th Merced are designated a wil an sceni rivers. Wil an scenic rivers are off-limit to appropriations year-round. Othe rivers an streams are fully-appropriated primarily durin irrigation season Appendix summarize selected critical reaches of th Bay-Delta Estuary's Central Valley Watershed that are designated a fully-appropriated by th State Water Resources Control Board.

Th Board's Full Appropriation Declaration blur th distinction between water rights claim and water usag by claimants Commendably, th Board has identifie reaches o streams tha are off-limits to ne permanent applications to appropriate water. C-WIN identifie several streams where it appear tha th Board ha excluded riparia an pre-1914 water rights i formulating its declaration. Thi appears to b th cas o th Sacramento mainstem, th Tuolumne, th Merced, and the Yuba. O these rivers, substantial periods of the year are still officially open under the

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[5] California Water Code §85021, passed November 2009.

Board's declaration to application to appropriate. Substantial amounts o pre-1914 water rights do no appea to b considered i th Board's determination tha stream i fully appropriated.

Sectio 1205(b does require tha th Board's declaration "shal contain a findin that th supply of water i th stream system i bein fully applie to *beneficia uses* where th board finds that previous water rights decision have determined that no water remains available for appropriation." (For lis o al Bay-Delta beneficia uses se sidebar, pag 26 above.) Note tha the full-appropriation declaration legislatio states tha the supply of water i "bein fully applie to beneficial uses an no merely to the claim o water right holders.

There i n explicit analysis in the 199 declaration by the State Water Resources Control Board of full application o water to beneficial uses as a direct consequence o citing its water rights decisions. This mean that th ful appropriation declarations are likely incomplete, albei from a different standpoint. Th Board may have construe Water Code Sectio 1205(b a requiring the Board to rely on its archive of water rights decision, appropriately enough. Bu Water Code Section 1205(b doe no expressly limi th Board to us only water rights decisions adjudications and othe determinative document to justify thes finding a evidenced by th Board's additional reliance o wil an sceni river designations It approved 201 flow objectives for th Sacramento an Sa Joaquin River basi (while legislated to b informational and predecisional i Water Code Sectio 85086(c)(1)) coul als b use to support findings o ful appropriation for the Sacramento River, th San Joaquin River, an thei othe majo tributaries Instream flows serve natural beneficia uses a surely a water rights claims serve economi uses Accounting for these instream flows a par o ful appropriation declarations would increase th period o full appropriation to includ November through June throughout th Sacramento Basin an February through June i th Sa Joaquin Basin given th magnitud o water rights claim we have identified.

Moreover, Board decision like Water Rights Decisio 1594 (D-1594 acknowledge th Board's dut to account for all beneficial uses, such as those protected by the Board's Delta water quality and flow objectives.

C-WIN's planning-level water availability analysis allocates unimpaired flow hydrology, amon instream flow objectives first, followed by water rights i order o priority statu for the Sacramento an Sa Joaqui River basins. This planning-level metho o water availability analysis demonstrates tha the waters o th Sacramento an San Joaqui River Basin from a plannin standpoint, shoul indee b declared fully appropriated. Th ful spectru of beneficia uses is fully accounted for i allocatin the Basins flows to ful protection o instream beneficia use as well a thos o al water rights claimant i California's water rights priorit system. Moreover, this water availability analysis use instream flow determinations tha th Board itsel endorse i 2010 a Delt protective of publi trus resources. I als indicates which majo claimant have either poorly reliable or n water rights onc all beneficial uses are accounted for.

problem wit th State Water Resources Control Board's fully-appropriated declaration involves it reliance o Water Right Decisio 159 (D-1594 from 1984 D-159 authorize th Board to plac into permits (whose priorit dates com after August 16 1978 a new permi condition (called Term 91 notifyin al permittees of its intent to curtai diversions o water right permittees. Curtailment occur when flow an water qualit condition in th Delt deman tha reservoir releases are neede to enabl th California Department o Water Resources an th U Bureau of Reclamation to mee Delta water qualit standards establishe by the Board. August 16 1978 is significant a th date o which th Board adopted Water Right Decisio 1485. This decisio made th Bureau an th Department responsible for meetin water qualit objectives i th Delta.

D-159 expressly addresses water availability for appropriation (diversion) i th Bay-Delta Estuary's Central Valley watershed by subordinating junior appropriative water rights to adherence to Delt water qualit objectives. D-159 i cited by th State Water Board a th water right decisio authorit for including th Sacramento-San Joaqui Delt i th 199 fully-appropriated streams water right order. Thi decisio reaffirms th Board's reserved jurisdictio to revisit the seaso o diversion o water right permittees i th Bay-Delta Estuar watershed, an i establishes wit standard permi Term 9 it authorit to curtail diversions by post-1978 diverters s that storage releases by the Bureau an th Departmen ca mee Delt water qualit objectives.

I this decision, th Board states:

> Th availability o water for appropriative water right permittees i affected by th quantit neede to satisfy holders o prior rights an th quantit necessary for protection o other beneficial uses. (State Water Resources Control Board 1983: 2)

I th process leadin u to D-1594 the Board initiated process to conduct planning-level water availability analysis. Unfortunately, it abandoned that analysis:

> Staf ha originally proposed comprehensive analysis of water supply an deman which attempted to identif an quantif water usag by al diverters below th foothill reservoirs withi th Delt watershed. [SWRCB Exhibit. 1 pp 19-20 Thi approach was discontinued [apparently i April 1983 according to reporter's transcript dated Apri 11 1983, p 14 lines 16-20 du to th lac of adequate dat for factors suc a return flow, groundwater accretions, unmeasured tributar inflow, riparia use appropriative use and Delt consumptive use (State Water Resources Control Board 1983 9-10)

D-159 states a leas twice tha application o Term 9 to post-197 permittees is an "interim solution" o an "interim measure." Nearly 3 years later, th Board stil employs Term 91's method of calculatin water availability. D-159 commit th Board to occasionally requiring the post-197 permittees i th Delta's extensive watershed to curtai deliveries when flows are insufficient to mee Delt water qualit objectives an protect th Delta's beneficia uses.

Our planning-level water availability analysis focuses o water rights claim compared to historical hydrology. A we earlier showed, i find there are far more water right diversion claim than there are flows in th Bay-Delta Estuary's Central Valley watershed (including th Trinity River claim of th Bureau). Ou water availability analysis incorporates Board-approved instream flow determination th Board approved a fully protective o public trust resources i th Bay-Delta Estuary and its watershed. Its results suggest that *making Delt water qualit an flow objectives full protectiv o publi trust resource will requir movin th priorit dat of Ter 8 permittees fa earlier tha 197 fo determinin when an fo whom Ter 9 diversio curtailment would occur* Thi i necessary becaus th State Water Resources Control Board (2010) found tha current Delt flow objectives o th mainstem and tributarie o th two basins, includin the Vernalis Adaptive Management Pla o th Sa Joaquin River, are insufficiently protective of th Delta's fish an wildlife beneficial uses (State Water Resources Control Board 2010 9-10 Conversely, this mean tha Term 9 *currently* applies Delta water qualit objectives that are well known to be ineffective at protecting public trust resources i the Delta.

C-WIN believes i wil b necessar for th State Water Resources Control Board to revisit Term 91 an D-1594' metho o estimating water availability i th Bay-Delta Estuary's Central Valley watershed when implementin ne Delt inflow (instream flow) objectives for th Sacramento and San Joaquin River Basin an their majo tributarie upstream o th Delta For th sam reason, the Board's 199 water rights order mus also be revisited to update an expand th season where appropriations would b prohibited a matter o protecting al beneficial use i compliance with Water Code Sectio 1205 through 1207. Th Board should includ these actions i th Bay-Delta Plan's implementation program.

I sum: th Board ha acknowledged tha existing Delt water qualit an flow objectives for the Bay-Delta Estuar are inadequate. (State Water Resources Control Board 2000 5 However, the Board *assumes* thes water qualit an flow objectives when i enforces Term 9 o post-197 water rights permittees. Improving these objectives wil mean th Board mus curtai diversions by water right permittees (als probably licensees wit priorit dates *earlier* tha August 16, 1978, in order for Board-required Delt water qualit an flow objectives to perform thei functions protecting Delt watershed publi trus resources. A par o it Phas II process to implemen the Bay-Delta Plan the Board mus take testimony o how to determine this earlier priority date.

I all type o hydrology an usin the Sacramento River Basi flow determination o 7 percent of unimpaired flow from November through June C-WIN's water availability analysis suggest that for th Sacramento River Basi above th Feather River confluence an th Feather River basi itself th earliest date for curtailmen shoul b December 19 1914 O th Yuba an th Bea Rivers, the date o curtailment coul b somewhat later, ranging from 192 o th Yuba to 194 o the Bear. O the America River, th earliest date shoul coincide wit th priorit date o Place County Water Agency's 1958 water rights.

I all type o hydrology an applying the Sa Joaqui River Basi flow determination o 6 percent of unimpaired flow from February through June, C-WIN's water availability analysis suggests that for th Stanislau an Merced Rivers, the Term 9 curtailment date shoul be Decembe 19 1914. O the Tuolumne River, th Term 91 curtailmen date shoul b 1871. O the upper San Joaquin River, ou analysis suggests tha Term 9 curtailmen dates should be on o before th dates o the Bureau o Reclamation's permit for Friant Dam and Millerton Lake i 1916. (See Appendi D.1 for Water Availability Analysis mode results.)

Th Board has acknowledged that current Delta water quality and flow objectives d not protect Delt fish and wildlife beneficia uses adequately. Th Board mus decrease th season o diversion for th Delt an it majo tributarie o th Sacramento an Sa Joaqui River Basi watersheds, because the Board is obligated under the Public Trust Doctrine to protect al beneficial uses in the Delta To implemen thi obligation, th Board must als revisit its Fully-Appropriated Streams Declaration an push bac the priorit date use to conduc diversion curtailments unde Term 91.

Cour Adjudication Still another pat that may b use i tha o adjudicatio by court of competin water rights claim in a watershed. I may take years of painstakin testimony and argumentation by attorneys and (usually) engineers But th present situation o extreme uncertainty and unreliability, clouded water titles, trespassing o th publi trust, and related boundar disputes o many surface an groundwater water rights throughout th Bay-Delta Estuary's Central Valley watershed argues for its consideration.

I th 1930 an 1940s, staf withi th Departmen o th Interior an th ol State Water Rights Board advocated a adjudication of water rights prior to construction of the Central Valley Project. Bot Governor Earl Warren an State Water Rights Board Chairman Henry Holsinger testified during th Clair Engle's Congressional hearing i 195 that a complete adjudicatio o water rights o th Sacramento River shoul have occurred prio to th completio o th Central Valley Project. I fact, the Engle committee concluded that, "[t]ha for al practical purposes the developed water supplies o th Sacramento River are overcommitted and oversubscribed." Thi was prio to approval and construction of the State Water Project. That project was predicated on obtaining som 5,000,00 acre- feet o water annually from nort coasta streams (Figure 11) With the exception o abou million acre-feet o Trinity River flows to the Central Valley Project servic area, this "surplus" of surface water to the Delta system never arrived. Adjustments to th State Water Project shoul have bee made earlier, but were not. Th logical result is that the Delta's native aquati ecosystems have collapsed.

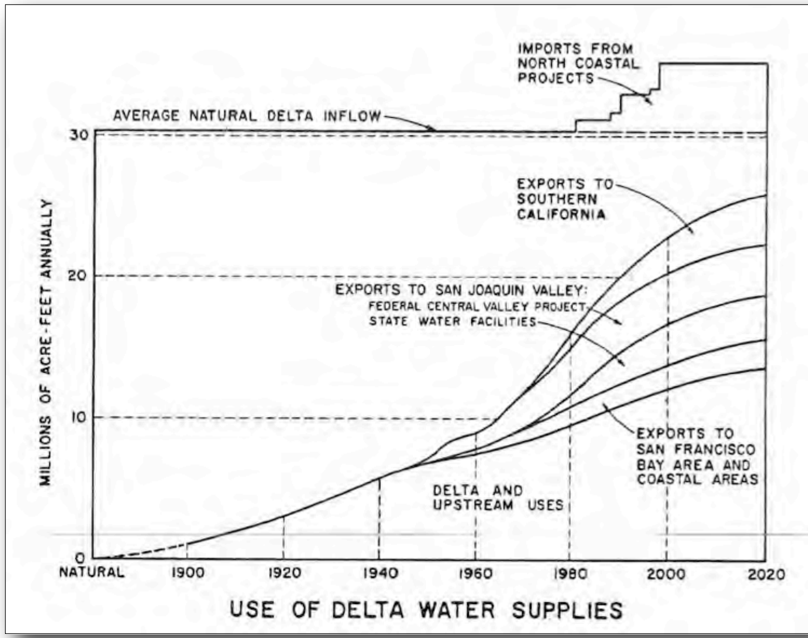

Figure 11
Source: California Department of Water Resources, 1960: 13.

reliable source o surplu water for the State Water Project an the Central Valley Project elude th Departmen and the Bureau, so far. Because surface water import from north coas watersheds were precluded by wild and scenic river designations the Departmen an th Bureau have instead tried to establish a "water market" to transfer water from norther California across th Delt as a interim strategy for increasing water supplie i dr years for low-priority water servic contractors south o th Delta. C-WIN, CSPA and AquAlliance se thi as a grave threat to th regional aquifers o th Sacramento Valley from the Delta to Redding.

Thi threat i manifest i "groundwater substitutio transfers." I suc water transfers, surface water rights are transferred by "willing sellers to the Departmen o th Bureau. Th agencie facilitate the transportation of the water in the deal to the buyer south of the Delta using their export pump nea Tracy. To continu producing thei crop however, th selle replaces or substitutes the surface water supply wit water pumped from underground. Th selle i thu able to achieve ne profit from th gross revenues from sellin surface water rights, les th cos of pumpin water from below ground, an stil ca sel a crop after harvest.

Suc transactions however assum tha groundwater may b treated simply as an individual's property under their land. Such legal theory runs straight into the reality of groundwater in the Central Valley watershed bein a regional commons shared resource, particularly among all individual landowners o th Sacramento Valley who overlie it extensive aquifers. On landowner o se of landowners in on general locatio may caus region-wide con o depression by pumpin lo o groundwater to replace surface water they sol to someon sout o th Delta Suc intensive pumpin ca damag th wells o neighbors nea to an far from the scen o the origina pumping Many o th Valley's rivers are well known a "gaining" streams—that is surface flows are actually enhance upslope by accretions from groundwater sources. Too much groundwater pumping lower down i th aquifers for the "surplus benefittin only th State Water Project an the Central Valley Project could drastically lower water tables upslope an reduce river flow permanently i allowed to becom "th ne normal." Potentially permanen injurie to many beneficial user of water i th Sacramento Valley would result.

glimpse o thi prospect occurred i 199 when th Departmen sponsored a drought water bank program. The program resulted in damag to municipa well an to individual wells in Durham an Cherokee areas o Butte County. More recently, th Departmen an the Bureau have sinc 2002 repeatedly sought "willing sellers to offer surface water amon the numerous publi an private Sacramento Valley water right holders i Sacramento, Yolo, Sutter, Butte, Glenn an Colusa counties Th State Water Resources Control Board i 1996 engaged in proceedings to determine th responsibility o Sacramento River Basi diverters to mee water qualit standards i th Bay-Delt Estuary. Th Board ha completed phase through of th proceeding that le i 200 to adoptio o Water Rights Decisio 164 (D-1641). Phas o tha proceeding was to focus o the Sacramento River and it tributaries I Phas 8, th Departmen o Water Resources an the Bureau o Reclamation, as operators o the state an federal export projects, claime that certain water right holder i th Sacramento Valley mus cease diversions o release water from storage to hel mee water qualit standards i the Delta. Sacramento Valley water user claime tha their water us ha no contributed to any water qualit problems in th delta and a senio water right holders and water user within the watershed and counties of origin they are not responsible for meetin thes standards. To avoid bot litigation an independen regulatory actio by th State Water Resources Control Board, water diverters throughout th Sacramento River Basi executed a agreement i Apri 2001 (Norther California Water Association, 2001 As a result o the Sacramento Valley Water Managemen Agreement, th Phas process was dismisse by th State Water Resources Control Board. (State Water Resources Control Board 2001)

Th Departmen an the Bureau have encouraged planning approaches to regional water managemen to facilitate water transfers, suc as thos i thi partial list:

- Th Departmen o Water Resources undertook draft an fina Program Environmental Impac Report i 199 o drought water bank bu to ou knowledge has never certified this document.
- Th Sacramento Valley Water Managemen Agreement, signe i 2002 bu which ten years o still lacks a programmatic environmental review document. I expired Decembe 31 2010.
- Th 200 Governor's Advisory Drought Planning Panel Report, Critical Water Shortage Contingency Plan, which als promised program environmental documen o drought response water transfer program, but was never undertaken.
- Th Sacramento Valley Integrated Regional Water Management Plan o 2006 overseen by a join powers authorit o numerous water agencie i th Valley.
- DWR's las Drought Water Ban i 200 sought authorizatio for over 100,00 acre-feet of temporary transfers o water, though only 16,000 acre-feet were eventually supplied to Southern California buyers.
- Th Norther Sacramento Valley Integrated Regional Water Managemen Plan now in development.
- Th Delta Stewardship Council's Delta Plan, whose planning scop includes the entire Sacramento Valley an assume groundwater surplus is necessary for meetin Delta export water demands The Council ha als expressed suppor for water transfers usin groundwater substitution.
- Th Bay Delt Conservation Plan which would provide coverage from 50-year habitat conservation plan for Governor Brown's recently announce Peripheral Tunnels Project. Thi project ha n identified water source, othe tha acknowledgement by th Bureau of Reclamation tha i would reroute existing surface flows around th Delt from the Sacramento River Basin (Vlamis et a 2012)

C-WIN, CSPA, AquAlliance, an othe knowledgeable experts are concerne tha lon term impact o regional us of groundwater to substitute for transferred surface supplies will accelerate the depletion o the Valley's groundwater supplies. There are significant gaps i scientists' grasp o how th aquifer system recharges; how surface flows an groundwater systems interact i th Valley's creeks an rivers; how supplies contained within uppe an lower aquifers interact; how the aquifers respond i th long-term to increasingly intense demand o them even durin wetter years. An th regional effect o decline i groundwater levels o river an creek flows and riparian corrido specie an wetland ecosystems ha never bee adequately explored. Thes are beneficial use upstream alon th majo tributaries o the Sacramento River Basi tha mus also be considered part of the public trust responsibilities of the State Water Resources Control Board in it Bay-Delta Plan (Vlamis e a 2012)

State an federal water planner assum tha surface an groundwater flows wil always be there to suppor thi hoped-for surplus Base o tha assumptio they continu eac winter an sprin to pla th next water transfer program tha relies o an encourages groundwater substitution transfers. Thi assumptio ha bee buil into th Departmen an th Bureau's chie water supply and operations planning tool, CalSIM II When surface water supplies for riparian and appropriative water right holder are exhausted i mode run through CalSIM II th model' automatic response i to ad pumpe groundwater to make u for any defici to water demand i the model (Draper an Bourez 2004 slid 20 Close et a 2003 26-27 California Department o Water Resources and U Bureau o Reclamation 2004 Appendi A Sacramento Valley groundwater activity i explicitly modele to includ "minimum groundwater pumping for thos lan uses tha rely exclusively on groundwater i th Valley. (California Departmen o Water Resources an U Bureau of Reclamation e a 2004: Appendi A) Sa Joaqui Valley groundwater i no modeled (Close e al 2003 Thi ca result i low estimates o salinit reaching th sout Delta (Sa Joaqui Valley CalSIM I External Review 2006: 45 Upper bounds on potential pumpin from aquifers in the Sacramento Valley are undefined According to Close e al:

> Thi doe not represent reality, since i CalSIM I i used for statewide planning, it would allow pumpin o vast quantitie o water for export to souther part o th state, somethin which agency staff [i.e. California Bay-Delta Authority Scienc Program an th Association o Bay Area Governments] clai i unrealistic. Realistic upper bounds to pumping from any o the aquifers represented in th model nee to b developed an implemented. (Close e a 2003 26-27)

Th Departmen an the Bureau responded that CalSIM I doe explicitly mode th "impac on groundwater storage o eac sub-basin." They state tha CalSIM I run that result in groundwater pumpin over an above th natural an artificia recharge an which cause depletio o th basin will cause CalSIM I to no longer run. They also state, however, that CalSIM I "does not include local ground water inventories" bu instead relies o historically-modeled calibration o approximated inventories. They state furthe tha "no groundwater i exported from th overlying watershed (except i the form o surface water return flow o tailwater that results from irrigation usin groundwater)." (California Departmen o Water Resources an U Bureau o Reclamation 2004: A-1) Thus, CalSIM I assume that groundwater "backstops"surface water rights holder and their need for supplies when i reality groundwater now backstops river flows (an al associated beneficial use associated wit those flows). I i smal comfort tha CalSIM I cease to work when a basi i depleted from th program's operations; more to th point, i fails to assume le alon build i rational groundwater management strategy o sustaine yield.

CalSIM II' reliance o groundwater to mee overall water deman when surface supplie must not b the d facto water supply development strategy for th state o California when supplie ru low. Whe supplies run low—as they are forecasted to a climate chang affects th America West—th state and it responsible an lea agencie mus increase othe mean o stretching water supplies. This can be don through water recycling, reuse, conservation, and a range o urban, industrial an agricultural efficienc measures.

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Michael B. Jackson (SBN 053808)
MICHAEL B. JACKSON, Attorney at Law
429 West Main Street, Suite D
P.O. Box 207
Quincy, California 95971
Tel. (530) 283-1007
Fax (530) 283-4999
mjatty@sbcglobal.net

Attorney for Petitioners

SUPERIOR COURT OF CALIFORNIA

COUNTY OF SACRAMENTO

California Water Impact Network, a non-profit Corporation, California Sportfishing Protection Alliance, a non-profit Corporation, and AquAlliance, a public benefit Corporation, Petitioners, vs. The California State Water Resources Control Board, The California Department of Water Resources, and DOES 1-100, Respondents	Case No.: 34-2010-80000653 **SECOND AMENDED COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF AND PETITION FOR WRIT OF ADMINISTRATIVE MANDATE (Code of Civ. Proc. §§ 526, 1060, 1094.5)**
The United States Bureau of Reclamation, Real Party in Interest	Judge: Hon. Michael P. Kenny Action Filed: September 3, 2010

INTRODUCTION

1. Petitioners California Water Impact Network (hereinafter "C-WIN"), the California Sportfishing Protection Alliance (hereinafter "CSPA"), and AquAlliance (collectively "Petitioners"), by and through their counsel, hereby allege on information and belief that the California Department of Water Resources (hereinafter "DWR"), is operating in violation of the Public Trust; Article X, Section Two of the California Constitution; the 1995 Water Quality Control Plan narrative standard for salmon; and State Water Resources Control Board Decision 1641 (hereinafter "D-1641"), all of which have led to the continuing and ongoing degradation of fish and wildlife.

2. Petitioners further allege that the State Water Resources Control Board (hereinafter "Board" or "SWRCB"), has failed to enforce permit and licensing conditions of the Porter-Cologne Act and D-1641 against DWR, thereby allowing DWR to cause extensive damage to the Bay-Delta estuary and the fish and wildlife that live therein.

3. Petitioners request a writ of administrative mandate challenging the approval by Respondent SWRCB of WR Order 2010-0002, which modified the Cease and Desist Order of WR Order 2006-0006 on January 5, 2010, and request that the Court set aside Board WR Order 2010-0002 and reinstate the Cease and Desist Order in WR Order 2006-0006 that required Respondent DWR to comply with interior Delta salinity standards by July of 2009.

4. Petitioners seek declaratory relief against DWR for violations of the Public Trust; Article X, Section Two of the California Constitution; the 1995 Water Quality Control Plan narrative standard for salmon; and D-1641 and seek an injunction to further pumping by DWR at the Banks Pumping Facility until DWR can comply with the law.

PARTIES

5. Petitioner C-WIN is a California non-profit public benefit organization with its principal place of business in Santa Barbara, California. C-WIN's organizational purpose is the protection and restoration of fish and wildlife resources, scenery, water quality, recreational opportunities, agricultural uses, and other natural environmental resources and uses of the rivers and streams of California, including the Bay-Delta, its watershed and its underlying groundwater

resources. Members of C-WIN reside in, use, and enjoy the Bay-Delta and inhabit and use its watershed. They use the rivers of the Central Valley and the Bay-Delta for nature study, recreation, and aesthetic enjoyment. Harm to the pelagic and anadromous fishery in the Bay-Delta and its watershed harms the California Water Impact Network and its members by threatening impairment of their use and enjoyment of these species and their habitat.

6. Petitioner CSPA is a California non-profit public benefit organization with its principal place of business in Stockton, California. CSPA's organization purpose is the protection, preservation, and enhancement of fisheries and associated aquatic and riparian ecosystems of California's waterways, including Central Valley rivers leading into the Bay-Delta. This mission is implemented through active participation in water rights and water quality processes, education and organization of the fishing community, restoration efforts, and vigorous enforcement of environmental laws enacted to protect fisheries, habitat and water quality. Members of CSPA reside along the Central Valley watershed and in the Bay-Delta where they view, enjoy, and routinely use the Delta ecosystem for boating, fishing, and wildlife viewing. Petitioner's members derive significant and ongoing use and enjoyment from the aesthetic, recreational, and conservation benefits of the Bay-Delta ecosystem. Harm to the Bay-Delta fisheries has had, and continues to have, a substantial negative impact on Petitioners' organizational members use and enjoyment of the Bay-Delta.

7. Petitioner AquAlliance is a California public benefit corporation organized to protect Northern California's waters to sustain family farms, recreation opportunities, vernal pools, creeks, rivers, and the Bay-Delta estuary. Currently, AquAlliance is a fiscally sponsored project of the Rose Foundation. Members and officers of AquAlliance are being affected by the over-pumping of the Bay-Delta and by the over-appropriation of water for excess water delivery south of the Bay-Delta. Mismanagement of water resources in the Bay-Delta deplete local lakes, and harm salmonids that travel through the lakes and streams used and enjoyed by AquAlliance members.

8. Respondent DWR is a state agency responsible for the State of California's management and regulation of water usage. DWR operates the State Water Project ("SWP"), a

water storage and delivery system of reservoirs, aqueducts, power plants and pumping plants, including the Oroville Reservoir and dam, the Clifton Court Forebay, the John E. Skinner Delta Fish Protective Facility, and the Harvey O. Banks Pumping Plant.

9. Respondent SWRCB the governing board that performs both adjudicatory and regulatory functions of the state in allocating water rights and ensuring water quality pursuant to the California Water Code. The Board has broad authority to carry out these functions, including the authority to hold hearings and conduct investigations in any part of the state necessary to carry out the powers vested in it. It also may require a state or local agency to investigate or report on technical factors, or comply with waste discharge requirements involved in water quality control. The Board may subject water rights to terms and conditions the board finds necessary to carry out a water quality control plan, and a water quality control plan may require changes to water rights, and it may reserve its jurisdiction to enforce these terms and conditions over time. The Board may hold an adjudicative proceeding to consider any changes to water rights to implement the plan.

10. Real Party in Interest the United States Bureau of Reclamation (hereinafter "Bureau" or "USBR"), is a federal agency required to comply with state laws relating to the control, appropriation, use, or distribution of water by the Reclamation Act of 1902. The Bureau operates the Central Valley Project (hereinafter "CVP" of "Project"), which reaches from the Cascade Mountains near Redding in the north some 500 miles to the Tehachapi Mountains near Bakersfield in the south. The Project is one of the world's largest water storage and transport systemscomprised of 20 dams and reservoirs, 11 power plants, and 500 miles of major canal as well as conduits, tunnels, and related facilities.

11. The true names and capacities of Respondents sued in the Petition under the fictitious names of DOES 1 through 100, inclusive, are unknown to Petitioners who therefore sue such Respondents by such fictitious names.

12. Whenever reference is made in this complaint to any act of Respondents, such allegation shall mean that each Respondent acted individually and jointly with the other Respondents named in that cause of action.

13. At all relevant times, each of the Respondents has acted as an agent, representative, or employee of each of the other Respondents and has acted within the course and scope of said agency or representation or employment with respect to the causes of action in this complaint.

14. At all relevant times, each Respondent has committed the acts, caused others to commit the acts, or permitted others to commit the acts referred to in this complaint and has made, caused, or permitted others to ignore the legal obligations referred to in this complaint.

JURISDICTION AND VENUE

15. Pursuant to Public Resources Code §§ 21168 and 21168.5, and Code of Civil Procedure section 1094.5, this Court has jurisdiction to hear this matter.

16. Venue is appropriate in this judicial district in accordance with Code of Civil Procedure §§ 401 and 393 because the respondents SWRCB and DWR are both located in Sacramento.

PROCEDURAL BACKGROUND

17. Violations of state permit and license requirements by DWR, and the Board's failure to enforce permit conditions, water quality standards, and its own decisions and order are causing, and continue to cause, extensive and irreparable damage to the Bay-Delta estuary and the public trust resources therein.

18. In 2000, the SWRCB adopted Decision D-1641, which established water quality objectives for the interior southern delta and conditioned DWR's pumping and export activities on meeting those standards.

19. On February 15, 2006, after DWR had repeatedly failed to meet the D-1641 standards, the SWRCB adopted WR Order 2006-0006, holding DWR responsible for meeting the water quality objectives described in D-1641 and imposing a time schedule requiring DWR to obviate the threat of non-compliance by no later than July 1, 2009. The order specifically rejected the possibility of any time extensions for compliance, stating "considering that the objectives were first adopted in the Water quality control plan in 1978… the State Water Board

will not extend the date for removing the threat of non-compliance beyond July 1, 2009."[1] WR Order 2006-0006 included a cease and desist order ("CDO") mandating DWR to cease and desist pumping and export activities if it failed to obviate the threat of non-compliance by July 1, 2009. DWR chose, as their preferred method of compliance, to build gates, known as permanent operable barriers.

20. In May of 2007, DWR informed the SWRCB that it would be unable to construct the permanent operable barriers that it planned to use to meet the D-1641 standards by the July 1, 2009 deadline, and requested an extension until July 1, 2011. No evidentiary hearing on the request to extend the compliance deadline was set by the Board at that time.

21. By June of 2009, one month before the CDO deadline, DWR had not begun construction on the proposed operable barriers to comply with the requirements of WR Order 2006-0006. That same month, a biological opinion from the National Marine Fisheries Service (NOAA Fisheries) was published that specifically prohibited construction of the proposed operable gates as a part of the South Delta Improvements Program (SDIP).

22. Therefore, on June 5, 2009 the Board issued public notice of an evidentiary hearing on whether the CDO in WR Order 2006-0006 should be extended. The Board asserted that the evidentiary hearing was noticed in response to DWR's May 2007 request to extend the compliance deadline. In late June of 2009 the SWRCB held an evidentiary hearing on potential modifications to the CDO in WR Order 2006-0006. The Board later adopted WR Order 2010-0002 on January 5, 2010, which modified the CDO and extended DWR's compliance deadline for complying with D-1641 standards to an uncertain future date, thereby allowing DWR to continue operating its pumps despite the continuing and ongoing degradation of fish and wildlife in the Delta.

23. In February of 2011, the Board officially denied Petitioner's Petition for Reconsideration of WR Order 2010-0002. Petitioners have therefore exhausted all available administrative remedies.

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[1] WR Order 2006-0006, p. 27, ¶ 5

STATEMENT OF FACTS

24. The Bay-Delta is the largest estuary on the west coast of the Americas, and serves as one of California's most environmentally important and economically valuable ecosystems. Millions of Californians depend upon the Bay-Delta Estuary as one of the sources of their drinking water. Still more use the Bay-Delta as a recreational resource, making it a major recreation and tourist destination. Of the Delta's approximate 738,000 acres, roughly two-thirds support agriculture. More than 500,000 acres of the Delta currently are in agricultural production.

25. In addition to supplying drinking water and serving agricultural interests, the Bay-Delta but is home to approximately 750 plant and animal species, including 130 species of fish. The Delta serves as a critical fishery habitat as it supports an estimated twenty-five percent (25%) of all warm water and anadromous sport-fishing species, and eighty percent (80%) of California's entire commercial fishery habitat.

26. An extraordinary variety of wildlife, including several species which cannot be found anywhere else, live in the Bay-Delta. Many other species depend upon the Bay-Delta for migratory corridor habitat, and numerous commercial and sport fisheries depend upon the Bay-Delta for their continued existence.

27. The Bay-Delta provides critical habitat for a number of species that are protected by the Endangered Species Act ("ESA"), including the Sacramento winter-run Chinook salmon, Central Valley spring-run Chinook salmon (*Onchorhynchus tschawytscha*), Central Valley steelhead (*Onchorhynchus mykiss*), and Delta smelt (*Hypomesus transpacificus*, collectively, the "Listed-Species").

28. Since 1993, the National Marine Fisheries Service ("NMFS") has listed the several fish in the Bay-Delta as "threatened" or "endangered," including the Sacramento River winter-run Chinook salmon and the Central Valley spring-run Chinook salmon.

29. In September of 1999 the National Marine Fisheries Service listed the Central Valley spring-run Chinook salmon as a threatened species, with a population of only 500.

30. The NMFS has also officially listed the Bay-Delta as critical habitat for the aforementioned threatened and endangered fish. As such, the Bay-Delta Estuary is one of California's most threatened ecosystems. The SWRCB designated the Delta's channels, the Sacramento and San Joaquin Rivers, and areas throughout the Bay as water-quality-limited water bodies, yet violations of water quality standards in the Delta are chronic.

31. Many of the Bay-Delta's fish are threatened with extinction. In the last three (3) years several populations of previously healthy species have also suffered catastrophic declines. Still others, including plankton and other food organisms that underpin the Bay-Delta's entire food chain, are in similarly poor health.

32. The collapse of the California salmon run has triggered severe fishing restrictions that have resulted in the near-complete closure of commercial and recreational salmon fishing in California for the 2008, 2009, and 2010 fishing seasons. The number of Chinook or King salmon returning from the Pacific Ocean to spawn in the Sacramento River and its tributaries dropped 67 percent from a poor year earlier. Restoration of California's anadromous fish populations is mandated by the Salmon, Steelhead, and Anadromous Fisheries Program Act of 1988 which states that it is the policy of the State to significantly increase the natural production of salmon and steelhead by the end of the 20th century.

33. Pursuant to the California Water Code, the SWRCB has a duty to protect the waterways of California by the imposition and enforcement of certain requirements to permits and licenses that regulate water quality in the State.[2]

34. Under California law, the SWRCB has an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible.[3]

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[2] See, Wat. Code § 100: "…The right to water or to the use or flow of water in or from any natural stream or watercourse in this State is and shall be limited to such water as *shall* be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water" (*emphasis added*); and Wat. Code § 275: "The department and board *shall* take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state" (*emphasis added*).

35. The SWRCB is also charged with complying with California Constitution Article X, Section 2, which requires that any right to the use or divert water from any natural stream or water in the State shall be reasonable.

36. The SWRCB has adopted several orders that, if enforced, would be protective of fish and wildlife in the Bay-Delta estuary. For example, the Porter Cologne Act required the Board to adopt the 1995 Water Quality Control Plan which includes a Narrative Standard for Fish and Wildlife (hereinafter "the narrative standard"). This narrative standard requires that water flow, water quality, and appropriate temperature conditions are sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991.

37. Consistent with the Clean Water Act, the Porter-Cologne Act requires the SWRCB to create and enforce a water quality control plan that includes water quality standards and objectives, which resulted in the SWRCB adopting D-1641.

38. Decision 1641, adopted by the SWRCB on December 29, 1999, establishes water quality objectives for the Bay-Delta Estuary as a part of the Board's implementation of the 1995 Bay-Delta Water Quality Control Plan. D-1641 also imposes a series of restrictions on the use of export pumps to protect fish and wildlife and assigned responsibilities to the persons or entities holding water rights permits to meet specific flow objectives to protect fish and wildlife. One such restriction requires that water quality objectives must be met at four different monitoring stations in the Bay-Delta before DWR pumping activities can continue. D-1641 holds DWR specifically responsible for meeting these flow objectives.

39. The Board has consistently assigned DWR responsibility for meeting salinity objectives in the Bay-Delta, including those objectives described in D-1641.

40. The SWRCB found that export pumping under the conditions imposed by D-1641 would not unreasonably affect or substantially injure any legal user of water, and would not unreasonably affect fish, wildlife, or other in-stream beneficial uses of water.

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[3] See *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419.

41. Contrary to the findings and conditions of D-1641, the SWRCB continuously fails to enforce its own Basin Plan standards, allowing DWR to continue pumping activities leading to the dramatic decline in the health and viability of the Bay-Delta estuary and the public trust recourses therein.

42. In spite of D-1641 Respondent DWR, with the tacit approval of the SWRCB, has increased its water exports by 53% percent since 2000. This increase exceeds the average of 2.1 million acre-feet that was exported during the 1990s, resulting in the dramatic decline of Delta fisheries. Meanwhile, Delta fish populations of salmon, striped bass, Delta smelt, and other listed and unlisted species collapsed.

43. DWR exports water that it claims is excess or surplus under Article 21 of the amended State Water Project contracts. The exported water is used largely to further development, water banking, and water transfers. Despite the recent and dramatic further decline in the health of the Bay-Delta estuary, DWR has continued to export increasing amounts of water in violation of D-1641, causing some substantial fish declines between the years of 2000 and 2010 with the approval of the SWRCB.

44. In 2008, 2009, and 2010 the populations of various California salmon runs have dramatically declined, resulting in the complete closure of commercial and sport-fishing salmon fishing in California for the 2008 and 2009 fishing seasons, and a substantial reduction in fishing in 2010. The number of Chinook or King salmon returning from the Pacific Ocean to spawn in the Sacramento River and its tributaries this fall dropped 67 percent from a year earlier.

45. Every scientific study done in the last decade (CalFed ROD, IEP Science Reviews, OCAP Biological Opinions on Delta smelt and listed salmonids) has found that exports from the Bay-Delta are largely to blame for the current fish and wildlife declines in the Delta.

46. The fish protection conditions of D-1641, when they are not enforced and allow increased export pumping, are not protective of the Bay-Delta fisheries. The lack of protection has resulted in a serious decline in the health of those fisheries and in their habitat. Increased SWP pumping necessarily decreases in-stream flow and Delta outflow, thereby increasing the concentration of pesticides, herbicides, and other toxins in the Bay-Delta waterways. Increased

export pumping by the SWP since 2000 has had a significant, negative impact on the survival of juvenile Chinook salmon emigrating through the Delta, particularly in the November through June period.

47. Numerous scientific studies, including the SWRCB's recent report to the State Legislature, indicate that increasing flows from the SWP to the Delta in the spring would protect marine wildlife habitat and the threatened water ecosystem. Increased flows in the San Joaquin River correlate to increased numbers of adult fall-run Chinook salmon, and spring flow coincides with the spawning season of a number of estuarine species, such as delta smelt, Sacramento split-tail, Green sturgeon, and striped bass.

48. The SWRCB has a duty of continuing supervision over the taking and use of appropriated water, and must allocate water resources in light of current knowledge and current needs. In the face of mounting evidence that water exports are harming fish and wildlife since 2000, the Board has refused to reduce DWR's water rights and export permits and has failed to evaluate permit conditions that would protect fish and wildlife and would reflect changed environmental circumstances in the Bay-Delta.

49. The SWRCB has continuously refused to act on public trust complaints against DWR and its activities at the Banks pumping plant, and has rejected Petitioners' attempts to address the allegations contained herein through administrative proceedings.

50. On January 5, 2010 the SWRCB modified WR Order 2006-0006 and the related Cease and Desist Order (CDO) against DWR for threatened violation of their permit/license requirements to meet the 0.7 EC standard in the interior southern Delta. Petitioners had strongly opposed the modification of the CDO, which had required complete compliance with the permit and license requirements by July of 2009. In its decision to modify the CDO in WR Order 2006-0006, the Board largely dismissed fish and wildlife concerns under the public trust, and failed to enforce Article X, Section 2 of the California Constitution.

51. By approving WR Order 2010-0002, the SWRCB has allowed Respondent DWR to violate the conditions of their permits, the agricultural water quality standards in the Bay-

Delta, D-641, and the CDO (WR Order 2006-0006), and has failed to exercise its duty to protect the public trust and guard against waste and unreasonable use.

FIRST CAUSE OF ACTION
Violation of the California Public Trust Doctrine

52. Petitioners restate and re-allege and incorporate all of the preceding paragraphs as if fully set forth herein.

53. Respondent DWR has increasing annual pumping in violation of the Public Trust Doctrine since 2000, despite the increasingly perilous collapse of Delta fish populations of salmon, striped bass, Delta smelt, and other listed and unlisted species.

54. Respondent DWR's decision to continue pumping despite the obvious damage to public trust resources has caused there to be a substantial decline in the food web, in fish numbers, in water quality, and in hydrologic changes which have caused injury to the ecosystem and to members of the public, including Petitioners. Present ecological conditions in the Bay-Delta have contributed to the closure of the commercial and sport-fishing fishing seasons off the California Coast, resulting in the near complete loss of recreational fishing opportunities for anglers.

55. On information and belief, unless the DWR is enjoined by this court, it will continue to violate the Public Trust, as described above, and Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

56. An actual controversy exists between Petitioners and Respondent DWR. Specifically, Petitioners contend and Respondent DWR denies that its pumping methods constitute a violation of the California Public Trust doctrine or that its failure to abide by salinity standards set by their water rights permits violates the Public Trust and injures Petitioners. As an actual controversy exists, Petitioners are entitled to and hereby seek a declaration that Respondent DWR has violated the Public Trust.

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SECOND CAUSE OF ACTION
Violation of Article 10, Section 2 of the California Constitution:
Unreasonable Method of Diversion

57. Petitioners restate and re-allege and incorporate all of the preceding paragraphs as if fully set forth herein.

58. Article X, Section Two of the California Constitution states that "the right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water."

59. Water levels in several Delta channels are reduced to unacceptably low levels by Respondent DWR's operation of the State Water Project pumps, harming fish and riparian diverters in the process. At present export levels, DWR's Method of Diversion from the Bay-Delta at the export pumps is unreasonable and has overwhelmingly contributed to the pelagic fish decline and the listing of several species as threatened or endangered.

60. Over the years and continuing to the present time, Respondent DWR's methods of diversion caused there to be insufficient in-stream flow and Delta outflow to support the environmental needs of the estuary which has caused injury to the ecosystem and to members of the public, including Petitioners.

61. Over the years and continuing to the present time, Respondent DWR has used an unreasonable method of diversion of water from their facilities in the Bay-Delta in violation of Article 10, Section Two of the California Constitution by continuing to increase volumes of water drawn from the Bay-Delta ecosystem, and limiting and ignoring research and information that indicated this method of diversion is causing a collapse in the Pelagic fisheries in the Bay-Delta and harm to the listed salmonids and other fish and wildlife.

62. On information and belief, unless enjoined Respondent DWR will continue to violate the California Constitution, as described above.

63. In light of the Respondent DWR's failure to comply with the California Constitution, and the significant likelihood of repeated violations in the future, Respondent DWR

must be permanently enjoined from continuing to divert water from the Bay-Delta until they comply with Article X, Section Two of the California Constitution. If Respondent DWR is not so enjoined, Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

64. An actual controversy exists between Petitioners on the one hand and Respondent DWR on the other. Specifically, Petitioners contend and Respondent DWR denies that its pumping methods constitute a violation of Article 10, Section Two of the California Constitution for unreasonable use methods of diversion, causing injury to Petitioners. As an actual controversy exists, Petitioners are entitled to, and hereby seek, a ruling that Respondent DWR has violated Article X, Section 2 of the California Constitution for unreasonable method of diversions.

THIRD CAUSE OF ACTION
Violation of Article X, Section 2 of the California Constitution: Unreasonable Use

65. Petitioners restate and re-allege and incorporate all of the preceding paragraphs as if fully set forth herein.

66. Article X, Section Two of the California Constitution states that, due to the conditions prevailing in the State “the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.”

67. Further, Article X, Section Two specifically states that “the right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.”

68. SWP export pumping from the Delta for water banking and resale by Respondent DWR at the current levels is an unreasonable use of the water resources of this State. Export pumping adversely effects fish and wildlife resources in the Delta, including spring-run Chinook

salmon (listed as threatened under the CESA and ESA) and winter-run Chinook salmon (listed as endangered under the CESA and ESA). The adverse impacts to fish include decreases in salmon smolt survival during outmigration from changes in hydrologic patterns in the Delta (increases in net reverse flows), entrainment at the export pumps, and increased predation at the pumps. On information and belief, unless enjoined Respondent DWR will continue to violate the California Constitution, as described above.

69. In light of the Respondent DWR's failure to comply with the California Constitution, and the significant likelihood of repeated violations in the future, Respondent DWR must be permanently enjoined from continuing to divert water from the Bay-Delta until they can comply with all applicable water quality standards and fish protection mechanisms, including appropriate screening of diversions. If Respondent DWR is not so enjoined, Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

70. An actual controversy exists between Petitioners on the one hand and Respondent DWR on the other. Specifically, Petitioners contend and Respondent DWR denies that its operation of the SWP violates Article X, Section Two of the California Constitution and injures Petitioners. As an actual controversy exists, Petitioners are entitled to, and hereby seek, a ruling that Respondent DWR has violated Article X, Section 2 of the California Constitution by failing to use water reasonably.

FOURTH CAUSE OF ACTION
Violation of the 1995 Water Quality Control Plan
Narrative Standard for Fish and Wildlife

71. Petitioners restate and re-allege and incorporate herein the foregoing paragraphs of this Complaint.

72. In accordance with the SWRCB 1995 Water Quality Control Plan, the Board adopted a narrative standard for fish and wildlife to double the natural production of salmon from the average number of fish in the Bay-Delta between the years 1967-1991. Due to the dramatic decline in salmon populations, Respondent DWR has failed to comply with the narrative salmon doubling standard as required by law.

73. In light of Respondent DWR's violation of the standard, and considering the significant likelihood of repeated violations in the future, Respondent DWR must be enjoined from export pumping at the Banks pumping facility in the Delta until such a time as DWR can operate in compliance with the narrative standard for fish and wildlife. If Respondent DWR is not so enjoined, Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

74. An actual controversy exists between Petitioners on the one hand and Respondent DWR on the other. Specifically, Petitioners contend and Respondent DWR denies that it is violation of the 1995 Narrative standard. As an actual controversy exists, Petitioners are entitled to, and hereby seek, a ruling that Respondent DWR has violated the 1995 Water Quality Control Plan Narrative Standard for Fish and Wildlife.

FIFTH CAUSE OF ACTION
Violation of and Failure to Enforce State Board Decision 1641

75. Petitioners restate and re-allege and incorporate herein the foregoing paragraphs of this Complaint.

76. Board decision 1641 implemented flow objectives for the Bay-Delta Estuary that Respondent DWR was specifically charged with meeting. Respondent DWR has repeatedly failed to meet the flow objectives in the Bay-Delta.

77. Respondent Board has a statutory duty to comply with its own water quality control plan, and has failed to enforce the flow objectives against Respondent DWR as set out in D-1641.

78. DWR has an affirmative duty to meet the interior southern Delta salinity objectives established pursuant to D-1641, yet the Board's approval of WR Order 2010-0002 obviates DWR's mandatory compliance with those standards until an undisclosed, future date.

79. In light of the Respondents DWR's failure to comply with Decision 1641, Respondent Board's failure to enforce D-1641 as required by law, and the significant likelihood of repeated violations in the future, Respondent DWR must be permanently enjoined from continuing to export water from the Bay-Delta until such a time as they fully comply with the

requirements of D-1641. If Respondent is not so enjoined, Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

80. An actual controversy exists between Petitioners on the one hand and Respondent DWR on the other regarding the extent to which their export pumping violates the conditions of D-1641, and Respondent Board's duty to enforce D-1641 as against DWR. Specifically, Petitioners contend and Respondent DWR denies that they are in violation of D-1641 by their export pumping in the Bay-Delta. Petitioners further contend and Respondent Board denies that they decided WR Order 2010-0002 without substantial evidence on the record and that their decision was arbitrary and capricious. As an actual controversy exists, Petitioners are entitled to, and hereby seek, a ruling that Respondent DWR is in violation of D-1641 and that Respondent Board decided WR Order 2010-0002 without substantial evidence in the record thereby rendering their decision arbitrary and capricious.

SIXTH CAUSE OF ACTION
Failure to Enforce Requirements of the Porter-Cologne Act

81. Petitioners restate and re-allege and incorporate herein the foregoing paragraphs of this Complaint.

82. Respondent SWRCB's actions in WR Order 2010-0002 constituted a prejudicial abuse of discretion, in that Respondent SWRCB did not proceed in the manner required by the Porter-Cologne Act, and substantial evidence does not support their Findings, as set forth below.

83. WR Order 2010-0002 fails to adequately analyze the reasonably foreseeable adverse effects of continued exceedence of the interior southern Delta salinity standards would have on fish and wildlife, water quality, and Delta agriculture in the Bay-Delta.

84. Respondent DWR has violated, and continues to violate, the interior southern Delta salinity standards required by D-1641. The SWRCB refuses to hold DWR to the water quality standards required by D-1641 and the Porter-Cologne Act, and the significant likelihood that DWR will continue to violate these standards in the future, demands that Respondent SWRCB must be required to set aside WR Order 2010-0002 and hold DWR to the requirements of Order WR 2006-0006. If Respondent DWR is allowed to continue pumping at the Banks

pumping facility in violation of the water quality standards, Petitioners will suffer irreparable injury for which there is no adequate remedy at law.

85. An actual controversy exists between Petitioners and SWRCB. Specifically, SWRCB denies Petitioners' contention that the Board is in violation of the Porter-Cologne Act. Petitioners allege that the SWRCB's method of "enforcing" DWR's permit conditions is not enforcement at all, and the adoption WR Order 2010-0002 is not based on substantial evidence. As an actual controversy exists, Petitioners are entitled to seek, and hereby do seek, a declaratory ruling that Respondent DWR is pumping in violation of the water quality standards of D-1641 with the SWRCB's permission in violation of the Porter-Cologne Act. Petitioner's further request a writ of administrative mandate requiring Respondent SWRCB to enforce the Porter-Cologne Act as required by law.

PRAYER FOR RELIEF

WHEREFORE, Petitioners respectfully request that the Court enter judgment as follows:

1. For a declaration that Respondent DWR's operations have violated the California Public Trust in the Bay-Delta;

2. For a declaration that Respondent DWR's operations are an unreasonable method of diversion in violation of Article X, Section 2 of the California Constitution;

3. For a declaration that Respondent DWR's operations are an unreasonable method of use in violation of Article X, Section 2 of the California Constitution;

4. For a declaration that Respondent DWR's operations have violated the 1995 Water Quality Control Plan narrative standard for salmon in that Respondent DWR has failed to meet the required doubling of the salmon population under the 1995 Water Quality Control Plan;

5. For a declaration that Respondent SWRCB has failed to enforce, and Respondent DWR's operations have violated, Decision 1641 in that Respondent DWR has failed to meet flow objectives necessary to protect beneficial uses in the Bay-Delta;

6. For a declaration that Respondent SWRCB has failed to enforce DWR's permit and license conditions under the Bay-Delta Water Quality Control Plan in accordance with the Porter-Cologne Act;

7. That the Court enjoin Respondent DWR from diverting water from the Bay-Delta until such a time as Respondent DWR's operations conform with the law;

8. That the Court enjoin Respondent SWRCB from allowing operation of state water export projects until such a time that Respondent DWR come into compliance with the law;

9. That the Court direct Respondents to remedy their violations of the California Public Trust, Article X, Section 2 of the California Constitution, the Porter-Cologne Act, the 1995 Water Quality Control Plan, and Decision 1641 within a reasonable time;

10. That the Court issue a writ of administrative mandate vacating and setting aside WR Order 2010-0002;

11. That the Court retain jurisdiction over this matter until such time as Respondents have fully complied with the law;

12. That the Court award Petitioners their costs of litigation pursuant to California Code of Civil Procedure § 1021.5; and

13. That the Court grant Petitioners such other further relief, including injunctive relief, as the Court may deem just and proper.

Dated: April 21, 2011

____

Michael B. Jackson
Attorney for Petitioners
C-WIN, CSPA, and AquAlliance

VERIFICATION

I, Michael B. Jackson, am the attorney for Petitioners herein and am authorized to execute this on their behalf. I have read the foregoing Petition for Writ of Mandate and Complaint for Injunctive and Declaratory Relief and am informed and believe, and thereon allege, that the matters stated therein are true and correct. I sign this verification on behalf of Petitioners pursuant to Code of Civil Procedure § 446, as Petitioners are located outside the county in which my office is located.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct and that this verification was executed on April 21, 2011 in Quincy, California.

____

Michael B. Jackson

Critique of Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report Public Draft

Economic Issues

December 1, 2014

Prepared for:

AquAlliance

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Contact Information

Mark Buckley, Lizzie Gooding, Ed MacMullan, and Sarah Reich prepared this report. ECONorthwest is solely responsible for its content.

ECONorthwest specializes in economics, planning, and finance. Established in 1974, ECONorthwest has over three decades of experience helping clients make sound decisions based on rigorous economic, planning and financial analysis.

For more information about ECONorthwest, visit our website at www.econw.com.

For more information about this report, please contact:

Ed MacMullan

ECONorthwest
72 West Broadway, Suite 206
Eugene, OR 97401
541-687-0051
macmullan@econw.com

Table of Contents

Executive Summary ES-1

1 Introduction and Context 1

2 The LTWT ignores relevant background information about the affected environment that would have helped inform the analysis 3

3 The LTWT relies on outdated and incomplete data 13

4 The LTWT underestimates negative impacts on the regional economy in the sellers area 20

5 The LTWT finds significant negative effects but the vague and incomplete proposed monitoring and mitigation plans would not address these effects 24

6 The LTWT ignores the economic costs of environmental externalities and subsidies that water transfers support 29

7 The LTWT underestimates the cumulative effects of water transfers 33

Executive Summary

The US Bureau of Reclamations and San Luis & Delta-Mendota Water Authority released the Public Draft of the *Long-Term Water Transfers Draft Environmental Impact Statement/Environmental Impact Report* (LTWT) in September 2014. The purpose of the LTWT, as we understand, is to evaluate the potential impacts of three proposed water-transfer alternatives, as well as a no action alternative. AquAlliance asked ECONorthwest to critique and provide written comments on the LTWT.

In general, the analysis described in the LTWT suffers from significant omissions and errors. These omissions and errors matter. As written the report provides stakeholders and decisions makers with a biased and incomplete description of the environmental and economic consequences of water transfers. In the following sections of this report we describe our critiques in detail. Our major critiques include the following.

The LTWT ignores relevant background information about the affected environment that would have helped inform the analysis. The LTWT provides a cursory description of the relevant affected environment that paints an incomplete picture of the context within which water transfers would happen. A more complete, accurate and up-to-date description would have included, for example: information from the many recent reports on California's climate and groundwater conditions; current data on water transfers; and, a market analysis of water prices, prices for agricultural commodities and how price changes influence the number and volumes of water transfers. As such, the deficient description is the shaky foundation upon which a lacking analysis rests. The resulting effort yields questionable results regarding the likely future frequency and amounts of water transfers and their environmental and economic consequences.

The LTWT relies on outdated and incomplete data. The analysis described in the LTWT relies on obsolete data for certain key variables and ignored other relevant data and information. For example, the analysis assumes a price for water that bears no resemblance to the current reality. It also ignored relevant research results on the impacts of groundwater pumping on stream flow depletion and the current status of groundwater levels as provided by monitoring wells. The water transfers at issue in the LTWT would not happen in an economic vacuum. Growers and water sellers and buyers react to changing prices and market conditions. The analysis described in the LTWT, however, is silent on these forces and how they would influence water transfers.

The LTWT underestimates negative impacts on the regional economy in the sellers area. The LTWT acknowledges that negative economic impacts would be worse if water transfers happen over consecutive years. The analysis, however, estimates impacts for single-year transfers, ignoring the data on the frequency of recent consecutive-year transfers. The analysis also fails to address the extent to which water transfers cause economic harm to water-based recreational activities.

The LTWT finds significant negative effects but the vague and incomplete proposed monitoring and mitigation plans would not address these effects. The LTWT proposed both a monitoring and mitigation program for significant negative impacts. Implementing these programs would take planning, effort and financial resources on the part of sellers, injured third parties, and regulatory agencies. The LTWT does not include these costs. The monitoring program is vague and depends on potential sellers implementing the program. This conflict of interest pits financial gain from water sales against complete and impartial monitoring efforts. This opens the door to lax, biased, or incomplete monitoring, which could lead to negative environmental and economic consequences for third parties. The monitoring program includes monitoring subsidence, however, the program is vague on requirements and what amount of subsidence would trigger a halt in water transfers. Injured third parties would bear the costs of bringing to the sellers' attention harm caused by groundwater pumping. The analysis described in the LTWT assumes that disagreements regarding third-party damages would be settled cooperatively between third parties and sellers, without presenting evidence substantiating such an optimistic assumption. The LTWT is silent on the economic consequences of sellers and injured third parties not cooperatively agreeing on harm and compensation.

The LTWT ignores the environmental externalities and economic subsidies that water transfers support. The LTWT lists Westlands Water District as one of the CVP contractors expressing interest in purchasing transfer water. The environmental externalities caused by agricultural production on Westlands are well documented, as are the economic subsidies that support this production. To the extent that the water transfers at issue in the LTWT facilitate agricultural production on Westlands, they also contribute to the environmental externalities and economic subsidies of that production. The LTWT is silent on these environmental and economic consequences of the water transfers.

The LTWT underestimates the cumulative effects of water transfers. Cumulative effects analyses under NEPA and CEQA are intended to identify impacts that materialize or are compounded when the proposed action is implemented at the same time as or in conjunction with other actions. The LTWT addresses cumulative effects for each resource area and provides a global description of the methods and actions considered for analysis in each resource area. The analysis, however, provides cursory discussion of potential cumulative effects for the regional economy, and ignores the full range of possible cumulative outcomes associated with the proposed transfer

1 Introduction and Context

The US Bureau of Reclamations (BOR) and San Luis & Delta-Mendota Water Authority (SLDMWA) released the public draft of the *Long-Term Water Transfers Draft Environmental Impact Statement/Environmental Impact Report* (LTWT) in September 2014. The LTWT covers water transfers that would happen between 2015 through 2024. Because the transfers would use federal and state infrastructure, the LTWT must comply with NEPA and CEQA guidelines. BOR is the lead agency regarding NEPA requirements, and SLDMWA is the lead agency for CEQA requirements.[1]

The premise underlying the proposed water transfers is that sellers, mostly in the Sacramento Valley, would idle cropland, switch to less water-intensive crops, and/or substitute groundwater for surface water, and send the surface water they would other wise have used through the Bay Delta to buyers in the south.

The proposed transfers would happen within a context of environmental conditions that both highlight the increasing demand for water throughout California and raise concerns regarding the environmental and economic effects of the water transfers at issue in the LTWT. These conditions include:

- Current drought conditions of historic proportion coming on the heals of consecutive dry years.
- Increasing concerns over the demands on groundwater and groundwater conditions throughout the state, including in the Sacramento Valley.
- Increasing competition for water from all user groups including agricultural, municipal and industrial users, and environmental requirements that help protect habitats and water quality.

Within this context, regulatory agencies face increasing demands from stakeholders for transparent decisions that rely on the best available science and information when balancing competing demands. For example, the relevant NEPA requirements for the LTWT analysis include:

> "Rigorous exploration and objective evaluation of all reasonable alternatives, …"[2]

AquAlliance asked ECONorthwest to review the LTWT and provide comments on the extent to which the analysis described in the report fulfills the NEPA requirement. We describe the results of our initial review and critique of the document in this report. The relatively short

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[1] LTWT, page 1-1, 2-1.

[2] LTWT page 2-1.

public comment period limited the extent of our review. Should the comment period be extended or reopened, we may expand and revise our comments.

The remainder of our report is as follows. In the next section, Section 2, we comment on the LTWT's incomplete description of the affected environment within which the water transfers would happen. We cite sources with relevant information that if included would yield a more complete and comprehensive description of the affected environment.

In Section 3 we highlight deficiencies in the data and analysis described in the LTWT. For example, we note that the model relies on outdated prices for water and agricultural commodities—two central components of the analysis. The analysis also estimates that water transfers would happen in a static environment where water prices and commodity prices remain fixed. These conditions do not reflect the dynamic reality of water demands and use.

In Section 4 we note instances in which the analysis described in the LTWT underestimates the impacts of water transfers on the regional economy in the source-water areas.

In Section 5 we draw attention to some of the deficiencies of the proposed monitoring and mitigation programs that the LTWT's authors claim will adequately address any negative effects of the transfers. These deficiencies include the inherent conflicts of interests in the programs, excluding the costs of the programs, and vague and ill-defined critical components of the programs.

In Section 6 we describe some of the environmental and economic externalities associated with the use of the transferred water.

In Section 7, we list some of the deficiencies in the analysis of cumulative effects. For example, the analysis ignores the impacts of transfers that would happen in addition to those at issue in the LTWT.

2 The LTWT ignores relevant background information about the affected environment that would have helped inform the analysis

The LTWT provides a cursory description of the relevant affected environment that paints an incomplete picture of the context within which water transfers would happen. A more complete, accurate and up-to-date description would have included, for example: information from the many recent reports on California's climate and groundwater conditions; current data on water transfers; and, a market analysis of water prices, prices for agricultural commodities and how price changes influence the number and volumes of water transfers. As such, the deficient description is the shaky foundation upon which a lacking analysis rests. The resulting effort yields questionable results regarding the likely future frequency and amounts of water transfers and their environmental and economic consequences.

Specific concerns regarding the LTWT's incomplete description of the affected environment in the Sacramento Valley include the following.

Incomplete description of current climate conditions

According to the California Department of Water Resources (DWR), 2013 was the driest year on record for many parts of the state.[3] Such drought conditions are one reason given for why growers and municipal and industrial (M&I) users in the south would purchase water from other parts of California. The analysis described in the LTWT fails to acknowledge, however, that other parts of the state, including the Sacramento Valley, also feel the effects of drought. How agricultural and M&I water users in the north respond to recent drought conditions would affect water transfers. The authors of the LTWT exclude these factors from their analysis.

For example, in a recent letter to the BOR, the Glenn-Colusa Irrigation District (GCID) indicated they were developing a groundwater supplemental supply program and that developing this program takes priority over participating in water transfers as described in the LTWT.

> "GCID's position is that it will pursue, as a priority, the proposed Groundwater Supplemental Supply Program over any proposed transfer program within the region, including Reclamation's Long-Term Water Transfer Program (LTWTP)."

[3] California Department of Water Resources (DWR). 2014a. *Public Update for Drought Response Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring*. April 30. Page ii.

> "… It is important to underscore that GCID would prioritize pumping during dry and critically dry water years for use in the Groundwater Supplemental Supply Program, and thus wells used under that program would not otherwise be available for USBR's LTWTP."[4]

GCID's focus on its own groundwater program over BOR water transfers is notable because the LTWT lists GCID as a potential seller with the largest volume of water for sale, 91,000 af.[5] GCID's reasons for pursuing its groundwater supply program include concerns over water availability during dry years.

> "The primary objective is to develop a reliable supplemental water source for GCID during dry and critically dry years. The proposed goals are as follows:
>
> - Increase system reliability and flexibility
> - Offset reductions in Sacramento River diversions by GCIS during drought years to replace supplies for crops and habitat
> - Periodically reduce Sacramento River diversions to accommodate fishery and restoration flows
> - Protect agricultural production"[6]

A related point is that the LTWT fails to discuss the possibility that current climate and water conditions may represent a new benchmark rather than a deviation from past trends. The increasing number of years with water transfers (described below), and reports on climate change and its impacts on water conditions, are two arguments in support of exploring this point. For example, according to a report commissioned by the Northern California Water Association (NCWA),

> "This year [2014] we face unprecedented drought conditions, following a decade of relatively dry years and increased demands on our groundwater resources. These increased demands have two principal causes. The reduced availability of surface water during dry years brings a predictable shift towards greater use of groundwater. The second is expanding and intensifying agricultural land use within the Sacramento Valley, together with increasing urban water demands, leading to increased reliance on groundwater even in 'normal' years."[7]

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[4] Bettner, T. 2014. *Letter to Brad Hubbard, Bureau of Reclamation* re Draft EIS/EIR on Proposed Long-Term Water Transfer Program. Glenn-Colusa Irrigation District. October 14. Pages 1 and 3.

[5] LTWT, Table 2-4, page 2-14.

[6] Bettner, 2014, page 2.

[7] Davids Engineering, Macaulay Water Resources, and West Yost Associates (DMW). 2014. *Sacramento Valley Groundwater Assessment Active Management – Call to Action.* Prepared for Northern California Water Association. June. Page 2.

Fails to consider concerns regarding the oversubscription of water resources

The analysis described in the LTWT fails to acknowledge the problem of supporting water transfers using "paper water," or oversubscribed water in the Sacramento Valley. A report on water transfer issues in California describes one aspect of this problem.

> "The inability of interested parties to agree on the volume of transferable water associated with the short-term fallowing of agricultural lands has caused substantial controversy and delays in approving certain water transfer proposals. The primary issue for interested parties is whether a fallowing-based transfer proposal would actually increase the burden on the CVP and SWP to maintain water quality and flow conditions in downstream portions of the Sacramento River and Delta because upstream transfer proponents were allowed to transfer what might prove to be 'paper' water."[8]

Stakeholders in the Sacramento Valley concerned about this problem researched the extent of paper water and found that rights to water significantly exceed available supply. Testimony by the California Water Impact Network submitted to the State Water Resources Control Board concluded that, "The ratio of total consumptive use claims to average unimpaired flow in the Sacramento River Basin is about 5.6 acre-feet of claims per acre-foot of unimpaired flow."[9] Thus, claims on water in the Sacramento Valley significantly exceed the available supply.

Incomplete description of current groundwater conditions

The LTWT excluded current information on groundwater conditions in the Sacramento Valley. This information includes concerns regarding historically low groundwater levels in certain areas of the Sacramento Valley, related concerns over subsidence caused by depleted groundwater, and a lack of groundwater monitoring information.

According to the DWR, groundwater levels are decreasing through out California, including in the Sacramento Valley. Groundwater levels decreased since the spring of 2013, and "notably" since the spring of 2010.[10] A related point, according to the DWR, is that there are "significant" gaps in groundwater monitoring data for areas throughout the state, including the Sacramento Valley.[11] There's also a lack of understanding

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[8] The Water Transfer Workgroup. 2002. Water transfer issues in California. Final Report to the California State Water Resources Control Board. June, page 20.

[9] Stroshane, T. 2012. *Testimony on water availability analysis for Trinity, Sacramento, and San Joaquin River basins tributary to the Bay-Delta Estuary*. October 26. California Water Impact Network. For Workshop #3 Analytical Tools for Evaluating the water Supply, Hydrodynamic, and Hydropower Effects of the Bay-Delta Plan November 13 and 14, 2012. Page 11.

[10] DWR, 2014a, page ii.

[11] DWR, 2014a, page ii.

regarding groundwater recharge and interactions between surface and groundwater in the Sacramento Valley. According to the NCWA report,

> "[G]roundwater changes can take many years to become apparent, and we have not yet been able to measure with certainty the long-term impacts of the current level of groundwater use as it affects our measures of sustainability."
>
> "Persistently declining groundwater levels in many areas of the Sacramento Valley over the past decade reveal that groundwater discharge exceeds recharge. Simply put: if the objective is to stem or reverse the trend, the groundwater balance must be adjusted either by putting more water into the ground or taking less out."[12]

According to the DWR, the Sacramento River hydrologic region has 23 groundwater basins ranked "high" or "medium" as described by the CASGEM groundwater basin prioritization study. These rankings describe a groundwater basin's importance in meeting demands for urban and agricultural water use. The San Joaquin River hydrologic region has nine "high," or "medium" ranked basins.[13]

A recent report from Glenn County indicates that current groundwater levels in the county are at the lowest levels recorded going back to the start of record keeping in the 1920s.

> "Data in reference to groundwater levels has been collected from both private and dedicated monitoring wells located within Glenn County, in some cases dating as far back as the 1920's. The lowest levels in these wells were most frequently associated with measurements from the 1976-77 monitoring period, which coincided with one of the more severe droughts in California's history. In the years following the 76-77 drought, groundwater levels often approached these historic lows but rarely fell below them. However, recent (2012-13) data indicate levels in many wells have declined below those historic thresholds and are now at the lowest levels observed since monitoring began."[14]
>
> "Readily available monitoring data obtained through DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) is available for 100 wells, and of those 100, 21 still show their lowest levels as occurring in 1977, while 21 had an all-time low water surface elevation level in 2013, and an

[12] DMW, 2014, page 10.

[13] DWR, 2014b. *California Groundwater Elevation Monitoring Basin Prioritization Process*. June. Page 5.

[14] Glenn County Water Advisory Committee, Ad-hoc Committee. 2014. *Report on Groundwater Level Declines in Western Glenn County*. May 6. Page 5.

additional 15 wells reached their lowest point in 2009-2012. Therefore, one out of every five monitored wells in the area was at its lowest-ever recorded level in 2013, and one out of every three wells monitored in the area was at its lowest-ever recorded level between 2009 and 2013."[15]

Regarding the limited groundwater modeling described in the LTWT, consulting hydrologist Kit Custis comments,

> "Because the groundwater modeling effort [described in the LTWT] didn't include the most recent 11 years record, it appears to have missed simulating the most recent periods of groundwater substitution transfer pumping and other groundwater impacting events, such as recent changes in groundwater elevations and groundwater storage [citation omitted], and the reduced recharge due to the recent periods of drought. Without taking the hydrologic conditions during the recent 11 years into account, the results of the SACFEM2013 model simulation may not accurately depict current conditions or predict the effects from the proposed groundwater substitution transfer pumping during the next 10 years."[16]

The DWR reports that areas of the Sacramento Valley are at risk for subsidence from depleted groundwater. Most of the groundwater basins susceptible to future subsidence are also ranked "high" and "medium" priority by the CASGEM groundwater basin prioritization analysis. According to the DWR and based on data from 2008 through 2014, approximately 36 percent of long-term wells surveyed in the Sacramento Valley are at or below the historical spring low levels. Another measure indicates that 50 percent of groundwater levels in 18 groundwater basins in the Sacramento Valley are at or below historical spring low levels.[17] A white paper by a consulting engineer on groundwater use and subsidence in the Sacramento Valley noted that subsidence may happen years after groundwater pumping and that real-time monitoring of groundwater pumping "will generally tend to underestimate the long-term settlement of the ground surface."[18]

Subsidence can cause substantial economic harm. According to a report by consulting engineers studying subsidence in California,

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[15] Glenn County Water Advisory Committee, Ad-hoc Committee. 2014. *Report on Groundwater Level Declines in Western Glenn County*. May 6. Page 6.

[16] Custis, K. 2014. *Letter to Barbara Vlamis*, November 10. RE: Comments and recommendations on U.S. Bureau of Reclamation and San Luis & Delta-Mendota Water Authority Draft Long-Term Water Transfer DRAFT EIS/EIR, dated September 2014. Page 5.

[17] DWR, 2014c. *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California*. Pages 9, 11.

[18] Mish, D. 2008. *Commentary on Ken Loy GCID Memorandum*. Page 4.

> "Land subsidence has been discovered in many areas of the state, causing billions of dollars of damage. Impacts from subsidence fall into the following categories:
>
> - Loss of conveyance capacity in canals, streams and rivers, and flood bypass channels;
> - Diminished effectiveness of levees;
> - Damage to roads, bridges, building foundations, pipelines, and other surface and subsurface infrastructure; and
> - Development of earth fissures, which can damage surface and subsurface structures and allow for contamination at the land surface to enter shallow aquifers."[19]

Subsidence in Colusa, Yolo and Solano counties in the Sacramento Valley during the 1976-77 drought caused widespread well casing damages, which made some wells unusable.[20] A recent series of reports by the Stanford Woods Institute for the Environment and the Bill Lane Center for the American West at the Water in the West center at Stanford University describe the subsidence concerns regarding groundwater pumping in California, including the Sacramento Valley.[21] Custis notes the types of infrastructure in the Sacramento Valley susceptible to damage from subsidence,

> "There are a number of critical structures in the Sacramento Valley that may be susceptible to settlement and lateral movement. These include natural gas pipelines, gas transfer and storage facilities, gas wells, railroads bridges, water and sewer pipelines, water wells, canals, levees, other industrial facilities."[22]

In response to concerns over groundwater use and related issues, the California legislature recently passed, and Governor Brown signed into law, the Sustainable Groundwater Management Act (Act).[23] The Act will affect groundwater users including those supplying water transfers. The LTWT makes no mention of how the Act could affect the context within which water transfers would happen, or the transfers themselves. This is a significant omission.

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[19] Borchers, J. and M. Carpenter. 2014. *Land Subsidence from Groundwater Use in California*. Luhdorff & Scalmanini Consulting Engineers. Support provided by the California Water Foundation. April. Page ES-2.

[20] Borchers, J. and M. Carpenter. 2014. *Land Subsidence from Groundwater Use in California*. Luhdorff & Scalmanini Consulting Engineers. Support provided by the California Water Foundation. April. Page ES-3.

[21] Water in the West. 2014. *Understanding California's Groundwater*. waterinthewest.stanford.edu.

[22] Custis 2014, page 28.

[23] opr.ca.gov/s_groundwater.php.

Carriage Water Costs

The LTWT assumes that required carriage water component of water transfers from the Sacramento River will account for 20 percent of transferred water.

> "Transfers from the Sacramento Rive assume a 20 percent carriage water adjustment to maintain Delta salinity."[24]

Recent data on the percentage of required carriage water are higher than the 20-percent assumption in the LTWT. For example, the DWR describes a recent carriage water percentage of 30.

> "Another cost related to transferring water is carriage water. … For the Sacramento River, this has generally been about 20 percent of the transfer water … It is worth noting, however, that in 2012 and 2013 carriage water losses for the Sacramento River were as high as 30 percent of transfer water."[25]

To the extent that carriage water requirements exceed 20 percent, the LTWT overestimates the amount of water delivered south through the Bay Delta to water purchasers, and thus the economic benefits of these transfers.

Data and modeling ignore recent trends in water transfers

Using water data from 1970 through 2003, the LTWT estimates that future water transfers will happen on average 12 out of 33 years.[26] Twelve of 33 years is a transfer probability of approximately 36 percent. By ignoring water data for years after 2003, the analysis excludes relevant information on the more recent dry trend and current historical drought. For example, Table 1-3 on page 1-17 of the LTWT lists years and amounts of water transfers from 2000 through 2014. This data shows that water transfers happened in 9 of the previous 15 years, or a transfer probability of 60 percent, almost double that used in the LTWT. For years after 2003, transfers happened in eight out of 11 years, for a transfer percent of approximately 73.

Other sources of data on the frequency of water transfers do not support the LTWT's water-transfer results. For example, a report by the Western Canal Water District (WCWD) includes a table showing water transfers from the Sacramento Valley through the Bay Delta from 2001 through projected 2010. The information in this table shows transfers happening in eight out of ten years.[27] A similar report by WCWD in 2014

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[24] LTWT page B-18.

[25] California Department of Water Resources. 2013. California Water Plan 2013 Update. Bulletin 160-13. Volume 3 Resource Management Strategies. Pages 8-9.

[26] LTWT, page 3.3-60 and -61.

[27] Western Canal Water District (WCWD). 2009. *Initial Study and Proposed Negative Declaration for Western Canal Water District 2010 Water Transfer Program*. Western Canal Water District, Richvale, California. January. Page 25.

included a table of water transfers for years 2006 through projected 2014. The data in that table shows transfers happening during seven of nine years.[28] Taken together, these two reports show water transfers from the Sacramento Valley south through the Bay Delta in 11 out of 14 years between 2001 through 2014. This works out to a transfer probability of approximately 79 percent.

These results demonstrate two important points. First, using a transfer probability of 36 percent greatly underestimates the actual years that transfers happened post-2003, the last year of data in the LTWT analysis. Underestimating transfers leads to underestimating the environmental and economic effects of the transfers.

Second, the data upon which conclusions in the LTWT rest do not depict actual conditions post-2003. That is, by relying on flawed or incomplete data, models that use this data produce flawed or biased results. The estimated transfer frequency (36 percent of years), does not match the recent actual transfer frequency (60, 73, or 79 percent, depending on the source and years included).

At an October 21st, 2014 public hearing in Chico, California on the LTWT, a consultant working with BOR on the LTWT commented on the water model and the 1970 through 2003 data upon which the model relies. In response to questions about why the model did not include data from the previous ten years, or why the period of analysis was not extended out to the current drought situation, the consultant replied that the modeling tools "are not up-to-date."[29]

According to resource agencies in California, variable, even extreme climate and rainfall conditions are the norm. Climate change is projected to make these trends worse and increase prediction uncertainties. The recent Bay Delta Conservation Plan describes this uncertainty,

> "Variability and uncertainty are the dominant characteristics of California's water resources."[30]
>
> "Precipitation is the source of 97% of California's water supply. It varies greatly from year to year, by season, and by where it falls geographically in the state.

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[28] WCWD. 2014. *Initial Study and Proposed Negative Declaration for Western Canal Water District 2014 Water Transfer Program*. Western Canal Water District, Richvale, California. February. Page 25.

[29] Transcript of October 21, 2014 public hearing in Chico, California on the LTWT EIS/EIR; Hacking, H. 2014. "Sacramento Valley water transfer idea leaves locals fuming. ChicoER News, October 22, 2014, http://www.chicoer.com.

[30] California Department of Water Resources (DWR). 2013. Bay Delta Conservation Plan. Public Draft. November Sacramento, CA. Prepared by ICF International (ICF 00343.12). Sacramento, CA. Page 5-1.

With climate change, the state's precipitation is expected to become even more unpredictable."[31]

"However, the total volume of water the state receives can vary dramatically between dry and wet years. California may receive less than 100 MAF of water during a dry year and more than 300 MAF in a wet year (Western Regional Climate Center 2011)."[32]

"The geographic variation and the unpredictability in precipitation that California receives make it challenging to manage the available runoff that can be diverted or captured in storage to meet urban and agricultural water needs."[33]

"Historically, precipitation in most of California has been dominated by extreme variability seasonally, annually, and over decade time scales; in the context of climate change, projections of future precipitation are even more uncertain than projections for temperature. Uncertainty regarding precipitation projections is greatest in the northern part of the state, and a stronger tendency toward drying is indicated in the southern part of the state."[34]

Consultants working for the BOR admit that the water model and data upon which the LTWT analysis and conclusions rest are not up to date. We note above the model's unreliability and poor projection capabilities regarding water transfers post-2003. The DWR concludes that variability and extremes characterize the state's weather and rainfall conditions, and that climate change is increasing this variability and uncertainty. Taken together, these facts raise questions regarding the veracity of the projected water transfers described in the LTWT, and the estimated environmental and economic consequences of those transfers.

The analysis does not adequately take into account recent trends in agricultural production

Not included in the LTWT's description of current conditions are recent trends in agricultural production that affect groundwater use and conditions in the Sacramento Valley. For example, according to a recent report, approximately half the increase in irrigated acres in the Sacramento Valley since 2008 (approximately 200,000 acres), happened on lands not served by surface water suppliers. Irrigating these lands takes approximately 300,000 acre-feet (af) of groundwater per year. [35]

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[31] DWR, 2013. Page 5-2.

[32] DWR, 2013, page 5-2.

[33] DWR, 2013, page 5-2.

[34] DWR, 2013, page 5-2.

[35] DMW, 2014, page 7.

A related point is the lack of discussion or analysis in the LTWT of trends in prices for agricultural goods produced with surface and groundwater, trends in prices for water, and how these factors affect grower decisions. For example, the analysis fails to address the extent to which historically high prices for water (discussed below) increase groundwater mining and sale in the Sacramento Valley, and how this affects water transfers and their environmental and economic consequences.

Another agricultural trend not discussed in the LTWT, but which has implications for water transfers and their consequences, is the increasing use of pressurized irrigation methods in the Sacramento Valley. Pressurized irrigation reduces groundwater recharge by limiting water percolation. Some growers supply their pressurized irrigation systems using groundwater, even when they have access to surface water. According to the report commissioned by the NCWA,

> "The increasing use of pressurized irrigation systems using groundwater is likely to be an increasingly important factor in the overall management of groundwater and surface water in the Sacramento Valley as a whole, particularly as such system displace the use of available surface water."[36]

In response to the recent trend in high prices for almonds, olives, walnuts and other tree crops, growers in the San Joaquin *and* Sacramento Valleys planted more acres of these tress and other permanent-type crops, and less acres of lower valued annual crops. Such a change increases and "hardens" demand for water in both valleys because growers no longer have the flexibility of idling these acres in response to drought.[37] Thus, one of the arguments in support of water transfers—that growers south of the Bay Delta planted increased acres of tree crops that have higher water demands—also affects growers and water use and demands north of the Bay Delta.

The LTWT is silent on these trends or how they would influence future water transfers from the Sacramento Valley.

[36] DMW, 2014, page 8.

[37] DMW, 2014, page 7.

3 The LTWT relies on outdated and incomplete data

In addition to the deficiencies described in previous sections, the analysis described in the LTWT relies on obsolete data for certain key variables. The analysis also ignored other relevant data and information. These shortcomings include the following.

The LTWT assumes a price for water that bears no resemblance to the current reality

The analysis described in the LTWT assumes a price of water of $225 per af of water.[38] This amount drastically underestimates the current price for water. Dollar amounts for water trades are not readily available to the public. However, information on the current price of water from news articles and other sources reveals a range of current prices that exceed $225 by a significant amount.

A report by Bloomberg News on the impacts of drought on water prices reports water prices of $1,000 to $2,000 per af. The article also quotes a spokesman for the BOR,

> "The rising prices are 'a function of supply and demand in a very dry year and the fact that there are a lot of competing uses for water in California,' said Mat Maucieri, a spokesman for the Bureau of Reclamation."[39]

An article in the Sacramento Bee on water transfers noted that one buyer was paying "in the neighborhood of $500 to $600 an acre-foot."[40] The Glenn-Colusa Irrigation District commenting on the LTWT noted that the $225 per af price used in the analysis was the price paid for water over eight years ago.[41]

Water users, sellers and buyers would surely respond differently to a market price of water of $1,000 to $2,000 per af, than they would to a price of $225. As such, the extent to which growers idle cropland, switch to less water intensive crops, and substitute groundwater for surface water in the LTWT likely does not reflect this difference. As we note below, missing from the LTWT analysis is an assessment of the economics of water markets, how sellers and buyers respond to changing water prices, and how this affects the type and amount of water transfers.

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[38] LTWT, page 3.10-27.

[39] Vekshin, A. 2014. "California Water Prices Soar for Farmers as Drought Grows," Bloomberg. July 24. http://www.bloomberg.com.

[40] Garza, M. 2014. "The Conversation: A controversial water transfer worth millions." The Sacramento Bee. May 25. http://www.sacbee.com/opinion/the-conversation/article99570.html.

[41] Glenn-Colusa Irrigation District. 2014. *Board of Directors Meeting of November 6, 2014, Item 6*.

Ignored impacts on tax revenues to local governments from IMPLAN results

The LTWT describes estimating impacts of water transfers on employment, labor income and total value of output using IMPLAN.[42] IMPLAN is a commonly used software and data package that helps analysts estimate economic impacts of policy changes or compare economic impacts of allocation alternatives, e.g., alternative logging proposals or alternative water-transfer amounts. According to the IMPLAN website, IMPLAN "… allows an analyst to trace spending through an economy and measure the cumulative effects of that spending."[43] IMPLAN traces the economic benefits of increased spending as it works its way through an economy, or, when spending decreases, the negative economic impacts of decreased spending. From our own experience using IMPLAN, and from information on the IMPLAN website, in addition to the employment, labor income and total value of output reported in the LTWT, IMPLAN also quantifies the impacts of alternatives on *government finances and tax revenues*.[44] For example, the IMPLAN website describes how the software can estimate state, local, and federal tax amounts collected (or lost) as a result of a change in an economy, such as reduced agricultural activity.[45]

Even though IMPLAN calculates impacts of alternatives on local government finances and tax revenues, the analysis described in the LTWT does not report these results. That is, the authors apparently choose not to report the output from IMPLAN on how the transfer alternatives would affect the dollar amounts of tax revenues to local governments as a result of the reduced agricultural activity and spending. Instead, the report notes that impacts "to local government finances, including tax revenues and costs, are described *qualitatively*." [emphasis added] [46] The report does not explain why the analysts chose to address impacts on local tax revenues of the water-transfer alternatives qualitatively, rather than rely on the estimates of tax impacts produced by IMPLAN.

Ignored own research results on stream flow depletion factors

The LTWT makes no mention of the results from studies of the impacts of groundwater pumping in support of water transfers on stream flow depletion. A technical memo on the impacts of groundwater pumping on stream flow depletion describes the analysis and concludes that,

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[42] LTWT, page 3.10-21.

[43] IMPLAN web site, implan.com/index.php?option=com_glossary&id=236&letter=E.

[44] IMPLAN. https://implan.com/index.php?option=com_content&view=article&id=532:532&catid=233:KB16.

[45] IMPLAN. https://implan.com/index.php?option=com_content&view=article&id=532:532&catid=233:KB16.

[46] LTWT, page 3.10-24.

> "The effect of groundwater substitution transfer pumping on stream flow, when considered as a percent of the groundwater pumped for the program, is significant."[47]

> "The three scenarios presented here estimated effects of transfer pumping on stream flow when dry, normal, and wet conditions followed transfer pumping. Estimated stream flow losses in the five-year period following each scenario were 44, 39, and 19 percent of the amount of groundwater pumped during the four-month transfer period."[48]

In spite of these results, information distributed by the DWR and BOR to those interested in making water transfers in 2014, cites a stream flow depletion factor of 12 percent.[49] It's not clear how BOR justifies using a 12-percent depletion factor when analyses conducted by their contractors found depletion factors of 44, 39 and 19 percent.

We understand that the same SACFEM model that produced other results in the LTWT also produced the stream flow depletion factors.[50] Yet, while the LTWT reports other results from SACFEM, it makes no mention of these results. It also ignores the assumed 12-percent depletion factor cited by DWR and BOR. Instead, it states that stream flow depletion will be studied at a later date.[51] This approach ignores their own modeling results on stream flow depletion.

Incomplete and selective use of information from groundwater monitoring wells

The LTWT omits a significant concluding passage when describing results from a groundwater monitoring well in the Sacramento Valley.

For well 21N03W33A004M, the LTWT states,

> "Water levels at well 21N03W33A004M generally declined during the 1970s and prior to import of surface water conveyed by the Tehama-Colusa Canal. During the 1980s, groundwater levels recovered due to import and use of surface water supply and because of the 1982 to 1984 wet water years [citation omitted]."[52]

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[47] Lawson, P. 2010. Technical Memorandum. Groundwater Substitution Transfer Impact Analysis, Sacramento Valley. CH2MHill. March 29. Page 8.

[48] Lawson, 2010, Page 8.

[49] DWR and BOR, 2014. Addendum to DRAFT Technical Information for Preparing Water Transfer Proposals. Information to Parties Interested in making Water Available for water Transfers in 2014. January. Page 33.

[50] LTWT, page 3.3-60.

[51] LTWT, page 3.1-21.

[52] LTWT, page 3.3-22.

The document cites a DWR report from 2014 on drought response and gaps in groundwater monitoring.[53] The description in the DWR report, however, includes this additional concluding passage that the LTWT authors excluded,

> "Water levels declined again in the 2008 drought period, followed by a brief recovery during 2010 to 2011, and *then returning to 2008 levels (which are notably lower than the 1977-79 drought levels)."*[54] [emphasis added]

The omission matters as it completely changes the conclusion regarding current groundwater conditions as reported by the well.

The description in the LTWT of results from well 15N03W01N001M match those from the DWR source document. That description concludes,

> "… After the 2008-2009 drought, water levels declined to historical lows. Water levels recovered quickly during 2010 and 2011, *then after returned to the trend of long-term decline*."[55] [emphasis added]

Taken together these results indicate a long-term trend in declining groundwater levels in areas around the wells. The LTWT discounts or ignores these results instead favoring results from other wells. On this point, consulting hydrologist Custis describes other relevant data on groundwater monitoring,

> "The Draft EIS/EIR doesn't provide maps showing groundwater elevations, or depth to groundwater, for groundwater substitution transfer seller areas in Sutter, Yolo, Yuba, and Sacramento counties.
>
> The DWR provides on a web site a number of additional groundwater level and depth to groundwater maps at: [website omitted]."[56]

Custis notes other deficiencies of the groundwater monitoring as described in the LTWT.

> "…[T]he Draft EIS/EIR provides only limited information on the wells to be used in the groundwater substitution transfers [citation omitted], and no information on the non-participating wells that may be impacted."[57]

Custis goes on to list other recommended groundwater monitoring information that the LTWT does not include.[58]

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[53] LTWT, page 3.3-22.

[54] DWR, 2014a, page 24.

[55] LTWT, page 3.3-22.

[56] Custis 2014, pages 9-10.

[57] Custis 2014, page 2.

A related point is the available monitoring data from past water transfers. DWR and BOR apparently already collect information on the impacts of groundwater pumping in support of water transfers on groundwater levels.[59] The LTWT makes no mention of this data or how it could help inform the analysis of impacts of water transfers at issue in the LTWT on groundwater levels and related concerns. It would seem that BOR has available data relevant to its analysis described in the LTWT but makes no use of this data. On this point Custis notes,

> "The BoR should already have monitoring and mitigation plans and evaluation reports based on the requirements of the DTIPWTP for past groundwater substitution transfers, which likely were undertaken by some of the same sellers as the proposed 10-year transfer project."[60]

The analysis relies on outdated prices for agricultural commodities

The analysis described in the LTWT uses outdated prices for agricultural commodities to estimate the volume and value of water transfers. The analysis relies on prices for rice, processing tomatoes, corn and alfalfa from 2006 through 2010.[61] The analysis compares the price of water, which as we note above bears no resemblance to current prices, with prices for agricultural commodities to estimate cases in which selling water is more profitable than producing crops. Using outdated commodity prices compounds the error of using water prices that greatly underestimate actual prices. The combined effect is misleading results and conclusions regarding the degree of participation by growers in the water transfer program.

No mention of how prices for water and agricultural commodities could impact the affected environment, water transfers and their environmental and economic consequences

The water transfers at issue in the LTWT would not happen in an economic vacuum. Growers and water sellers and buyers react to changing price and market conditions. The LTWT, however, is silent on these forces and how they would influence water transfers.

The analysis depicted in the LTWT assumes a static water price of $225 per af and prices for agricultural commodities as they existed in 2006 through 2010.[62] Such a static analysis

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[58] Custis 2014, page 2.

[59] See for example, DWR and BOR, 2014. *DRAFT Technical Information for Preparing Water Transfer Proposals. Information to Parties Interested in making Water Available for water Transfers in 2014*. January; DWR and BOR. 2013. *DRAFT Technical Information for Preparing Water Transfer Proposals. Information to Parties Interested in Making Water Available for Water Transfers in 2014*. October.

[60] Custis 2014, page 24.

[61] LTWT, page 3.10-27, -28.

[62] LTWT, page 3.10-27.

provides a single estimate, or a snapshot view, of estimated water transfers. A more informative and useful analysis would have described how changing water and commodity prices influence the conclusions re the number and volumes of water transfers. Such a sensitivity analysis would allow readers to better compare current or expected future prices with prices in the analysis to see how these conditions affect results.

The LTWT is also silent on likely transaction costs and how they influence water transfers. Water transactions, particularly out-of-basin and cross-Delta, would require a diverse and substantial set of transaction costs that are not quantitatively included in the analysis. Omitting these transaction costs either overestimates the benefit potential to buyers and sellers of these transactions, or implies that these transaction costs will be borne by the public. Communication, information, and contracting costs have long inhibited water markets in California, and while mechanisms for overcoming these challenges have improved, they do have real costs, particularly across diverse regions and incorporating farmers using differing operations.[63] Transaction costs are hurdles to transactions, functionally a third party that must be satisfied before the buyer and seller can find opportunities to both be made better off by the transaction. For example, if a seller is willing to sell water at $250 per af, and a buyer is willing to pay $300 per af, if there are $60 per af in transaction costs, the transaction cannot efficiently take place.

Cross-Delta transaction would also impose a number of costs on the Delta conveyance system. Pumping costs at Banks and Jones Pumping Plants should be incorporated into transaction costs. Transactions could also affect congestion and overall capacity for these plants and the SWP and CVP systems overall. Energy, management, staffing, delays, and other costs and impositions could arise that would either require compensation by the buyers and sellers, or externalities on other parties.

Permitting, liability, and long-term protection of water rights all contribute to additional concerns for buyers and sellers that functionally generate additional forms of transaction costs. If these are incorporated into willingness-to-pay for buyers and willingness-to-accept for sellers, the transactions become less desirable. Alternatively, if these costs are borne by public agencies, as with the variety of other transaction costs mentioned above and referenced qualitatively throughout the LTWT, the burden for taxpayers could be substantial. These public contributions require demonstration of benefits to the public as a whole. The LTWT does not demonstrate benefits to portions of the public that are not party to transactions. On this point Custis notes,

> "Because the spatial limits of groundwater substitution pumping impacts are controlled by hydrogeology, hydrology, and rates, durations and seasons of pumping, the impacts may not be limited to the boundaries of each seller's service area, GMPs [groundwater

[63] Haddad, B. M. 2000. *Rivers of Gold: Designing Markets to Allocate Water in California*. Island Press.

management plan], or County. There is a possibility that a seller's groundwater substitution area of impact will occur in multiple local jurisdictions, which should results [sic] in project requirements coming from multiple local as well as state and federal agencies. The Draft EIS/EIR doesn't discuss which of the multiple local agencies would be the lead agency, how an agreement between agencies would be reached, or how the requirements of the other agencies will be enforced."[64]

Overall, the estimates of benefits and costs of transactions, as well as identification of efficient transactions, do not include the diverse and substantial set of transaction costs that cross-Delta transfers would require. Therefore the analysis either overestimates the benefits of the LTWT, or hides public costs to manage and overcome these transaction costs.

[64] Custis 2014, page 9.

4 The LTWT underestimates negative impacts on the regional economy in the sellers area

In this section we describe our comments on the analysis of regional economic effects in the LTWT.

Underestimates economic effects on regional economy in sellers area

In the sections above, we describe omissions and errors regarding the estimated number and volumes of water transfers. Some of these errors could lead to underestimating the number and volume of water transfers, some could have the opposite effect. In this subsection we focus on additional examples of how the LTWT likely underestimates the number and volume of water transfers that will happen in the future. By underestimating the water transfers the LTWT also underestimates the negative impacts of the transfers on the regional economy in the sellers area.

The negative economic effects listed in the LTWT include:

- Approximately 500 lost jobs in Glenn, Colusa, Yolo, Sutter, Butte and Solano counties.
- Over $20 million in lost labor income and over $61 million in lost economic output in these same counties.
- Unquantified but increased pumping costs for water users in areas where groundwater levels decline.
- Unquantified but negative affects on other local economic effects.
- Unquantified but negative affects on tenant farmers.[65]

The LTWT analysis of some regional economic effects assumes non-consecutive years of water transfers. If water transfers happen in consecutive years, impacts would be greater than reported in the LTWT.

> "Local effects would be more adverse if cropland idling transfers occurred in consecutive years. Business owners would likely be able to recover from reduced sales in a single year, but it would be more difficult if sales remained low for multiple years."[66]

As shown in LTWT Table 1-3 on page 1-17, from 2004 through 2014, there have been eight water-transfer years out of 11, and 5 cases of consecutive transfer years. Given these recent

[65] LTWT, page 3.10-45 and -46.

[66] LTWT, page 3.10-33.

conditions, it is likely that consecutive years of water transfers will happen more frequently than assumed in the LTWT.

Incomplete description of impacts on pumping costs

The LTWT reports that farmers in the Sacramento and San Joaquin Valleys pay water-pumping costs of approximately $0.32 per af.[67] The LTWT analysis estimates that as a result of groundwater-substitution transfers, pumping costs for "many growers" would increase by $0.32 to $1.60 per af.[68] This represents a non-trivial increase of 100 to 500 percent. In some cases, cost increases could be $6.40 to $8.00 per af.[69] Expressed on a percentage basis these amounts are increases of 2,000 to 2,500 percent. The LTWT describes these increases in pumping costs as "adverse." The analysis, however, does not report a total estimated increase in pumping costs or describe the increase as a percentage of current costs, either of which would have helped the reader better understand the significance of the increase.[70] A related point is that the analysis of pumping costs in the LTWT relies on results from the water modeling, the deficiencies of which we describe above and elsewhere in this report.

It's also not clear from the description of the analysis if the "adverse" effects on pumping costs apply only to those participating in water transfers, or also affect third parties that will not benefit from the transfers.

No mention of costs of deepening or installing new wells

The LTWT makes no mention of increased costs of deepening or installing new wells as a result of the impacts of groundwater pumping on groundwater levels. As we note above in section 2 under the description of current groundwater conditions, the CASGEM groundwater basin prioritization study lists 23 basins in the Sacramento Valley ranked "high" or "medium" dependent on groundwater. These basins support private residential wells, public water supply wells, and irrigation wells.[71] Recent news reports describe the intensity of well drilling operations in California's Central Valley.[72] To the extent that groundwater pumping in support of water transfers lowers groundwater levels, some

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[67] LTWT, page 3.10-24.

[68] LTWT, page 3.10-36.

[69] LTWT, page 3.10-36.

[70] A related point is that Figures 3.10-5 and 3.10-6 are confusing in that the captions include "September 1990" and "September 1976," respectively. The discussion on page 3.10-36, which introduces the figures, makes no mention of these dates or their significance.

[71] DWR, 2014b, pages 2-5.

[72] Howard, B.C. 2014. California drought spurs groundwater drilling boom in Central Valley. National Geographic. August 15. http://news.nationalgeographic.com/news.2014/08/140815-central-valley-california-drilling-boom-groundwater-drought-wells/; Khokha, S. 2014. Drought has drillers running after shrinking California water supply. National Public Radio. June 30. http://www.npr.org/2014/06/30/325494399/drought-has-drillers-running-after-shrinking-california-water-supply.

current water users depending on groundwater may face increased costs of deepening or installing new wells. The analysis described in the LTWT does not address these costs.

Underestimates the significance of impacts on unemployment rates

Any negative impacts of water transfers on agricultural production and related unemployment effects, would take place against a backdrop of already hurting economies. As Figure 3.10-7 illustrates, current unemployment rates in the seller counties runs between approximately 8 and 18 percent. The LTWT analysis estimates that water transfers will idle approximately 500 workers in the Sacramento Valley. The analysis assumes that impacts of transfers on unemployment would be temporary.

> "Reductions in employment associated with cropland idling transfers would contribute to unemployment in the region. However, cropland idling effects are temporary and under the Proposed Action, cropland idling transfers would not occur each year over the 10-year period."[73]

As we note above, however, data on the frequency of recent water transfers do not support the LTWT assumptions regarding infrequent future water-transfer years. Thus, the LTWT analysis likely underestimated the negative impacts of the plan on unemployment in the Sacramento Valley.

No mention of economic harm to local economies from lost water-based recreational activities

The analysis of regional economic effects in the LTWT focuses on impacts of water transfers on agricultural production and related businesses. The LTWT ignores other negative impacts on the regional economy. For example, the LTWT is silent on the impacts of water transfers on reservoirs such as Lake Oroville and others in the sellers area, and the related impacts on the region's water-based recreational economy. In their letter commenting on the LTWT, the Butte County Board of Supervisors noted their concerns that the LTWT "… failed to take into account the reduction in stream flows and the lowering of Lake Oroville that will harm the local economy."[74] In an earlier letter to Governor Brown commenting on the BDCP, the Butte County Board of Supervisors noted the importance of the lake to the region's economy, and the fact that the State of California has not fulfilled commitments made regarding developments at Lake Oroville.[75] Ignoring the potential impacts of water transfers on Lake Oroville and the associated economic impacts compounds the negative effects of the State's failure to fulfill past commitments at the lake.

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[73] LTWT, page 3.10-49.

[74] Teeter, D. 2014. *Letter to Brad Hubbard, BOR, and Frances Mizuno, SLDMWA*, November 25. Re: Long-Term Water transfers Program Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR). Page 2.

[75] Lambert, S. 2012. *Letter to The Honorable Edmund G. Brrown, Jr*. August 14. Re: Butte County's Opposition to the Bay Delta Conservation Plan (BDCP). August 14. Page 2.

Arbitrary limits on crop idling

The analysis in the LTWT relies on arbitrary limits on crop idling as a means of avoiding negative economic impacts. The DWR and BOR document that provides technical guidance for those interested in making water transfers describes the possibility of negative economic effects of crop idling, however, the guidelines for the amount of idling that would cause economic harm appear arbitrary. The relevant passage from the document states,

> "Cropland idling/crop shifting transfers have the potential to affect the local economy. Parties that depend on farming-related activities can experience decreases in business if land idling becomes extensive. Limiting cropland idling to 20 percent of the total irrigable land in a county *should* limit economic effects."[76] [emphasis added]

While the statement may be true, it lacks the analytical rigor that would satisfy NEPA requirements for, "Rigorous exploration and objective evaluation of all reasonable alternatives, …"[77] As such, the guidelines on crop idling seem arbitrary rather than the result of rigorous and objective analysis.

Table 3.10-22 lists the total number of acres affected by cropland idling in the analysis described in the LTWT. As shown in this table, approximately 60,000 acres could be idled in Glenn, Colusa, Yolo, Sutter, and Butte counties.[78] In the table below, we show the total number of acres of irrigable land in each county, and 20 percent of these acres. According to the guidelines noted above, up to 257,000 acres could be idled in these counties without significant economic effects. This seems doubtful. Rather than relying on arbitrary rules of thumb and assumed limited economic effects of idling, a more complete and transparent assessment of the economic effects of water transfers would take an analytical and quantified approach.

Table 1: Acres of Cropland, by County, 2011.

County	Acres of Cropland	20 Percent of Acres
Butte	224,592	47,969
Colusa	291,435	56,246
Glenn	250,493	50,099
Sutter	239,846	58,287
Yolo	281,228	44,918
Total	1,287,594	257,519

Source: US Department of Agriculture. 2011. California Cropland Data Layer. National Agricultural Statistics Service. Research and Development Division, Geospatial Information Branch, Spatial Analysis Research Section.

[76] DWR and BOR, 2013. *DRAFT Technical Information for Preparing Water Transfer Proposals. Information to Parties Interested in Making Water Available for Water Transfers in 2014*. October. Page 22.

[77] LTWT page 2-1.

[78] LTWT, page 3.10-26.

5 The LTWT finds significant negative effects but the vague and incomplete proposed monitoring and mitigation plans would not address these effects

The LTWT concludes that water transfers will have some significantly negative impacts on groundwater resources. As we note in earlier sections of this report, the analysis described in the LTWT likely underestimates the negative effects of water transfers. For example, the analysis likely underestimates the frequency of water-transfer years, and so the negative effects of the transfers. The analysis also ignores negative impacts on water-based recreational activities and the associated negative economic consequences. The monitoring and mitigation plans focus only on the negative effects listed in the LTWT. Thus, they would address only a subset of the likely total negative economic consequences of the water transfers. In addition, the vague and incomplete proposed monitoring and mitigation plans would not adequately address those negative effects listed in the LTWT. Concerns regarding these plans include the following.

The LTWT ignored the costs of monitoring and mitigation

The LTWT proposes both a monitoring and mitigation program for significant negative impacts of water transfers on groundwater resources. Implementing these programs would take planning, effort and financial resources. The LTWT, however, does not include these costs in their analysis of alternatives. For example, water sellers would be required to monitor and record groundwater conditions and coordinate with regulators regarding the impacts of their groundwater pumping on groundwater levels. Water seller will incur costs monitoring, measuring, recording, and reporting the necessary information. The LTWT excludes these and related costs from the analysis.

Likewise, the mitigation of negative groundwater consequences would also require time, effort, and costs to water sellers, third parties negatively affected by groundwater pumping, and regulators. LTWT excludes these costs as well.

The monitoring and mitigation programs include inherent conflicts of interests

The monitoring program as described in the LTWT is vague and depends on sellers implementing the program. This conflict of interest pits financial gain from water sales against complete and impartial monitoring efforts. This opens the door to lax, biased, or incomplete monitoring, which could lead to negative environmental and economic consequences for third parties not part of the water transfers.

The monitoring program includes provisions for a coordination plan that would share information among "well operators and other decision makers."[79] Such confidential results would keep other stakeholders in the dark regarding the impacts of water transfers. Given the fact that multiple wells belonging to multiple property owners can access the same groundwater aquifer, and that groundwater pumping can affect flows of surface water, such a confidential program seems counter to the wellbeing of the regional economy in the sellers area. An open monitoring program with public results would better communicate the potential environmental and economic risks of groundwater pumping in support of water transfers.

If the seller's monitoring program finds that water sales are causing "substantial adverse impacts"[80] the seller will be responsible for implementing a mitigation program. The conflict of interest is obvious.

One method of avoiding the obvious conflicts of interests is requiring monitoring by independent third parties not involved with or affected by groundwater pumping in support of water transfers. Such monitoring could be detailed, transparent and public, which would alleviate concerns over the risks and consequences of negative environmental and economic effects of groundwater pumping. Mitigation decisions and requirements should likewise be detailed, transparent and public for the same reasons.

Insufficient monitoring period

As described in the LTWT, groundwater levels would be monitored through March of the year following a transfer. It's not clear that this limited monitoring period is sufficiently long enough to track potential impacts on groundwater of water transfers. For example, the report cited above for the NCWA states,

> "…[G]roundwater changes can take many years to become apparent, and we have not yet been able to measure with certainty the long-term impacts of the current level of groundwater use as it affects our measures of sustainability."[81]

An insufficient monitoring period could underestimate the impacts of groundwater pumping on groundwater levels and impacts on stream flow depletions. Lowering groundwater level and increasing stream flow depletions would generate negative environmental and economic impacts. The monitoring period in the LTWT may cause analysts to underestimate the environmental and economic effects of the water-transfers alternatives.

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[79] LTWT, page 3.3-89.

[80] LTWT, page 3.3-90.

[81] DMW, 2014, page 10.

Insufficient monitoring for land subsidence

The monitoring program includes monitoring subsidence, however, the program is vague on monitoring requirements and what amount of subsidence would trigger a halt in water transfers. Custis describes a number of technical deficiencies in the proposed mitigation plan.

> "The Draft EIS/EIR should be able to provide the specific thresholds of subsidence that will trigger the need for additional extensometer monitoring, continuous GPS monitoring, or extensive land-elevation benchmark surveys by a licensed surveyor as required by GW-1. The Draft EIS/EIR should also specify in mitigation measure GW-1, the frequency and methods of collecting and reporting subsidence measurements, and discuss how the non-participating landowners and the public can obtain this information in a timely manner. In addition, the Draft EIS/EIR should provide a discussion of the thresholds that will trigger implementation of the reimbursement mitigation measure required by GW-1 for repair or modifications to infrastructure damaged by non-reversible subsidence, and the procedures for seeking monetary recovery from subsidence damage [citation omitted]."
>
> "Specific 'strategic' subsidence monitoring locations should be given in mitigation measure GW-1 based on analysis of the susceptible infrastructure locations and the potential subsidence areas."[82]

Implementing the Custis recommendations will take time and financial resources for water sellers, local jurisdictions and third parties negatively affected by groundwater pumping. The LTWT does not include the costs of these measures in the analysis. Thus, the costs of the water transfers described in the LTWT underestimate the true costs of the program.

Vague significance criteria

The mitigation program includes a number of vague descriptions of critical components. Relevant missing descriptions include details on:

- How regulators and stakeholders would define "substantial adverse impacts" from groundwater pumping.
- What constitutes a "significant" increase in pumping costs suffered by injured third parties.
- Required modifications to damaged third-party infrastructure or the installation of new infrastructure.

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[82] Custis 2014, page 28.

- The procedure that injured third parties would use when making claims against a seller.
- The procedure that regulators and stakeholders would use when investigating third-party claims.
- What constitutes "legitimate significant effects" on third parties.[83]

A vague and ill-defined mitigation program increases risks of environmental and economic harm, and shifts the costs of such harm from water sellers to third parties and society in general. The analysis described in the LWTW does not identify, describe or quantify these risks, costs and consequences. A related point is that the LTWT makes no mention of BOR addressing these or similar issues as part of reviewing past annual water transfers. Including such information from past water transfers—if BOR considered these effects—in the LWTW could help illustrate or describe the uncertainties listed above.

The mitigation plan puts costs on to injured third parties

Injured third parties bear the costs of bringing to the sellers' attention harm caused by groundwater pumping. Also, the LTWT states that proposed mitigation options would be developed "in cooperation"[84] with injured third parties. This approach places costs on injured third parties rather than on sellers. That is, those who would not benefit financially from the program bear the costs of bringing negative impacts to the sellers' attention. They also would incur costs of documenting and presenting their damages in the context of an ill-defined mitigation program. This raises equity concerns that those suffering costs of the program bear the additional costs of identifying, describing and calling attention to their costs. The analysis described in the LTWT further assumes that disagreements regarding third-party damages would be settled cooperatively, without presenting evidence substantiating such an optimistic assumption. The LTWT is silent on the economic consequences of sellers and injured third parties not cooperatively agreeing on harm and compensation.

As we note above, information the BOR collected from past water transfers may help inform the types and amounts of costs that injured third parties could incur as a result of the water transfers at issue in the LTWT.

BOR's role in monitoring and mitigation

The LTWT describes a substantive role for BOR in the monitoring and mitigation program, without specifics of how BOR would implement its responsibilities. Topic not addressed include:

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[83] LTWT, page 3.3-88 through -91.

[84] LTWT, page 3.3-91.

- The costs to BOR of monitoring and mitigation.
- The details of interactions between sellers, injured third parties, and BOR staff regarding the details of monitoring and mitigation.
- The details of collecting, organizing and publishing relevant details of monitoring and mitigation.
- The details of decision making processes that affect monitoring and mitigation.
- The details of interactions between BOR and other federal or state agencies, and BOR and local jurisdictions.

Lead CEQA agency

SLDMWA is the lead state agency regarding CEQA compliance. It is also one of three potential buyers for the transferred water.[85] This arrangement creates a conflict of interest in that the lead CEQA agency also has a self interest in facilitating the water transfers. As described on their website, SLDMWA delivers approximately 3 million af of water to member agencies.[86] SLDMWA has a financial and operational interest in delivering water to its members. Thus, SLDMWA is not an impartial agent.

The LTWT provides no information on why SLDMWA is the lead state agency and not the California Department of Water Resources.

[85] LTWT EIS/EIR, Table 1-2, page 1-5. The other two buyers are Contra Costa Water District and the East Bay Municipal Utility District.

[86] SLDMWA web site, www.sldmwa.org/learn-more/about-us/.

6 The LTWT ignores the economic costs of environmental externalities and subsidies that water transfers support

The LTWT lists Westlands Water District as one of the CVP contractors expressing interest in purchasing transfer water.[87] The environmental externalities caused by agricultural production in Westlands are well documented, as are the economic subsidies that support this production. To the extent that the water transfers at issue in the LTWT facilitate agricultural production in Westlands, they also contribute to the environmental externalities and economic subsidies of that production. The LTWT is silent on these environmental and economic consequences of the water transfers.

In this section we summarize recent information on the environmental externalities and economic subsidies of agricultural production on Westlands that water transfers would support.

The environmental and economic externalities of Westlands have a long history

For decades, high levels of selenium have posed a serious environmental threat to drinking water, soil quality, and agriculture in the Westlands Water District.[88] This naturally occurring element leaches into soil and drinking water when irrigation water is applied and when significant levels accumulate, has been known to cause deformities and death in wildlife and human beings.[89] The most extreme example of this type of degradation occurred from 1981-1986 during the Kesterson Disaster, when the federally operated San Luis Unit diverted selenium-rich wastewater into the Kesterson National Wildlife Refuge, killing over one thousand birds and causing severe birth defects.[90]

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[87] LTWT, page 1-5.

[88] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land

[89] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land

[90] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. Environmental Working Group. Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land; Environmental Working Group. 2010b, September 28. U.S. Taxpayers Paid nearly $60 million to Farmers on Westlands Toxic Lands. Environmental Working Group. Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land; Luoma, Samuel N. and Teresa S. Presser. (2000). Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension. U.S. Geological Survey. (Open-File Report 00-416). Menlo Park, California.

Current environmental concerns

Since the Kesterson Disaster, the Westlands has followed a "no-discharge policy" where irrigated wastewater is reused on agricultural land or stored in groundwater aquifers.[91] In spite of the well-documented concerns regarding selenium contaminated runoff from Westlands, as yet there is no official monitoring of selenium levels in the district.[92] The San Luis Act (1960) gives the BOR, not the Westlands Water District, responsibility for disposing of Westland Water,[93] but as of yet neither entity has implemented any meaningful solution. This failure prompted the Westlands District to bring a lawsuit against the BOR in 1995, which was finally brought to the Ninth Circuit Court of Appeals in 2000.[94] The court upheld a lower court's decision to force the BOR to provide drainage to the district but allowed that solutions other than a drain might be considered.[95]

At first, it seemed that large-scale retirement of farmland was the solution favored by both the Westlands and the federal government.[96] In 2001, the District released a fact sheet entitled "Why Land Retirement Makes Sense for the Westlands Water District" advocating for a possible deal with the federal government that would retire up to 200,000 acres of agricultural land. According to the federal government's National Economic Development analysis, this option would result in an economic gain of $3.6 million per year excluding any additional savings as a result of reduced crop subsidies.[97] Instead, after more than a decade of negotiations, the federal

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[91] State of California. Centerl Valley Regional Water Quality Control Board. Irrigated Lands Program – Development of the Long-term Program. http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/new_waste_discharge_requirements/western_tulare_lake_basin_area_wdrs/index.shtml#octdec2013

[92] State of California. Centerl Valley Regional Water Quality Control Board. Irrigated Lands Program – Development of the Long-term Program. http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/new_waste_discharge_requirements/western_tulare_lake_basin_area_wdrs/index.shtml#octdec2013

[93] US Bureau of Reclamation. 2012a, August 7. *CVP Ratebooks - Irrigation, 2012*. Retrieved from http://www.usbr.gov/mp/cvpwaterrates/ratebooks/irrigation/2012/index.html; U.S. Bureau of Reclamation. 2012b, September. San Luis Unit Drainage, Central Valley Project. ***Reclamation: Managing Water in the West.*** Retrieved from http://www.usbr.gov/mp/PA/docs/fact_sheets/San_Luis_Drainage.pdf.

[94] US Bureau of Reclamation. 2012a, August 7. *CVP Ratebooks - Irrigation, 2012*. Retrieved from http://www.usbr.gov/mp/cvpwaterrates/ratebooks/irrigation/2012/index.html; U.S. Bureau of Reclamation. 2012b, September. San Luis Unit Drainage, Central Valley Project. ***Reclamation: Managing Water in the West.*** Retrieved from http://www.usbr.gov/mp/PA/docs/fact_sheets/San_Luis_Drainage.pdf.

[95] US Bureau of Reclamation. 2012a, August 7. *CVP Ratebooks - Irrigation, 2012*. Retrieved from http://www.usbr.gov/mp/cvpwaterrates/ratebooks/irrigation/2012/index.html; U.S. Bureau of Reclamation. 2012b, September. San Luis Unit Drainage, Central Valley Project. ***Reclamation: Managing Water in the West.*** Retrieved from http://www.usbr.gov/mp/PA/docs/fact_sheets/San_Luis_Drainage.pdf.

[96] Westlands Water District. 2001, October 16. Why Land Retirement Makes Sense for Westlands Water District. *Westlands Water District*.

[97] Westlands Water District. 2001, October 16. Why Land Retirement Makes Sense for Westlands Water District. *Westlands Water District*; Sharp, Renée. 2010, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/agmag/2010/10/throwing-good-money-after-bad-lands.

government and the Westlands Water District finally signed an agreement in 2014 which lifts the federal government's obligation to provide drainage to the district, forgives the nearly $400 million the district owes to the federal government for its part in the construction of the Central Valley Project (CVP), assures the district almost 900,000 acre-feet of water per year from the CVP, and requires only 100,000 acres of land be retired.[98] This leaves over 100,000 more acres of selenium-degraded land that the Westlands Water District will now need to decide how to drain in the years to come.[99] In addition, while the BOR's Environmental Assessment found that there would be no significant environmental impact as a result of the interim renewal contracts with the Westlands and other CVP districts, several environmental groups have criticized the study as violating federal environmental requirements, including the National Environmental Policy Act of 1969.[100]

Economic subsides to the Westlands water district

As the largest water district in California and the largest recipient of water under the Central Valley Project, the Westlands Water District receives significant crop, water, and power subsidies to supplement its agricultural activities. According to a report by the Environmental Working Group, between 2005 and 2009, the federal government issued almost $55 million of counter cyclical and direct crop subsidies to 356 individuals in the district.[101] The district's 350 farms networks are entitled to over 1.1 million acre-feet of water per year, more than twice the allocation of the City of Los Angeles.[102] In 2002, the group estimated that the federal

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[98] California Water Impact Network. 2014, October 16. Obama Selling Out California to Westlands Water District. *California Water Impact Network.* Retrieved from http://www.c-win.org/content/media-release-obama-selling-out-california-westlands-water-district-secret-deal-forgives-gov; US Department of the Interior. 2013, December 6. *PRINCIPLES OF AGREEMENT FOR A PROPOSED SETTLEMENT BETWEEN THE UNITED STATES AND WESTLANDS WATER DISTRICT REGARDING DRAINAGE.* Retrieved from www.c-win.org/webfm_send/453; Boxall, Bettina. 2014, October 21. Amid California's drought, a bruising battle for cheap water. *Los Angeles Times.* Retrieved from http://www.latimes.com/local/california/la-me-westlands-20141021-story.html#page=2.

[99] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land.

[100] US Bureau of Reclamation. 2013, December 7. *Central Valley Interim Renewal Contracts for Westlands Water District, Santa Clara Valley Water District, and Pajaro Valley Water Management Agency 2014-2016.* (FONSI-13-023). Sacramento, CA; Minton, Jonas, Kathryn Phillips, et al. 2014, January 14. The Environmental Assessment [EA] for Westlands Water District et. al. Central Valley Project Interim 6 Contract Renewals for Approximately 1.2 MAF of water [Letter to Rain Emerson, Bureau of Reclamation].

[101] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land; Environmental Working Group. 2010b, September 28. U.S. Taxpayers Paid nearly $60 million to Farmers on Westlands Toxic Lands. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land.

[102] Boxall, Bettina. 2014, October 21. Amid California's drought, a bruising battle for cheap water. *Los Angeles Times.* Retrieved from http://www.latimes.com/local/california/la-me-westlands-20141021-story.html#page=2; Environmental Working Group. 2005, September 14. Soaking Uncle Sam: Why Westlands Water District's New Contract is All Wet. *Environmental Working Group.* Retrieved from http://www.ewg.org/research/soaking-uncle-sam.

government paid $110 million per year in water subsidies, making its water drastically less expensive than that allocated to urban households.[103]

In 2002, the Westlands Water District received more than $70 million in power subsidies Although the Westlands receives 25% of all water from the CVP, it consumes 60% of the electricity required to deliver water to all districts and 60% of all government granted power subsidies to the CVP.[104]

As mentioned above, the federal government has subsidized the Central Valley Project since its construction. While farmers were meant to pay $1 billion of the $3.6 billion project cost fifty years after its completion, it's estimated that by 2008, only 20% of that debt had been repaid.[105]

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[103] Boxall, Bettina. 2014, October 21. Amid California's drought, a bruising battle for cheap water. *Los Angeles Times.* Retrieved from http://www.latimes.com/local/california/la-me-westlands-20141021-story.html#page=2; Environmental Working Group. 2005, September 14. Soaking Uncle Sam: Why Westlands Water District's New Contract is All Wet. *Environmental Working Group.* Retrieved from http://www.ewg.org/research/soaking-uncle-sam; Environmental Working Group. 2007, May 30. Power Drain: The Biggest Winner: Westlands. *Environmental Working Group.* Retrieved from http://www.ewg.org/research/power-drain/biggest-winner-westlands.

[104] Environmental Working Group. 2007, May 30. Power Drain: The Biggest Winner: Westlands. *Environmental Working Group.* Retrieved from http://www.ewg.org/research/power-drain/biggest-winner-westlands.

[105] Environmental Working Group. 2010a, September 28. Throwing Good Money at Bad Land. *Environmental Working Group.* Retrieved from http://www.ewg.org/Throwing-Good-Money-at-Bad-Land.

7 The LTWT underestimates the cumulative effects of water transfers

Cumulative effects analyses under NEPA and CEQA are intended to identify impacts that materialize or are compounded when the proposed action is implemented at the same time as or in conjunction with other actions. In Chapters 3 and 4, the LTWT addresses cumulative effects for each resource area and provides a global description of the methods and actions considered for analysis in each resource area. Section 3.10 provides a cursory discussion of potential cumulative effects for the regional economy, but ignores the full range of possible cumulative outcomes associated with the proposed action.

According to NEPA and CEQA requirements, cumulative effects analysis must examine the possibility of effects occurring across several dimensions. When multiple projects produce effects within the same geographic and temporal range, they may:

- Expand or contract the set of possible impacts.
- Increase or decrease the likelihood of specific potential impacts.
- Accelerate or decelerate the timing of specific potential impacts.
- Change the trajectory of potential impacts.
- Increase or decrease the economic importance of specific potential impacts.
- Shift the distribution of uncertainty or risk borne by different groups.

Cumulative effects may arise as multiple projects interact in a linear fashion, resulting in impacts that are additive. Interactions might also be non-linear, either offsetting each other to be less than additive, or exacerbating each other to be greater than additive.

The LTWT does not adequately consider cumulative effects within this framework, so misses important interactions that could result in significant impacts beyond those identified for the project alone.

One of the greatest potential sources of cumulative impacts is non-CVP water transfers. Although transfers under the SWP were considered, the possibility of other transfers occurring was not. Additional transfers would have similar impacts in the sellers' region, and may also lead to net effects that exceed sustainable thresholds and have a larger impact than each would individually. For example, the analysis

- Ignores cumulative effects of additional water transfers on water prices, and fails to examine the effects of price on the decisions and behaviors of farmers in the context of other water transfers.
- Ignores effects resulting from additional water transfers that have the potential to influence agricultural prices, and how those agricultural prices influence decisions about water transfers.

- Treats effects as "temporary" and thus not significant, and thereby fails to adequately account for potential thresholds in the local agricultural economy where short-term effects would become long-term effects.
- Assumes mitigation for groundwater effects of the proposed action would make farmers whole, so fails to properly account for potential threshold effects in groundwater resources, and associated costs to farmers.
- Ignores the possibility that increased uncertainty related to groundwater levels, agricultural market conditions, etc. from the proposed action, in conjunction with other actions, would adversely affect farmers.
- Ignores the cumulative effects of additional water transfers on environmental resources and conditions including aquatic, riparian, terrestrial and avian species and habitats.

WATER RIGHTS WITHIN THE BAY/DELTA WATERSHED
STATE WATER RESOURCES CONTROL BOARD

The water right permit system administered by the State Water Resources Control Board (State Water Board) applies to surface water bodies and to a narrow classification of groundwater, “subterranean streams flowing in known and definite channels.” (Wat. Code, § 1200.) Aquifers that are not part of a subterranean stream are classified as “percolating groundwater.” There are two basic categories of surface water rights: post-1914 appropriative; and pre-1914 appropriative and riparian. The State Water Board has very limited information on water use for either of these classes of water rights, and the little information it does have has not been synthesized and is not maintained electronically. The State Water Board has no information on groundwater use in the Delta watershed.

Post-1914 Appropriative Water Rights

The State Water Board has permitting and licensing authority over surface water diversions associated with post-1914 appropriative water rights within the legal Delta and within the Delta watershed. December 19, 1914 is the effective date of the Water Commission Act that established the modern procedures to regulate surface water appropriation. Surface water appropriations established prior to this date are not bound by these procedures. The State Water Board maintains paper and electronic files for post-1914 permitted and licensed water rights, pending water right applications, and also state filings, which are state filed water right applications reserved for future use by individuals and entities in the areas where water originates. The information in its files includes the holder of the water right, point of water diversion, limitations on the rate, amount, and season of diversion, the place and purpose of use of the water, and any other terms or conditions placed on the water right. These limitations on rate, amount, and season of use are used to determine the “face value” of the water right, defined as the total annual amount of diversion authorized for direct diversion or storage by a permit or license. The term is primarily used in the calculation of water right fees and does not take into account water availability, bypass requirements, or other conditions that may have a practical effect of limiting diversions. Further, the State Water Board has continuing authority to change existing water rights, following formal notice and opportunity for hearing, in order to protect the public trust and water quality and to prevent the waste, unreasonable use, and unreasonable method of use or diversion of water.

Water right permit and license holders are required to file progress reports with the State Water Board, and to report their water diversion and use amounts (Cal. Code of Regs, tit. 23, § 847). These reports are to be completed annually for water right permit holders and triennially for water right license holders. Approximately 68 percent of permit and license holders submit completed water use reports to the State Water Board. The Water Code does not contain specific enforcement provisions that would allow the State Water Board to enforce against the lack of reporting. Use information reported to the State Water Board is stored in paper files and there has been no verification of the quality of this information except as part of limited enforcement actions. Summary information is therefore not available to compare face value of water rights to actual use. Some water users who hold multiple rights report the same use information for all of their rights. For instance, a right holder may use 2500 acre-feet per year of water under three different water rights. If that user reports a use of 2500 acre-feet for each of the three rights, a cursory review might lead the reviewer to conclude that 7500 acre-feet of water is being used, although this is not the case.

Pre-1914 Appropriative and Riparian Water Rights
The State Water Board does not have permitting and licensing authority over Pre-1914 appropriative or riparian water rights. The State Water Board does however collect Statements of Water Diversion and Use (Statements) from water diverters claiming riparian and pre-1914 water rights. (Wat. Code, § 5100 et seq.) The State Water Board has approximately 5,500 Statements of Water Diversion and Use on file for pre-1914 and riparian rights in waters tributary to the Delta. These Statements, however, do not provide complete information about riparian and pre-1914 water diversions in California. Of particular significance in the Delta, certain diverters are statutorily exempt from filing Statements; Water Code section 5101 exempts diversions that are reported by the Department of Water Resources (Department) in its hydrologic data bulletins or that are included in the consumptive use data for the Delta lowlands published by the Department in its bulletins. (*Id.*, § 5101, subds. (e)-(f).) The State Water Board estimates that there are approximately 1,600 unreported Pre-1914 and riparian diversions in the Delta. Additionally, even if a water diverter is statutorily required to file a Statement, there is no penalty for failure to file a report. (*Id*., § 5108.)

Groundwater
Percolating groundwater is not subject to the State Water Board's permitting system and, in most of the state, is not regulated by any other public agency. When considering a proposed appropriation of groundwater, or determining whether an unpermitted diversion in close proximity to a stream is an unauthorized diversion, the State Water Board must evaluate the legal classification of the groundwater from which the water is being appropriated to determine whether it is a subterranean stream, which is under the jurisdiction of the State Water Board, or percolating groundwater, which is not. (See *North Gualala Water Co. v. State Water Resources Control Board* (2006) 139 Cal.App.4th 1577 [43 Cal.Rptr.3d 821] [upholding State Water Board's use of four-part test in determining legal classification of groundwater].) To the extent groundwater is classified as a subterranean stream, it is managed as surface water. (See also Wat. Code, § 2500 [statutory adjudication procedures, under which all rights in a stream system are determined, apply to surface waters and subterranean streams, not percolating groundwater]. The State Water Board has no legal authority to require users of percolating groundwater to report their uses of water, other than in four southern California counties. The State Water Board does not therefore maintain information on extraction of percolating groundwater within the Delta watershed.

Water Use versus Water Rights
The mean annual unimpaired or full natural flow in the Delta Watershed between 1921 and 2003 was 29 million acre-feet per annum (AFA), with a maximum of 73 million AFA

in 1983.[1] Unimpaired flow is flow that would be expected in the Delta watershed in the absence of storage and other human developments. In contrast, the total face value of the approximately 6,300 active water right permits and licenses within the Delta managed by the State Water Board, including the already assigned portion of state filings, is approximately 245 million AFA. There are 100 rights with a face value of 500,000 AFA, or more that account for 84% of the total face value of the water rights within the Delta watershed. The Central Valley Project and State Water Project hold 75 permits and licenses within the Delta watershed that account for 53% of the total face value of the water rights within the watershed. The total face value of the unassigned portion of state filings for consumptive use (excluding state filings for the beneficial use of power) within the Delta watershed is approximately 60 million AFA. This does not mean that this 60 million AFA is hydrologically available for appropriation. Prior to assignment of a state filing, the State Water Board will require that an applicant provide evidence that water is available to support the assignment. Clearly, actual use must be only a small fraction of the face value of these water rights, particularly since face value does not include pre-1914 and riparian water rights. There are three primary reasons why the face value of water rights is greater than actual diversions:

1. When approving a water right application, the State Water Board has to find that water is available for appropriation for the project being proposed. In making that determination, the State Water Board looks at both the demand characteristics associated with the proposed use and the likelihood that supply will be adequate to supply that demand. The State Water Board is required to maximize the beneficial use of water. Historically, the State Water Board has approved permits for agricultural projects if water is available in 50 percent of years, under the condition that water cannot be diverted in years in which there is insufficient supply to satisfy prior vested rights.

2. Water rights are issued based on the maximum rate of diversion (for direct diversion projects) and the maximum annual diversion to storage (for reservoirs and other impoundments). For large storage projects, the maximum annual diversion to storage generally only occurs in the year in which the project initially fills. Most modern water rights include a bypass condition which can limit diversion amounts below the "face value" amount in many years. Some water rights include a condition that limits the amount of water that can be diverted in combination with other water rights. This information is difficult to capture in a database format.

3. Some projects are covered by multiple rights for the same molecules of water. The State Water Board's regulations require that separate water rights be obtained for non-consumptive and consumptive uses of water. Large multi-use reservoirs will have at least two permits as a result, one that allows non-consumptive uses like recreation at and below the reservoir and one that allows consumptive uses such as municipal and irrigation uses. Similarly, the same molecule of water may be diverted several times by several different water right holders as it works its way down a river. If the water is not consumptively used,

[1] DWR, Bay Delta Office, California Central Valley Unimpaired Flow Data, Fourth Edition Draft, May 2007

or lost to deep groundwater recharge, it likely returns to a river and is rediverted downstream.

Actual use under existing water rights is clearly a better metric to compare with unimpaired flows than is face value but the State Water Board has limited information on actual use. Comprehensive review and synthesis of the State Water Board's paper files would however provide only a crude estimate of actual historic and current use because of gaps in reporting and unreliability of the data already collected. Finally, there is a linkage between water availability in many surface waters and groundwater pumping but the State Water Board has no information on percolating groundwater pumping in the Delta watershed.

1.D.2.2 Attachments to Comments of California Water Impact Network and California Sportfishing Protection Alliance

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California Sportfishing Protection Alliance
"An Advocate for Fisheries, Habitat and Water Quality"
3536 Rainier Avenue, Stockton, CA 95204
T: 209-464-5067, F: 209-464-1028, E: deltakeep@me.com, W: www.calsport.org

21 July 2015

Mr. Thomas Howard
Executive Director
Ms. Barbara L. Evoy
Deputy Director, Division of Water Rights
State Water Resources Control Board
1001 "I" Street, 24th Floor
Sacramento, CA 95814
Barbara.Evoy@waterboards.ca.gov

VIA: Electronic Submission
Hardcopy if Requested

RE: COMPLAINT: Against SWRCB, USBR and DWR for Violations of Bay-Delta Plan, D-1641 Bay-Delta Plan Requirements, Clean Water Act, Endangered Species Act, Public Trust Doctrine and California Constitution

Dear Mr. Howard and Ms. Evoy:

The California Sportfishing Protection Alliance (CSPA) hereby submits a complaint against the State Water Resources Control Board (SWRCB), United States Bureau of Reclamation (USBR) and California Department of Water Resources (DWR) for violations of the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Delta Estuary (Bay-Delta Plan) and violations of D-1641 implementing requirements of water quality standards, Clean Water Act (CWA), Endangered Species Act (ESA), Public Trust Doctrine and the California Constitution.

Specifically, CSPA alleges that the SWRCB's sequential weakening of D-1641 requirements violates the federal CWA and represents a de facto change in the standards themselves, that the SWRCB has failed to enforce Bay-Delta water quality standards and has failed to enforce its 2010 Cease & Desist Order against USBR and DWR for violations of southern Delta salinity standards, that USBR and DWR are presently violating water quality standards protecting fish & wildlife and agricultural beneficial uses, and that USBR and DWR have failed to comply with the SWRCB 2010 Cease & Desist Order. CSPA additionally alleges that the SWRCB, USBR and DWR have failed to comply with their respective responsibilities and obligations under the ESA, Public Trust Doctrine and Article X of the California Constitution.

We incorporate by reference the protests, objections, exhibits and workshop comments and presentations that CSPA et al., the Bay Institute, Restore the Delta and Sequoia Forestkeeper et al. have previously made during the 2014 and 2015 SWRCB proceedings regarding USBR and DWR's Temporary Urgency Change Petitions (TUCPs) for the operation of the State Water Project and Central Valley Project.

Given the impending extinction of Delta smelt and possibly several other species, we ask the SWRCB to act expeditiously in responding and requiring USBR and DWR to respond to the allegations herein and to immediately reestablish D-1641's critical year requirements for the protection of fish and wildlife.

Dr. Peter Moyle has been publicly quoted as predicting the imminent demise of Delta smelt. Agency biologists have privately told us "they're gone." Should Delta smelt perish, it will not be the drought that sent them into extinction: it will be the failure of the SWRCB to comply with and enforce minimal standards for drought sequences that it adopted to prevent such catastrophe. Fallowed fields will be replanted when the drought is over; extinct species are forever lost. It would be tragic if the SWRCB's legacy were that its failure to comply with the law sent species that evolved and prospered over millennia into extinction. And longfin smelt are next in line.

Violations of Bay-Delta Standards & D-1641 Requirements

The federal CWA requires the adoption of water quality standards consisting of the designated uses of navigable waters and the water quality criteria or objectives necessary to protect those designated uses. Antidegradation requirements are an integral part of water quality standards.

The current water quality objectives in the 2006 Bay-Delta Plan for the San Francisco Bay/Sacramento-San Delta Estuary are the same as those in the 1995 Water Quality Control Plan. Many of those objectives were also in the 1978 Bay-Delta Plan.

The SWRCB's Decision 1641, issued in 2000, is the current implementation plan for Bay-Delta water quality standards. Implementation plans that do not protect the designated use of the waters do not comply with applicable water quality standards. D-1641 contains objectives to protect fish and wildlife, agricultural, municipal and recreational designated beneficial uses of the Bay-Delta estuary. Those objectives are expressed as narrative, concentration and or flow.

There is continuing disagreement between the SWRCB and U.S. Environmental Protection Agency (USEPA) concerning whether the CWA regulates the quantity of water or flow. However, flow and constituent concentration are flip sides of the same coin. Reductions in flow increase the concentration of pollutants. The U.S. Supreme Court observed that a lowering of quantity or flow could destroy all of the beneficial uses of a river, and specifically that "… there is recognition in the Clean Water Act itself that reduced stream flow, *i.e.*, diminishment of water quantity, can constitute water pollution." *PUD No. 1 of Jefferson County v. Washington Department of Ecology,* (1994), 511 U.S. 700, 17.

This complaint addresses violations of agricultural objectives, expressed as concentration, and fish and wildlife objectives, expressed as both flow and concentration. For example, fish and wildlife objectives are expressed as both minimum Delta outflow and salinity concentration. However, the preferred habitat of estuarine species like Delta and longfin smelt is predicated on the concentration of salinity. A key to Delta smelt abundance, X2, is determined by the concentration of salinity and not by flow.

In an effort to avoid having to secure USEPA approval, the SWRCB suggests that it only modified the implementation of water quality objectives and not the objectives themselves. However, the sequential or serial weakening of standards and refusal to enforce violations of standards constitutes a de facto change in the standards themselves, especially when the serial weakening of and failure to enforce standards is replicated over decades in similar situations.

In 2013, the SWRCB Executive Director allowed USBR and DWR to operate to critical year criteria, without being subject to enforcement, instead of to the prevailing dry year criteria. In 2014, the Executive Director issued a series of TUCP Orders substantially weakening and extending the modifications of water quality objectives and requirements on 31 January, 7 February, 14 February, 28 February, 18 March, 9 April, 11 April, 18 April, 2 May and 7 October. The SWRCB denied multiple objections and petitions for reconsideration of the TUCP Orders on 24 September 2014. So far in 2015, the Executive Director has issued a series of TUCP Orders modifying and weakening water quality objectives and requirements on 3 February, 5 March, 6 April and 3 July.

Beyond the SWRCB's de facto weakening of Bay-Delta water quality objectives, the USBR and DWR have failed to comply with even the modified objectives. Violations of salinity standards at Threemile Slough and Jersey Point have occurred in 2015 and are continuing. Additionally, the sequential Cease & Desist Order compliance schedules adopted by the SWRCB in WR Orders 2006-0006 and 2010-0002 that allowed USBR and DWR to avoid actual compliance with southern Delta salinity objectives have expired and USBR and DWR are now in violation of WR Order 2010-0002 and the southern Delta salinity objectives at Old River Near Tracy, Old River near Middle River and San Joaquin River at Brandt Bridge. Further, the Vernalis salinity objective was violated on 5 days in July 2015.

This pattern and practice has replicated itself over decades. For example, during the 1987-1992 drought, D-1485 Bay-Delta standards were violated 246 times in the period from 1988 through 1991, and the SWRCB declined to take enforcement action. In 1992, the SWRCB, citing an effort to preserve sufficient cold water in Shasta Reservoir to meet temperature requirements for spawning salmon, weakened Suisun Marsh salinity and Rock Creek chloride requirements in WR Order 92-02. Of particular note, the SWRCB, referencing WR Order 90-05, stated in WR 92-02 at page 9:

> The State Water Board also has advised the USBR that decisions on water deliveries are subject to the availability of water, and that water should not be considered available for delivery if it is needed as carryover to maintain an adequate cold water pool for the fishery.

However, the USBR and DWR have ignored that advice and have continued to maximize water deliveries in the initial years of drought sequences and failed to maintain sufficient carryover storage to protect fisheries and public trust resources. The pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards has been extensively discussed and documented in previous protests, objections and SWRCB TUCP workshops and is incorporated by reference and need not be repeated here.

Violations of Bay-Delta Agricultural Salinity Objectives

Water quality objectives contained in the Bay-Delta Plan include salinity standards to protect agricultural beneficial uses. Table 2 objectives include electrical conductivity (EC) requirements of 2.78 mmhos/cm in the Sacramento River at Emmaton between 1 April and 15 August of critical dry years; EC requirements of 2.20 mmhos/cm in the San Joaquin River at Jersey Point between 1 April and 15 August of critical dry years and EC requirements of 0.7 mmhos/cm (April-August) and 1.0 mmhos/cm (September-March) at four locations in the South Delta (Vernalis, Brandt Bridge, Old River near Middle River and Old River at Tracy Road) in all years.

On 6 April 2015, the SWRCB Executive Director approved a Temporary Urgency Change Petition submitted by USBR and DWR to move the Emmaton EC compliance location to Threemile Slough from April through June. On 30 June 2015, the Executive Director provided interim approval of a subsequent TUCP, and, on 3 July he issued an order approving an extension of the relocated Emmaton objective to Threemile Slough until 15 August 2015. This action was similar to an action in the 2014 TUCP Order by the Executive Officer that moved the compliance point to Threemile Slough.

Had the SWRCB Executive Director not relocated the Emmaton compliance point, EC would have violated objectives on or about 1 May 2015, when the 14-day running average EC was 2.81 mmhos/cm, and would be ongoing in the present. As of 16 July 2015, 14-day running average EC at Emmaton was 5.26 mmhos/cm. During 2014, the Emmaton objective was exceeded on or about 26 May, and exceedances continued through 23 July.

Beginning on 7 July 2015, the EC objective of 2.78 mmhos/cm at the relocated Threemile Slough compliance point has been violated. The 14-day running average EC concentrations stated respectively for each day were 2.85, 2.94, 3.03, 3.09, 3.11, 3.15, 3.18, 3.20, 3.21, 3.21, 3.18, 3.14, 3.01, 2.91 and 2.84 mmhos/cm from 7 through 21 July. The 15-minute EC data from the DWR gage at Threemile Slough is included in Attachment A. As of this writing, violations are continuing.

Beginning on 8 July 2015, the EC objective of 2.20 mmhos/cm at Jersey Point has been violated. The 14-day running average EC concentrations stated respectively for each day were 2.204, 2.234, 2.242, 2.233, 2.250, 2.239 and 2.238 and 2.231, 2.219 and 2.207 mmhos/cm from 8 through 17 July. The 15-minute EC data from the USBR gage at Jersey Point is included in Attachment A.

USBR and DWR have not requested changes regarding salinity objectives at compliance stations in the South Delta in any of their 2014 and 2015 TUCPs and no changes or variances have been granted. D-1641 included a 5-year time schedule to meet the southern Delta 0.7 mmhos/cm EC objective. The objective became effective on 1 April 2005. Violations occurred. The SWRCB, in Order 2006-0006, issued a Cease & Desist Order that required USBR and DWR to take corrective actions in accordance with another time schedule in order to obviate violations of water quality objectives for EC by 1 July 2009. Violations continued. The SWRCB extended the compliance deadline yet again in Order 2010-0002. CSPA and South Delta Water Agency petitioned for reconsideration of Order 2010-0002 but the SWRCB denied both petitions.

Order 2010-0002 required USBR and DWR to implement measures to obviate the threat of non-compliance with South Delta EC objectives and to submit a detailed plan and completion dates for actions that would ensure compliance. Order 2010-0002 extended the timeline for compliance to allow the SWRCB time to consider the possibility of modifying the responsibilities of USBR and DWR for meeting the objective, as part of its 2006 review of the 2006 Bay-Delta Plan. However, Order 2010-0002 explicitly states that *"the pending proceeding to consider changes to the interior southern Delta salinity objectives and associated program of implementation and any subsequent water right proceeding shall be deemed to have been completed if the State Water Board has not issued a final order in the water right proceeding by January 1, 2013, unless the Deputy Director for Water Rights determines that the water right proceeding has been initiated, is proceeding as expeditiously as reasonably possible, and will be completed no later than October 1, 2014."* Emphasis added.

After three consecutive compliance deadlines have expired, violations of southern Delta EC objectives continue. Pursuant to the 2010-0002 Cease & Desist Order, the "compliance schedule" concluded on 1 January 2013 because a 2006 Bay-Delta Plan water rights proceeding was not underway and could not be successfully concluded by October 2014. The USBR and DWR have failed to provide a detailed plan and completion date for coming into compliance with salinity objectives and are presently violating those objectives. We have documented more than 1,400 days of violations of the 1.0 or 0.7 mmhos/cm EC objective at the Old River at Tracy Road compliance site alone since April of 2007, including every day this year. In fact, between 10 June and 15 July 2015, all three southern Delta locations have violated the 30-day running average EC objective everyday and the EC objective at Vernalis was violated 7-9 July.

In summary, from 1 January through the end of 14 July 2015, legally promulgated water quality criteria in Table 2 of the Bay-Delta Plan to protect agricultural beneficial uses was exceeded numerous times: specifically, Emmaton salinity criterion was exceeded at least 79 days; Old River Near Tracy salinity criterion was exceeded at least 199 days; San Joaquin River at Brandt Bridge salinity criterion was exceeded at least 96; days and Old River near Middle River salinity criterion was exceeded at least 40 days. In July 2015, the modified 14-day running average salinity criterion at Threemile Slough was exceeded 7 July and continues to be exceeded, the 14-day salinity criterion at Jersey Point was exceeded 8 July through 17 July and the 30-day salinity criterion at Vernalis on the San Joaquin River was exceeded 7 - 11 July. The USBR and DWR have failed to provide a plan and date for achieving compliance with southern Delta salinity criteria and, consequently, have been violating the SWRCB's Cease & Desist Order since 1 January 2013 (566 days, as of 20 July 2015).

Violations of Bay-Delta Fish and Wildlife Salinity Objectives

Table 3 of the Bay-Delta Plan contains Delta outflow requirements, several of which are also expressed as salinity concentration. For critically dry years, the requirements mandate a minimum monthly average Net Delta Outflow Index (NDOI) of 7,100 cubic feet per second (cfs) or a daily average or 14-day running average of EC less or equal to 2.64 mmhos/cm at

Collinsville. For July, August, September and October of critically dry years, the requirements are an NDOI of 4,000, 3,000, 4,000 and 3,000 cfs, respectively. During dry years, the July, August, September and October requirements are 5,000, 3,500, 4,000 and 4,500 cfs, respectively.

As noted above, so far in 2015, the Executive Director has issued a series of TUCP Orders modifying and weakening water quality objectives and requirements on 3 February, 5 March, 6 April and 3 July. The 2 February TUCP Order reduced NDOI requirements and salinity objectives from 7,100 cfs/2.64 mmhos/cm requirements to 4,000 cfs, increased allowable exports when the 7,100 cfs objective wasn't being met, allowed the Delta Cross Channel Gates to be opened under certain circumstances and reduce San Joaquin River flow requirements from 710/1,140 to 500 cfs.

The 5 March TUCP Order exempted water transfers from export provisions and increased exports when outflow was between 5,500 and 7,100 cfs. The 6 April extended outflow/salinity and export requirements through June, shifted the time period and reduced the volume of the San Joaquin pulse flow from 3,110 to 710 cfs, reduced minimum San Joaquin River outflow requirements to 300 cfs in May and 200 cfs in June and moved the Western Delta salinity compliance point on the Sacramento River at Emmaton to Threemile Slough.

The 3 July TUCP Order reduced Delta outflow requirements in July from 4,000 to 3,000 cfs, with a 7-day running average of no less than 2,000 cfs, reduced the minimum Sacramento River flow requirements at Rio Vista from 3,000 cfs (September, October) and 3,500 cfs in November to a monthly average of no less than 2,500 cfs, with a 7-day average of no less than 2,000 cfs and extended the change in the salinity compliance point from Emmaton to Threemile Slough on the Sacramento River through 15 August.

From 1 January through the end of June 2015, legally promulgated water quality criteria in Table 3 of the Bay-Delta Plan to protect fish and wildlife beneficial uses were exceeded numerous times. Specifically, Delta outflow criterion was exceeded approximately 124 days, Collinsville salinity criterion was exceeded at least 146 days and San Joaquin River flow criterion was exceeded approximately 112 days.

Violations of the Public Trust and Article X of the California Constitution

Article X, Section 2 of the California Constitution provides that:

> The right to water or to the use of the flow of water in or from any natural stream or water course in this state is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.

Because of this Constitutional requirement, the SWRCB must consider the reasonableness of a particular method of diversion of water when evaluating (or reevaluating) all permitted uses of water and the requirements controlling those uses. "The limitations of Art. X, Section 2 … apply to all water users of the state and serve as a limitation on every water right and method of diversion." See *Yuba River D-1644* at p. 29. Both USBR and DWR are water users subject to Article X, Section 2 in the operation of their respective projects in the Central Valley.

Considering the conditions of drought which are described in the "drought emergency" declared by Governor Brown - the curtailments of water rights, the waiver of D-1641 standards to protect fish and wildlife and water quality in the Delta watershed - it is time for the SWRCB to declare flood irrigation by agriculture during the drought emergency a waste and unreasonable use until the emergency is over.

If the SWRCB can require urban conservation, it can also require conservation in agriculture. Flood irrigation in the Sacramento Valley in particular is unreasonable when the endangered salmon are facing extirpation. Increased evaporation from spreading water on the ground alone likely uses more stored water than that needed to save the fishery.

Alfalfa and irrigated pasture alone consumes 8.6 MAF of water in California and provides low net revenue and few jobs. The SWRCB can and must reduce the quantity of water allocated to irrigated pasture and low-value crops like alfalfa that use prodigious amounts of water during the drought emergency. To continue this use is unreasonable and a waste of water and must be stopped or reduced until the drought emergency is declared over.

The continued killing of threatened and endangered species by obsolete and non-protective export pumping facilities simply because the state and federal water contractors refuse to pay for new state-of-the-art fish screens is an unreasonable method of diversion. This is especially true when water diverted through those facilities deprives listed species of water and primary production necessary for survival. The SWRCB can and must curtail south Delta exports during the drought emergency until D-1641 water quality standards are met.

The SWRCB must also consider public trust issues in proceedings that concern water rights and water quality based on reserved jurisdiction or under the doctrine of reasonable use. The SWRCB may also modify permits of "the projects" that require the appropriator to reduce the quantity of exports. *United States v. SWRCB* (1986) 182 Cal.App. 3d 82, 124-131. The SWRCB has a complaint procedure that can exercise authority over both federal and state water projects by virtue of having state water rights permits issued by the Board.

The State's management responsibilities include broad discretion to promote trust uses, such as the continued survival of the Bay/Delta estuary and dependent endangered species, provided the discretion is exercised consistent with constitutional and statutory constraints. *People v. California Fish Co.* (1913) 166 Cal. 576, 597. While the State has discretion to promote trust issues, the SWRCB has "an affirmative duty" to protect trust resources. See *Illinois Central Railroad v. Illinois,* 146 U.S. 387; and *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419 (The state may not abdicate its supervisory role any more than the state may abdicate its police power); see also Stevens, The Public Trust: *A Sovereign's Ancient Prerogative Becomes the People's Environmental Right*, 14 U.C. Davis Law Review 195, 223.

Fish and wildlife are natural resources unequivocally protected by state sovereignty, whereby ownership of the resource is reserved to the states. *Geer v. Connecticut*, (1896) 161 U.S. 519.

The court in *Audubon v. Superior Court*, (1983) 33 Cal.3d. 419 held that "no one may obtain a vested right to undertake an act that is harmful to the trust." See also *SWRCB D-1644* (Yuba River) at page 29. The supremacy of the public trust over private individuals is reflected in a "judicial presumption against state or legislative alienation of trust resources." *People v. California Fish*; see also *Illinois Central v. Illinois* (1892) 146 U.S. 387; *Montana v. U.S.*, (1981) 450 U.S.544. Historically, state sovereign ownership was limited to "the traditional triad of uses" – commerce, navigation, and fishing.

However, in 1971 the California Supreme Court expanded the protected uses to cover the environment generally. *Marks v. Whitney* (1971) 6 Cal 3d. 251, 259-260. State sovereign ownership imposes restraints on the state's discretion regarding the use of navigable waters. The use of trust resources must be consistent with the general trust purposes or it is invalid. *State of California v. Superior Court* (Lyon) (1981) 29 Cal 3d. 210, 220-230; *Marks v. Whitney*, supra; *City of Long Beach v. Mansell*, (1970) 3 Cal 3d. 462, 482-485. Preservation of a public trust resource such as the San Francisco Bay/Delta estuary is a legitimate disposition of the public trust resource, and is consistent with general trust purposes. Thus, tidelands and water may be burdened with a negative easement against any active use or disposition of the trust reserve. Id; *National Audubon*, supra; *State of California v. Superior Court* (Fogerty), (1981) 29 Cal 3d. 240, 249-250.

Consequently, the SWRCB has both the authority and responsibility under its reserved jurisdiction in the permits and licenses of the USBR and DWR, and under its continuing authority and responsibilities pursuant to the public trust and reasonableness doctrine to protect fisheries, public trust resources and beneficial uses. To protect those resources and uses, it established minimum water quality objectives and requirements for critical dry years in the Bay-Delta Plan and D-1641.

USBR and DWR's pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards established to protect public trust resources as successive dry years occur has been amply documented in multiple documents and TUCP proceedings over the last several years. The SWRCB has failed to establish minimum reservoir storage levels that ensure compliance with water quality standards protective of public trust resources. When successive dry years occur, it then routinely weakens those standards, with little regard to its public trust and constitutional obligations.

To weaken those water quality objectives and requirements simply because USBR and DWR recklessly delivered water that was otherwise necessary to maintain sufficient carryover storage to comply with water quality objectives and to protect public trust resources and agricultural beneficial uses in the Delta is a violation of Public Trust Doctrine and the California Constitution. To send fisheries into extinction while continuing to supply water for low value crops like pasture and alfalfa is an unreasonable use of water.

It is not the SWRCB's responsibility or legal right to sacrifice public trust resources and Delta beneficial uses in order to absolve USBR and DWR of the consequences of their egregious mismanagement. If customers of water contractors are now suffering because USBR and DWR failed to exercise prudence and due diligence in water management and rashly delivered near normal water supplies in initial drought years with little thought that another dry year might occur, it is USBR and DWR and not the SWRCB that have the responsibility to alleviate the suffering they caused.

The SWRCB has failed to balance the public trust. The California Legislature, in the Sacramento-San Joaquin Delta Reform Act of 2009, mandated the SWRCB to develop new flow criteria for the Delta ecosystem that are necessary to protect public trust resources. Following an extensive public proceeding, the SWRCB prepared a report titled "*Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem.*" The SWRCB's 2010 Report stated: "Recent Delta flows are insufficient to support native Delta fishes for today's habitats" and recommended 75% of unimpaired Delta outflow from January through June, 75% of unimpaired Sacramento River inflow from November through June and 60% of unimpaired San Joaquin River inflow from February through June as necessary to protect public trust resources. While the flow report did not balance the public trust against other beneficial uses or consider economics, it did conclusively establish that present flows are seriously insufficient to protect public trust resources.

The Legislature also mandated the California Department of Fish and Wildlife (DFW) to develop *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta.* Following an extensive public proceedings throughout 2010, the DFW's report mirrored the conclusions and recommendations contained in the SWRCB flow report.

Five years after those reports were issued, the SWRCB has not begun to balance the public trust. It has, however, significantly weakened water quality standards and Delta flows. Fisheries have continued to decline and we are now faced with the imminent likelihood that one or more native species will become extinct.

An example of the SWRCB's egregious failure to even attempt to balance the public trust is demonstrated in the paucity of flows allocated to protect water quality and fisheries in July 2015. Releases from upstream-of-Delta rim reservoirs (Keswick, Whiskey Town, Oroville, Bullards Bar, Folsom, Camanche, New Hogan, New Melones, Don Pedro, New Exchequer and Friant) averaged 22,039 cfs or 43,703 AF daily 1 July through 19 July. Delta outflow for the same period averaged 2,990 cfs or 5,928 AF, most of which was necessary to allow operation of the state and federal project export pumps. In other words, under the most favorable light, only 13.6% of reservoir releases were allocated to protect fish and wildlife and Delta agricultural beneficial uses. The situation is even more bizarre on the San Joaquin River. Between 1 and 19 July, only 2.9% of flows released from New Melones, Don Pedro, New Exchequer and Friant reached the Delta. Whatever represents a reasonable public trust balancing, it is not 2.9% or 13.6% of flow, as water quality standards are violated and listed fish species plunge toward extinction.

Another example of the disregard for the public trust was provided in SWRCB staff's presentation on Sacramento-San Joaquin Watershed Use at the SWRCB 20 May 2015 Workshop on the TUCP, Emergency Drought Barrier, and Water Right Curtailments. Staff revealed that the 2015 TUCP Orders had reduced regulatory outflow by 78% to allow export pumping to increase by 46%. Increasing water exports is apparently a higher priority to the SWRCB than protecting water quality, critical habitat for listed species and public trust resources.

Violations Are Likely to Cause or Contribute to Extinction of Species

Since DWR's State Water Project began exporting water from the Delta, the DFW Fall Midwater Trawl indices for striped bass, Delta smelt, longfin smelt, American shad, splittail and threadfin shad have declined by 99.7, 97.8, 99.9, 91.9, 98.5 and 97.8 percent, respectively. The U.S. Fish & Wildlife Service's (USFWS) Anadromous Fisheries Restoration Program (AFRP) documents that, since 1967, in-river natural production of Sacramento winter-run Chinook salmon and spring-run Chinook salmon have decline by 98.2 and 99.3 percent, respectively, and are only at 5.5 and 1.2 percent, respectively, of doubling levels mandated by the Central Valley Project Improvement Act, California Water Code and California Fish & Game Code. Numerous species have been listed pursuant to state and federal endangered species acts.[1]

Populations of Bay-Delta fisheries plummeted during the 1987-1992 period and have never recovered from the impacts resulting from the serial violations of water quality objectives. Winter-run Chinook salmon were listed as threatened under the federal ESA emergency interim rule and endangered under the California Endangered Species Act (CESA) in 1989. Delta smelt were listed as threatened under both state and federal endangered species in 1993. Many of the noxious invasive species that have been identified as adversely impacting native fisheries became established and/or entrenched during that period.

The estuary's pelagic and anadromous fisheries have continued to decline since the 1987-1992 period. And now, the further weakening of water quality standards in 2013-2015 threatens to catapult several species into extinction.

For example, the 2014 Fall Midwater Trawl, 2015 Spring Kodiak Trawl and Summer Townet Delta smelt indices were the lowest in history. The Summer Townet index for Delta smelt was 0.0. Trawl #8 of the 20-mm Survey, conducted in late June, found only a single Delta smelt in Sacramento River at Threemile Slough, no longfin smelt and few striped bass. Compared to 2012, the 2015 trawl #8 of the 20-mm Survey catch-per-unit-effort of Delta smelt, striped bass and longfin smelt were down 98.9, 98.0 and 100 percent, respectively. Perhaps most alarmingly, the Survey identified no Delta smelt in Cache Slough and the Sacramento Deep-Water Ship

[1] Southern DPS green sturgeon (*Acipenser medirostris*), federal threatened, candidate for federal endangered; Delta smelt (*Hypomesus transpacificus*), state endangered, federal threatened, Longfin smelt (*Spirinchus thaleichthys*), state threatened; Central Valley steelhead (Oncorhynchus mykiss), federal threatened; Sacramento winter-run Chinook salmon (Oncorhynchus tshawytscha), state endangered, federal endangered; Central Valley spring-run Chinook salmon (Oncorhynchus tshawytscha), state threatened, federal threatened; Central Valley fall/late-fall-run Chinook salmon (*Oncorhynchus tshawytscha*), federal species of concern, state species of special concern; Sacramento splittail (*Pogonichthys macrolepedotus*), state species of special concern; Pacific lamprey (*Entosphenus tridentate*), federal species of concern and river lamprey (*Lampetra ayresi*), state species of special concern. The state and federal Project also have the potential to adversely affect Killer whales or Orcas (Southern Resident DPS) (*Orcinus orca*), federally listed as endangered because they are dependent upon Chinook salmon for 70% of diet and reduced quantity and quality of diet is one of the major identified causes of their decline.

Channel and trawl #9 found only one. The northern population of Delta smelt seems to have, as expected, succumbed to excessive temperature.

Delta smelt are at extreme risk of imminent extinction. There are multiple threats to the Delta Smelt population that contribute to its vulnerability and risk of extinction. Chief among these threats are reductions in freshwater inflow to the estuary; loss of larval, juvenile and adult fish at the state and federal Delta export facilities and urban and agricultural water diversions; direct and indirect impacts of the Delta Smelt's planktonic food supply and habitat; and lethal and sub-lethal effects of warm water and toxic chemicals in Delta open-water habitats.

Weakened water quality objectives and failure to enforce objectives have significantly reduced Delta outflow, increased Delta salinity and moved the Low Salinity Zone further upstream (eastward) into the Delta, thereby increasing the degree of each of these threats. Presently, remnants of the population are confined to a small area of the Low Salinity Zone where water temperatures have been significantly above levels identified in the literature as highly stressful and barely below the lethal endpoint.

The continued violations of Bay-Delta Plan and D-1641 objectives and requirements are an obvious and direct threat to the remnants of Delta smelt living in the Low Salinity Zone. Allowing these "weakened standards" to be violated is a direct disregard for the remaining population, placing them under extraordinary risk by bringing them further into the zone of water diversions, degrading their habitat into the lethal range of water temperature, further degrading their already depleted food supply, and increasing the concentrations of toxic chemicals being discharged into the Delta.

The various Biological Reviews, agency concurrence letters and the SWRCB's TUCP Orders acknowledge the manifold threats to Delta smelt and other estuarine species but dismiss them and disregard the consequences of further weakening of already inadequate standards.

USBR's March Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September, submitted to the SWRCB and fish agencies, acknowledged that the Delta smelt population had plunged to an all time low. It observed that drought impacts Delta smelt by reducing the area of low salinity habitat and food availability, impacting reproductive potential impairing fecundity, and reducing turbidity, thereby limiting predator avoidance. It pointed out that warm, slow-moving water promotes conditions in which parasites and toxic *Microcystis* blooms thrive, and that non-native Delta smelt predators, like black bass, and food competitors, like *Corbicula*, have increased during the present drought. It admitted that Delta smelt have a strong positive association with the position of X2 and that under the TUCP Delta smelt would not be in areas optimal for growth and survival because X2 would move further upstream.

With respect to longfin smelt, the USBR biological review observed that the TUCP will reduce outflow and that increased outflow is one of the best predictors of longfin smelt year class strength. Consequently, it is likely that the TUCP will exacerbate poor longfin smelt recruitment and survival and that longfin smelt larvae will have an increased risk of entrainment into the south Delta where they are not expected to survive warming water temperatures.

Despite knowing that smelt were already at historically low abundances, that the drought had increased already deleterious conditions, and that further reductions in outflow would exacerbate impacts, the USBR and DWR proposed the TUCP on 24 March 2015 and requested agency concurrence. Incredibly and inexplicably, the USFWS and CDFW, acutely aware that subsequent fish surveys had revealed a catastrophic collapse in population abundance and knowing that the Biological Opinions assumed compliance with D-1641 criteria and that there were significant "uncertainties" in the conclusions of the Biological Review, issued brief, cursory three-page concurrence letters three days latter, on 27 March, that claimed that reducing Delta outflow by 25 to 40% below D-1641 critical dry year criteria would not jeopardize the continued existence of smelt.

Of course, senior agency supervisors made these decisions. And we know, from private discussions with fishery agency staff, that the senior agency supervisors, many of whom participate in the secret weekly meetings of the Real-Time Drought Operations Management Team (RTDOT), ignored and rejected the recommendations and pleas from biological and technical staff that the TUCPs posed a threat to the continued existence of these species. Over the last several years, we have consistently told the SWRCB what would occur should they approve the various TUCPs. Sadly, the results from subsequent fish surveys and trawls establish that we were right and the SWRCB, USBR, DWR and fishery agencies were wrong!

The SWRCB was acutely aware of the adverse consequences of approving the recent TUCP. The 3 July 2015 TUCP Order acknowledges on pages 12 and 13:

> "The extreme drought conditions that have been occurring for the last four years are having significant impacts on fish and wildlife," Delta smelt indices "…*are at record low numbers*," "*Delta smelt have a strong positive relationship with a specific location in the low salinity zone (LSZ) referred to as X2*…" and "*...habitat quality and quantity diminish the more frequently and further the LSZ movers upstream*…" It points out that "…*there are likely to be few adult Delta smelt that live through the summer*…" and "…it *appears fish density has become so low that the SKT (Spring Kodiak Trawl) has reached or gone below its minimum effective detection ability*," and that in supplemental USFWS in sampling in the lower San Joaquin River "catch of *adult Delta smelt declined precipitously to zero in the final month of sampling*." Emphasis added.

The 3 July 2015 TUCP Order, discussing the biological reviews, observes on page 14:

> The proposed TUCP changes will have effects on physical habitat and water quality which may affect Delta smelt. The changes *will add to the already unfavorable conditions* related to the dry conditions. The Biological Review finds that reductions in inflows and outflows associated with the changes to Delta outflow, Western Delta agricultural salinity and Sacramento River flows may *reduce the general quality of habitat conditions throughout the Delta.* Further, survival of Delta smelt that are currently in the interior and North Delta may be *reduced through increased exposure to degraded habitat and predators and increased travel time for migrating fish*. In the lower San Joaquin River, the upstream relocation of X2 may result in a greater proportion of the

> available habitat encompassing areas of high semi-aquatic vegetation and associated low turbidities. This could result in lower prey availability and higher predation rates on juvenile Delta smelt. Further constraining Delta Smelt closer to the upstream spawning areas in the lower Sacramento River, San Joaquin River, and the Cache Slough Complex/SDWSC *will increase Delta smelt exposure to less favorable conditions.* Conditions in these regions are generally warmer in the summer than locations further west due to prolonged heat waves and less marine influence. Juvenile Delta smelt may be able to reside in thermal refugia to reduce these effects, but *it is not clear how long that cool water refugia will be available this summer*. In addition, due to the more upstream location of X2, it is also likely that summer *Delta smelt distributions will not be in areas for optimal growth and survival* further west in Suisun Bay. Reduced inflows and outflows may also *affect Delta smelt's ability to move downstream to cooler habitats* with more food resources. These effects could *pose additional risks to the persistence of local populations.* Emphasis added.

With respect to estuarine habitat and species, the 3 July 2015 TUCP Order on page 15 observed:

> The Biological Review focused on species listed under ESA and CESA, but the proposed action is *also likely to have adverse effects on other beneficial uses protected under D-1641*," "Since most of these species are not afforded the protections of ESA and CESA, *many have undergone population declines over the history of water development in the Bay-Delta*" and "*...decreasing Delta out flow constrains habitat by moving X2 and the LSZ inland* from the shallow, more favorable habitats of Suisun Bay to the deeper, channelized, and less hospitable habitats of the lower Sacramento and San Joaquin Rivers and their confluence. This reduction in habitat quantity and quality *will also likely result in lower survival and recruitment of several other estuarine dependent species*. Emphasis added.

Despite the serious risks of extinction of Delta smelt and other estuarine species, the SWRCB issued the TUCP Order on 3 July 2015. Apparently, the determination to deliver large quantities of water to Sacramento Settlement Contractors similar to the quantities they received over the last several years outweighs the potential extinction of species. In other words, the irrigation of vast tracts of pasture, alfalfa and other low value crops in the Sacramento Valley is more important than the continued existence of species that evolved and prospered over millennia.

Violations of the Federal Clean Water Act

The Code of Federal Regulations, at 40 CFR §131.20 states that the "State shall from time to time, but at least once every three years, hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards." The State is required to submit the results of the review to USEPA for review and approval.

Over the last 20 years since adoption of the present standards in 1995, the SWRCB has reviewed the water quality standards pertaining to the Delta only once, in 2006. In the 2006 review, no changes were made in the 1995 standards despite the continued decline of the estuary's pelagic and anadromous fisheries. The present proceeding to review Bay-Delta standards is years away from completion. The SWRCB is in violation of the federal CWA.

Following disapproval of the results from the state's 1991 proceeding to revise the 1978 Water Quality Control Plan, USEPA promulgated specific water quality standards for the Delta. The federal standards are significantly more protective of the ecosystem than present state standards. Even though the SWRCB subsequently issued its present standards in late 1995, the federal standards remain at 40 CFR §131.37. The SWRCB has refused to acknowledge or comply with the federal standards. Consequently, the SWRCB is in violation of the federal CWA.

The SWRCB has failed to comply with state and federal antidegradation requirements in lowering water quality. At a minimum, antidegradation requirements require that water quality standards must protect "fishable" beneficial uses. The SWRCB has undertaken no analysis of the impacts to beneficial uses and the trade-offs or costs between a temporary loss of water to state and federal water contractors to irrigate low value crops like pasture and alfalfa and the decline of fisheries and likely extinction of species. Nor is there any analysis of the relative benefits of weakening water quality standards in order to provide water to state and federal water contractors at the cost of depriving Delta farmers of water and water quality.

USBR and DWR's pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards as successive dry years occur has been amply documented in multiple documents and TUCP proceedings over the last several years. The SWRCB has failed to establish minimum reservoir storage levels that ensure compliance with water quality standards in the event of successive dry years and then routinely weakens those standards when droughts occur.

The numerous violations of water quality criteria enumerated above, the serial weakening of water quality criteria and implementation requirements, the refusal to enforce violations of water quality criteria, the failure to timely review water quality criteria and the approval of the pattern and practice of creating conditions that prevent water quality criteria from being met in sequential dry years constitute violations of the CWA. Consequently, the SWRCB, USBR and DWR have violated the CWA.

Violations of the Endangered Species Act

In enacting ESA, Congress stated that the purpose of the ESA is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." 16 U.S.C. § 1531(b). As part of conserving endangered or threatened species, ESA prohibits the "taking" of any such listed species. 16 U.S.C. § 1538(a)(1)(B). A "take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." 16 U.S.C. § 1532(9). To "harm" a listed species in the context of a "take" includes "[any] act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." 50 C.F.R. § 17.3 (1994). An indirect injury to a listed species through habitat modification also constitutes a "take." *Babbitt v. Sweet Home Chapter of Communities for A Great Oregon*, 515 U.S. 687 (1995). The 9th Circuit Court of Appeals ruled that "under Sweet Home, a habitat modification which significantly impairs the breeding and sheltering of a protected species amounts to 'harm' under the ESA." *Marbled Murrelet v Pacific Lumber Company*, 83 F.3d 1060 (9th Cir. 1996).

USBR and DWR have operated to a pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards. The SWRCB has operated to a pattern and practice of weakening water quality standards and thereby significantly degrading the habitat and impairing essential behavioral patterns, breeding, feeding, or sheltering of listed species. The SWRCB, USBR and DWR are in violation of the ESA.

Delta smelt and other estuarine species' abundances have plummeted over the last few years to the point where they are facing the likelihood of imminent extinction. Over this period, the SWRCB has acceded to multiple requests by USBR and DWR to weaken basic minimum standards adopted to protect listed species and their habitats. These serial actions by the SWRCB have seriously modified and degraded the habitat and impaired the breeding and sheltering of listed species to the point of impending extinction.

The fact that USFWS, NMFS and CDFW have routinely issued concurrence letters in response to the TUCPs, frequently within hours or several days of receiving Reinitiation of Consultation requests, cannot be a valid excuse or defense. Since initial listings under EWA or CESA, abundances of listed species have continued to plummet. USFWS, NMFS and CDFW have essentially defined themselves as "capture agencies" and chaperoned listed species on their road to extinction.

Notwithstanding the letters of concurrence from USFWS, NMFS and CDFW that claim these actions are consistent with existing Biological Opinions, nothing in the ESA legally allows or justifies the SWRCB, USBR or DWR to further degrade the habitats of species lingering on the precipice of extinction. Collectively, the excuses, justifications and serial weakening of water quality criteria emanating from the secret RTDOT meetings while the fishery agencies remain embraced in denial as fisheries plummet toward extinction, surely constitute one of the saddest and most wretched spectacles we've ever witnessed and could be easily construed as an illegal conspiracy to defraud the public of public trust resources to the benefit of special interests.

A Final Thought

It is not simply water quality, fisheries and public trust resources that have been sent to the scaffold: it is also the public's security. With the exception of Shasta, water storage in all of the rim reservoirs is significantly below this time last year. Several are already below 1976-1977 levels and others are headed toward historic lows. As of 20 July, storage in the rim reservoirs totaled 5,632,522 AF and was being depleted by 43,703 AF daily or 1,354,796 AF monthly.

Historically, El Nino years have had an equal chance of being dry or wet. Should California experience another dry year, the impacts will be far greater than those endured this year. The

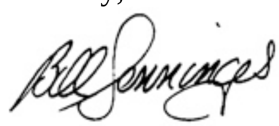
SWRCB's failure to establish minimum reservoir storage levels and its inability to protect the public and public trust resources by saying no to special interests in sequential dry years has placed the state in grave jeopardy. California deserves better.

In Conclusion

We request that the SWRCB immediately use its public trust, constitutional and water rights authorities to require USBR and DWR to comply with D-1641 critically dry year water quality objectives, reduce water deliveries to low value crops in order to meet Bay-Delta objectives and to ensure sufficient reservoir storage to comply with temperature and other water quality objectives, and issue sanctions against USBR and DWR for their willful disregard for public trust resources and Delta beneficial uses. We also request that the SWRCB accelerate the present review of Bay-Delta standards, including a comprehensive balancing of the public trust with competing uses, and provide us a response to our 13 August 2014 complaint regarding illegal diversion by DWR and USBR and petition to adjudicate Central Valley waters.

Thank you for considering these comments and responding to this complaint. If you have questions or require clarification, please don't hesitate to contact us.

Sincerely,



Bill Jennings, Executive Director
California Sportfishing Protection Alliance

Attachment

Cc: Felicia Marcus, Frances Spivy-Weber, Tam M. Doduc, Steven Moore, Dorene D'Adamo, Michael George

California Sportfishing Protection Alliance
"An Advocate for Fisheries, Habitat and Water Quality"
3536 Rainier Avenue, Stockton, CA 95204
T: 209-464-5067, F: 209-464-1028, E: deltakeep@me.com, W: www.calsport.org

2 August 2015

Mr. Thomas Howard
Executive Director
Ms. Barbara L. Evoy
Deputy Director, Division of Water Rights
State Water Resources Control Board
1001 "I" Street, 24th Floor
Sacramento, CA 95814
Barbara.Evoy@waterboards.ca.gov

VIA: Electronic Submission
Hardcopy if Requested

RE: COMPLAINT: Against SWRCB and USBR for Violations of Central Valley Basin Plan, WR Order 90-05, Clean Water Act, Endangered Species Act, Public Trust Doctrine and California Constitution

Dear Mr. Howard and Ms. Evoy:

The California Sportfishing Protection Alliance (CSPA) hereby submits a complaint against the State Water Resources Control Board (SWRCB) and United States Bureau of Reclamation (USBR) for violations of the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan), violations of WR Order 90-05 and Sacramento River temperature requirements and for violations of the Clean Water Act (CWA), Endangered Species Act (ESA), Public Trust Doctrine and the California Constitution.

Specifically, CSPA alleges that the SWRCB has failed to implement crucial Basin Plan water temperature criteria and CWA requirements protecting water quality and fish and wildlife beneficial uses with respect to USBR's water rights permits and licenses and has failed to take enforcement actions against USBR's habitual violations of the Basin Plan, CWA and WR Order 90-05 temperature criteria and requirements. CSPA alleges that USBR has failed to comply with explicit temperature criteria protecting fish and wildlife beneficial uses contained in the Basin Plan, CWA and WR Order 90-05. CSPA additionally alleges that the SWRCB and USBR have failed to comply with their respective responsibilities and obligations under the ESA, Public Trust Doctrine and Article X of the California Constitution.

CSPA incorporates by reference the comments, protests, objections (including exhibits) and workshop presentations submitted and presented over the last two years in the SWRCB drought proceedings related to Temporary Urgency Change Petitions (TUCP) and SWRCB TUCP Orders by CSPA et al., Bay Institute, Sequoia Forestkeeper and Restore the Delta. Those documents can be found on the SWRCB's State Water Project and Central Valley Project Temporary

Urgency Change Petition webpage under the headings *Comments/Objections/Protests/Petitions for Reconsideration* and *Temporary Urgency Change Petitions and Drought Workshops.*

We file this complaint in the wake of poor natural production of the 2013 brood year of Sacramento River winter-run, spring-run and fall-run Chinook salmon and the destruction of the 2014 year classes. Given the presence of lethal temperatures in the Sacramento River this year that threaten a repeat of last year's disaster, CSPA asks the SWRCB to act expeditiously in responding and in requiring USBR to respond to the allegations herein. CSPA requests that the SWRCB immediately re-establish protective, non-lethal temperature criteria at the Clear Creek compliance point and that the SWRCB require USBR to reduce water deliveries in order to preserve what's left of cold water reserves in Shasta Reservoir. CSPA further requests the SWRCB to issue sanctions against USBR for failure to comply with the Basin Plan, CWA and ESA.

WR Order 90-05 and the initial listing of winter-run Chinook salmon came on the heels of myriad exceedances of temperature criteria and alarming salmon population declines following the drought of 1976-1977 and the initial years of the 1987-1992 drought. Subsequent droughts brought similar population declines followed by only partial rebounds in wetter years that show a parallel long-term decline in anadromous fisheries. Failure to adopt and enforce defensible temperature criteria has been a key factor in the continued decline of Sacramento Chinook salmon to the point where winter-run and spring-run are now threatened with extinction and California's commercial salmon fishery is wholly dependent on grow-and-truck hatchery production for survival.

As discussed more fully below, the Central Valley Regional Water Quality Control Board (Regional Board) established temperature criteria in the Sacramento River, pursuant to the CWA and the SWRCB implemented the temperature criteria in USBR's permits and licenses in WR Order 90-05. In doing so, the SWRCB implemented temperature criteria based on average daily temperatures without determining whether average daily temperatures were protective of aquatic life and, additionally, exempted almost 43% of identified fish spawning habitat from temperature requirements. The SWRCB then ignored the Basin Plan's Controllable Factors Policy and it's own admonition to USBR that water necessary to meet water quality criteria was not available for delivery. When the National Marine Fisheries Service (NMFS) listed winter-run Chinook salmon as threatened under the ESA, the SWRCB ignored the presence of other species and relocated the temperature compliance point further upstream.

Over the next 23 years, the SWRCB participated in back-room temperature management group meetings that recommended ever-changing temperature compliance points, based upon the quantities of water USBR had remaining in storage after deliveries to its water contractors. The SWRCB subsequently approved the recommendations of the temperature management group of which it is a participating member. These approvals generally relocated temperature compliance points further and further upstream, often eliminating as much as 90% or more of spawning habitat protected by the Basin Plan. And despite these yearly concessions, USBR has violated temperature criteria in nearly every year without a single enforcement sanction being issued by the SWRCB.

The SWRCB has ignored USBR's failure to comply with the National Marine Fisheries Service's (NMFS) OCAP Biological Opinion's (BO) Reasonable and Prudent Action (RPA) performance measures regarding end of September carryover storage at Shasta Reservoir and the percentages-of-time USBR is required to meet temperature criteria at specific compliance points. It has sidestepped the BO's RPA drought exception procedures when end of September Shasta storage is projected to be less that 1.9 million acre-feet (MAF). It refuses to address the conflict that exists under these conditions, between USBR delivering "nondiscretionary" water to Sacramento Settlement Contractors and achieving compliance with temperature objectives, despite the fact that the BO observes that these poor conditions "… could be catastrophic to the species, potentially leading to a significant reduction in the viability of winter-run."

The SWRCB is aware that USBR lacks the legal authority to curtail "nondiscretionary" contract water deliveries to Sacramento Settlement Contractors to meet ESA requirements. Despite being notified of a likely conflict between the delivery of this "nondiscretionary" water and compliance with temperature requirements, the SWRCB refused to use its authorities to reduce water deliveries in order to retain sufficient cold water storage necessary to meet temperature criteria. The BO does not address ESA section 7(a)(2) compliance for individual water supply contracts and, consequently, delivery of water that is "nondiscretionary" for the purposes of the ESA is not exempt from ESA section 9 take prohibitions. In effect, the SWRCB has sanctioned the illegal "take" of endangered species by the USBR and Sacramento Settlement Contractors.

USBR's delivery of 1.3 MAF of water to Sacramento River contractors in 2014 depleted limited cold water reserves in Shasta Reservoir leading to significant exceedances of water temperature criterion. The 2014 year classes of Sacramento winter-run, spring-run and fall-run Chinook salmon were virtually destroyed. Although the SWRCB acknowledged that it had made a serious mistake last year, it has inexplicably elected to repeat the mistake in 2015.

Rejecting the politically unpalatable option of reducing water deliveries to Sacramento Settlement Contractors to ensure compliance with temperature criteria, the SWRCB has instead approved USBR's request to increase the temperature compliance target from a daily average of 56ºF to 58ºF. This despite the fact that the NMFS pointed out in April that an increase to 58ºF would result in adverse impacts to incubating winter-run eggs and alevin in redds and that 58ºF was identified in the scientific literature as lethal to incubating salmon eggs and emerging fry. The subsequent concurrence by NMFS because "the plan provides a ***reasonable possibility*** that there will be ***some juvenile winter-run survival*** this year" is an unacceptable and illegal standard of compliance with the BO and ESA. [Emphasis added.]

The SWRCB justified the higher temperature criterion as necessary to preserve cold water in Shasta to avoid depletion of the cold water pool and more devastating impacts later in the year. However, the urgent need to preserve cold water was apparently unimportant to the SWRCB as USBR delivered 366,794 acre-feet (AF) of water in April and May to Sacramento River water contractors while exporting another 312,686 AF in the first five months of the year. Depletions (i.e., water deliveries) between Bend Bridge and Wilkins Slough in June and July of this year totaled another 500,771 AF.

CSPA et al. and others pleaded with the SWRCB to reduce these water deliveries in order to protect cold water storage. The NMFS summed up the situation in their 1 July 2015 concurrence letter regarding USBR's temperature management request in observing, "We note that these conditions could have been largely prevented through upgrades in monitoring and modeling, and reduced Keswick releases in April and May." Daily average June/July temperatures in the Sacramento River at the Clear Creek compliance point have been significantly higher this year than they were last year.

As we show below, a 56ºF daily average temperature criterion is not protective of Chinook salmon spawning, egg incubation and fry emergence. The U.S. Environmental Protection Agency (USEPA), the states of Washington, Oregon and Idaho, both North Coast and Central Valley Regional Boards, NMFS, California Department of Fish and Wildlife (CDFW), the Pacific Fishery Management Council and the majority of the scientific literature have either adopted or recommended more restrictive temperature criteria based upon a daily maximum and/or a seven-day mean of daily maximums.

In sum, the SWRCB essentially bases its implementation of temperature criteria for Sacramento River Chinook salmon on the amount of water USBR has left over after supplying its contractors. Notwithstanding the law and the fact that protection, restoration and enhancement of fish and wildlife is a coequal purpose of the Central Valley Project (CVP), water deliveries always come first regardless of water year type.

Should winter-run Chinook salmon, Delta and longfin smelt and potentially several other species that have evolved and thrived over millennia go extinct, it will not be because of drought. It will be because the SWRCB has refused to comply with its responsibilities under the Water Code, CWA, ESA, Public Trust Doctrine and California Constitution.

Sacramento River Salmon Fisheries are in a State of Collapse

The precipitous collapse of the Central Valley's pelagic and anadromous fish populations in recent decades has been extensively documented in our referenced documents and need not be repeated at length here. Numerous species dependent on the Sacramento River for all or part of their life cycle have been listed pursuant to state and federal endangered species acts.[1]

Since 1967-68, the U.S. Fish & Wildlife Service's (USFWS) Anadromous Fisheries Restoration Program (AFRP) documents that, since 1967, in-river natural production of Sacramento River

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[1] Southern DPS green sturgeon (*Acipenser medirostris*), federal threatened, candidate for federal endangered; Delta smelt (*Hypomesus transpacificus*), state endangered, federal threatened, Longfin smelt (*Spirinchus thaleichthys*), state threatened; Central Valley steelhead (Oncorhynchus mykiss), federal threatened; Sacramento winter-run Chinook salmon (Oncorhynchus tshawytscha), state endangered, federal endangered; Central Valley spring-run Chinook salmon (Oncorhynchus tshawytscha), state threatened, federal threatened; Central Valley fall/late-fall-run Chinook salmon (*Oncorhynchus tshawytscha*), federal species of concern, state species of special concern; Sacramento splittail (*Pogonichthys macrolepedotus*), state species of special concern; Pacific lamprey (*Entosphenus tridentate*), federal species of concern and river lamprey (*Lampetra ayresi*), state species of special concern. The Project also has potential to adversely affect Killer whales or Orcas (Southern Resident DPS) (*Orcinus orca*), federal listed as endangered because they are dependent upon Chinook salmon for 70% of diet and reduced quantity and quality of diet is one of the major identified causes of their decline.

winter-run, spring-run and fall-run Chinook salmon have decline by 98.2, 99.3 and 91.2 percent, respectively, and are only at 5.5, 1.2 and 31.6 percent, respectively, of doubling levels mandated by the Central Valley Project Improvement Act, California Water Code and California Fish & Game Code.

The construction of Shasta Dam eliminated the ability of Sacramento River winter-run, spring-run and late-fall-run Chinook salmon to reach the cold spring-fed headwaters of the Upper Sacramento, Pit, McCloud and Fall Rivers to spawn.[2] Before the Dam was constructed, there were an estimated 34,634 spawning sites for winter-run salmon available in the Upper Sacramento, McCloud, and Pit River systems. With the exception of Battle Creek, 100% of the winter-run salmon spawned upriver from the present site of Shasta Dam.[3] Pre-Shasta populations of spring-run salmon once had at least 51,377 spawning sites dispersed throughout the Upper Sacramento, the McCloud, and Pit Rivers (PG&E's Pit River dams eliminated an additional 7,444 upriver spawning sites without mitigation). Only about 15% of the fall-run salmon generally spawned above the present site of Shasta Dam. Most fall-run spawned within the lower river and its foothill reaches at elevations less than 500 feet. The construction of Shasta Dam eliminated approximately 201 miles of historically available habitat in the Pit, McCloud and Upper (little) Sacramento Rivers.[4]

Shasta/Keswick dams not only eliminated the vast majority of spawning habitat for winter-run, spring-run and late-fall-run Chinook salmon, they eliminated the quality of drought-proof habitat. The remaining habitat is subject to droughts and USBR's failure to retain sufficient reservoir storage in sequential low water years to meet temperature requirements. Additionally, the remaining spawning habitat is crammed into the 59 miles between Keswick and Red Bluff Diversion Dam (far less in most years) and does not provide necessary spatial separation between overlapping stocks, which leads to superimposition of redds. Under these degraded conditions, it is imperative that every effort be extended to ensure that the quality of remaining spawning habitat is protected. This means complying with temperature objectives for sensitive life stages during critical drought years.

Following the construction of Shasta Dam, significant numbers of winter-run Chinook salmon spawned below Red Bluff. Between 1987 and 1992, 19% of winter-run salmon spawned in the Sacramento River below Red Bluff as far down as Hamilton City. After construction of Red Bluff Diversion Dam in 1964, it was noted that 60% of fall-run Chinook salmon spawned below the Dam.[5] A 1988 DWR report titled *Water Temperature Effects on Chinook Salmon (Oncorhynchus tshawytscha), With Emphasis on the Sacramento River, A Literature Review*

[2] Yoshiyama RM, Fisher FW, Moyle PB. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. N Am J Fish Manage 18(1998):487–521.

[3] Hallock RJ, Rectenwald H. 1989. Environmental factors contributing to the decline of the winter-run chinook salmon on the upper Sacramento River. In: Northwest Pacific chinook and coho salmon workshop proceedings. Bethesda (MD): American Fisheries Society. p 141–5.

[4] Yoshiyama RM, Gerstung ER, Fisher FW, Moyle PB. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. In: Sierra Nevada ecosystem project: final report to Congress. Volume III: assessments, commissioned reports, and background information. Davis (CA): University of California, Centers for Water and Wildlife Resources. p 309–61.

[5] Hallock, as cited in Lufkin 1991, p 100. Lufkin A, editor. 1991. California's salmon and steelhead: the struggle to restore an imperiled resource. Berkeley (CA): University of California Press.

reported: "By 1976 spawning activity was nearly uniform in the reaches from Balls Ferry to Keswick, Red Bluff to Balls Ferry, and Hamilton City to Red Bluff. More recent data show that the reach from Hamilton City to Red Bluff receives more spawning activity than do both upper reaches combined."[6]

SWRCB Order 90-05 limited temperature protection to Red Bluff, excluding 44 river miles and more than half of the then-extant Chinook spawning habitat from temperature protection. This had the effect of shifting spawning upriver. USBR's failure to provide adequate temperature control on the Sacramento River has pushed spawning ever further upstream. Between 2001 and 2005, only about 1% of winter-run salmon spawned below Red Bluff.[7]

The CDFW annually surveys the Sacramento River to estimate numbers of Chinook salmon that return and spawn. The results are published in annual reports titled *Chinook Salmon Populations for the Upper Sacramento River Basin* and include the results of aerial surveys of spawning redds. CDFW staff recommends using aerial redd data only for comparisons of redd distributions by river sections or for specific needs such as use of a specific area as a spawning location. Aerial redd surveys do not provide complete counts of new redds, but it is assumed that the proportion of redds visible in the various sections during a single flight are identical.

These reports establish that significant Chinook salmon spawning occurs below Red Bluff and, consequently, the Basin Plan's temperature criteria for the reach between Red Bluff and Hamilton City are both justified and necessary. They also illustrate the compression of salmon spawning that has occurred in the extreme upper reaches below Keswick because USBR has failed to provide adequate cold water flows to meet temperature criteria in the river.

- In 2005, 21.1% of fall-run, 15.2% of spring-run, 9.8% of late-fall-run redds were identified below Red Bluff Diversion Dam and 88.9% of winter-run, 30.3% of fall-run, 29.5% of spring-run, and 51.63% of late-fall-run redds were found above the Highway 44 Bridge in Redding.[8]
- In 2007, 17% of fall-run and 10% of late-fall-run redds were below Red Bluff and 83% of winter-run, 25% of fall-run, 43% of spring-run, and 60% of late-fall-run redds were compressed into the 5 miles above Highway Bridge 44 in Redding.[9]
- In 2008, 6% of fall-run and 10% of late-fall-run redds were found below Red Bluff and 92% of winter-run, 35% of spring-run 56% of late-fall-run and 7% of fall-run redds were compressed into the reach above the Highway 44 Bridge.[10]

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[6] Boles G, Turek S, Maxwell C. 1988. *Water Temperature Effects on Chinook Salmon (Oncorhynchus tshawytscha), With Emphasis on the Sacramento River,* California Department of Water Resources. pp. 2, 18.

[7] OCAP BA, 5-12, 2008.

[8] Killam D, Harvey-Arrison C, Chinook Salmon Populations for the Upper Sacramento River Basin 2005, SRSSAP Technical Report No. 6-3, 2006: California Department of Fish and Game, Summary of Aerial Redd Survey Data 2008, Table 2, p. 9.

[9] Killam D, Kreb B, Chinook Salmon Populations for the Upper Sacramento River Basin 2007, SRSSAP Technical Report No. 08-4, 2008: California Department of Fish and Game, Summary of Aerial Redd Survey Data 2008, Table 2, p. 8.

- In 2011, 11% of fall-run redds were below Red Bluff and 78% of winter-run and 88% of late-fall-run and 34% of fall-run redds were above the Highway 44 Bridge. There were no spring-run aerial flights.[11]
- In 2012, 21% of fall-run redds were observed below Red Bluff and 99% of winter-run and 83% of late-fall-run and 22% of fall-run redds were identified into the reach above the Highway 44 Bridge.[12]

Failure to provide adequate temperatures protective of sensitive life stages of Chinook salmon and the resultant compression of spawning habitat are major factors in the continued decline of the species and the threatened extinction winter-run and spring-run salmon.

Violations of the CWA, Basin Plan, WR Order 90-05 and CVPIA

The Regional Board's Basin Plan was adopted pursuant to the CWA and approved by the EPA. With respect to the Sacramento River, the Basin Plan explicitly states, "The temperature shall not be elevated above 56ºF in the reach from Keswick Dam to Hamilton City nor above 68ºF in the reach from Hamilton City to the I Street Bridge during periods when temperature increases will be detrimental to the fishery." Hamilton City is located at River Mile (RM) 199 on the Sacramento River. These temperature requirements protecting Chinook salmon extend up-river for 103 miles to Keswick Dam (RM 302).

As described above, the construction of Shasta and Keswick Dams eliminated virtually the entire historical spawning habitat for winter-run and spring-run Chinook salmon and forced these species to spawn in the river below Keswick. Historically, only 15% of fall-run Chinook salmon spawned in the Sacramento River upstream of Shasta Dan. The majority spawned in the lower river between Keswick and Hamilton City and until recently more than half spawned in the reach between Red Bluff Diversion Dam and Hamilton City.

The Basin Plan also states that temperature objectives are limited to "controllable factors" and "in determining compliance with the water quality objectives for temperature, appropriate averaging periods may be applied *provided that beneficial uses will be fully protected*." Emphasis added.

The Basin Plan's Controllable Factors Policy states:

> Controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of the waters of the State that are subject to the authority of the State Water Board or Regional Water Board, and that may be reasonably controlled.

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[10] Killam D. Chinook Salmon Populations for the Upper Sacramento River Basin in 2008, SRSSAP Technical Report No. 09-1, 2009: California Department of Fish and Game, Summary of Aerial Redd Survey Data 2008, Table 3 p. 9.

[11] Killam D. Chinook Salmon Populations for the Upper Sacramento River Basin in 2011, RBFO Technical Report No. 03-2012: California Department of Fish and Game, Summary of Aerial Redd Survey Data 2011, Table 2 p. 15.

[12] Killam D. Chinook Salmon Populations for the Upper Sacramento River Basin in 2012, RBFO Technical Report No. 02-2013: California Department of Fish and Game, Summary of Aerial Redd Survey Data 2012, Table 2, p. 14.

In 1990, the SWRCB issued WR Order 90-05, which implemented the Basin Plan with respect to USBR's water rights and licenses for the CVP. It requires USBR to meet a daily average water temperature of 56ºF in the Sacramento River at Red Bluff Diversion Dam (RM 243) during periods when higher temperatures will be detrimental to the fishery. WR Order 90-05 states that when factors beyond the control of USBR prevent attainment of 56ºF temperatures at Red Bluff Diversion Dam, USBR may, after consultations with the fishery agencies and subject to approval of the SWRCB, designate an upstream location where it can meet the 56ºF requirement.

The SWRCB addressed controllable factors in maintaining cold-water pools for temperature control in WR Order 92-02 (Order Establishing Drought-Related Requirements for the Bay-Delta Estuary During 1992) when it referenced WR Order 90-05, at page 9:

> The State Water Board also has advised the USBR that decisions on water deliveries are subject to the availability of water, and that water should not be considered available for delivery if it is needed as carryover to maintain an adequate cold water pool for the fishery.

WR Order 90-05 ignored and failed to protect the 44 miles of river between Hamilton City and Red Bluff that comprises almost 43% of the spawning habitat protected by the Basin Plan. The Order also violated the Basin Plan when it established an average temperature of 56ºF, without regard to whether daily average temperatures that allow daily exceedances above 56ºF will *fully protect beneficial uses* during critical periods. As we demonstrate below, daily average temperature criteria are not protective of the fishery, as daily maximums can be lethal to fish.

The SWRCB also ignores and violates the Basin Plan's Controllable Factors Policy and its own advice to USBR as it approves the yearly Sacramento River Temperature Management Plans (TMPs) submitted by USBR to the SWRCB that shifts the compliance point upstream thereby further restricting the amount of spawning habitat available to salmon. As discussed more fully below, in recent years the SWRCB has approved TMPs that establish the compliance point at Clear Creek. This compresses spawning to a 10 mile reach below Keswick: a 90% reduction of Basin Plan and 83% reduction in BO protected spawning habitat. In 2015, SWRCB even violated its average daily 56ºF criterion, when the Executive Officer unilaterally approved an USBR request to raise the temperature standard to a target of 57ºF not to exceed 58ºF.

USBR has consistently operated to a pattern and practice of maximizing water deliveries without regard to reserving sufficient water storage to comply with water quality standards. It schedules water deliveries in the spring based on assumptions of future rainfall and not what was stored from the preceding wet season. The adverse consequences of this reckless policy are magnified during drought sequences. Delivering excessive quantities of water and draining reservoirs to the point of not being able to comply with water quality standards is not a defensible excuse for the failure to provide adequate cold water to protect fisheries. The pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards has been extensively discussed and documented in previous protests, objections and SWRCB TUCP workshops and is referenced and need not be repeated here.

The SWRCB has acquiesced and participated in this pattern and practice. It has disregarded Basin Plan and CWA requirements, relied upon average temperature criteria, approved temperature criteria that permit lethality, excluded significant reaches of identified spawning habitat from requirements to comply with temperature criteria, approved relocated compliance locations based upon USBR's willingness to reserve storage to meet water quality standards, and failed to enforce violations of temperature criteria.

Enactment of the Central Valley Project Improvement Act (CVPIA) in 1992 seems to have been forgotten. Co-equal with water supply, the protection, restoration and enhancement of fish and wildlife are now primary purposes of the CVP. Mitigation for previous dam construction, contributions to efforts to protect the Bay-Delta and the doubling of natural production of anadromous fisheries in Central Valley rivers are now CVP purposes.

Yet, USBR, with SWRCB approval, ignores the CVPIA requirement to achieve a reasonable balance between competing demands, and continues to operate the CVP primarily to deliver water to its customers and only secondarily to protect and enhance fisheries and public trust values. Deliveries to Settlement Contractors cannot take precedence over fish and wildlife requirements because the water rights of both USBR and the Settlement Contractors are subject to compliance with water quality criteria, the reasonable use doctrine and public trust balancing.

Both the SWRCB and USBR appear to regard NMFS' BO for the Long-Term Operational Criteria and Plan for Coordination of the CVP and SWP (OCAP) as having primacy over the CWA, Basin Plan, WR Order 90-05 and Public Trust Doctrine. Additionally, NMFS appears to believe that its BO protecting Chinook salmon spawning on the Sacramento River is subservient to USBR's desires to maximize water deliveries to its Settlement Contractors.

The NMFS OCAP BO's Reasonable and Prudent Action (RPA) 1.2.1 (page 592) establishes performance measures for temperature compliance points and End-of-September (EOS) carryover storage that must be attained.

Performance measures for EOS storage at Shasta Reservoir include:

- 87 percent of years: Minimum EOS storage of 2.2 MAF
- 82 percent of years: Minimum EOS storage of 2.2 MAF and end-of-April storage of 3.8 MAF in following year (to maintain potential to meet Ball's Ferry compliance point)
- 40 percent of years: Minimum EOS storage 3.2 MAF (to maintain potential to meet Jerry's Ferry compliance point in the following year)

Review of Shasta Reservoir storage records reveals that, over the last 10 years, USBR has failed to meet the performance requirements. They met the 2.2 MAF EOS storage requirement only 50% of the time, met the 2.2 MAF EOS and 3.8 MAF end-of-April requirement only 60% of the time and met the EOS storage of 3.2 MAF requirement only 30% of the time.

Reasonable and Prudent Action performance measures for temperature compliance points during the summer season, measured as a 10-year running average, include:

- Meet Clear Creek Compliance point 95% of the time
- Meet Balls Ferry Compliance point 85% of the time
- Meet Jelly's Ferry Compliance point 40% of the time
- Meet Bend Bridge Compliance point 15% of the time

Review of daily average temperature data for the Clear Creek compliance point (RM 292), Balls Ferry (RM 276), Jelly's Ferry (RM 266) and Bend Bridge (RM 258) compliance points reveals that, between 2007 and 2015, there were temperature exceedances at Bend Bridge and Jelly's Ferry in all years, exceedances at Ball's Ferry 66.6% of the years and exceedances at Clear Creek 55.5% of the years.

The NMFS OCAP BO's RPA 1.2.3.C (page 600) establishes drought exception procedures if the February forecast, based on 90% hydrology, shows that the Clear Creek temperature compliance point or 1.9 MAF Shasta Reservoir EOS storage is not achievable. Under these conditions, there is clear potential that minimal requirements for winter-run egg survival and spring-run spawning requirements will not be achieved due to depletion of the cold water pool, resulting in temperature-related mortality to both winter-run spring-run salmon. The BO's effects analysis concludes that these conditions could be catastrophic to the species.

Consequently, RPA 1.2.3.C requires preparation of a contingency plan, relaxation of Wilkins Slough criteria to at most 4,000 cfs and:

> *Notification to State Water Resources Control Board that meeting the biological needs of winter-run* and the needs of resident species in the Delta, *delivery of water to nondiscretionary Sacramento Contractors* and Delta outflow requirements per D-1641, *may be in conflict* in the coming season and *requesting the Board's assistance* in determining appropriate contingency measures, and *exercising their authorities* to put these measures in place. [Emphasis added.]

The BO makes clear that an appeal to the SWRCB was necessary because Sacramento Settlement Contractor withdrawal volumes of water from the river can be substantial and because the court had concluded that USBR did not have discretion to curtail deliveries to Sacramento Settlement Contractors to meet federal ESA requirements. Unfortunately, while the SWRCB has the authority to reduce water deliveries to Settlement Contractors, it has demonstrated in this and previous droughts that it lacks the political will to do so.

Review of Shasta storage levels and deliveries to Sacramento Valley Contractors reveals that in the second drought year of 2013, USBR delivered 1.6 MAF to Sacramento Settlement Contractors and 249 TAF to Tehama-Colusa Canal, thereby drawing down EOS storage to only 1.9 MAF. In the third drought year of 2014, with a February projection of Shasta EOS storage to be less than 1.9 MAF, USBR delivered 1.99 MAF of water to Sacramento Settlement Contractors and Tehama-Colusa Canal drawing down Shasta EOS storage to only 1.16 MAF. Failure to meet temperature criteria in 2014 devastated the winter-run, spring-run and fall-run year classes.

In the fourth drought year of 2015, USBR scheduled 75% of contracted water deliveries on 27 February despite a February projection of Shasta EOS storage of only 903 TAF. In April and May, USBR delivered 337,339 AF of water to the Settlement Contractors and 36,898 AF to the Tehama-Colusa Canal, forcing USBR to request that the SWRCB increase the 56ºF temperature criterion at Clear Creek compliance point to 58ºF. In April 2015, the NMFS said that the fishery agencies believed an increase in the temperature criterion to 58ºF would result in significant impacts and a likelihood of adverse impacts to incubating winter-run eggs and alevin in redds compared to a daily average of 56ºF. But, by 1 July 2015, NMFS had been ***persuaded*** that an increase to 58ºF was consistent with the BO because there was a ***reasonable possibility*** that there would be ***some juvenile winter-run survival*** this year.

USBR's continuing lack of compliance with temperature requirements is illustrated in a review of Sacramento River temperature control history in the NMFS' OCAP BO. Figure 6-18, on page 263, titled *Historical exceedances and temperature control point locations in the upper Sacramento River from 1992 through 2008* shows Shasta storage, the starting compliance point and changes in temperature compliance points and the reasons for the changes. It reveals that compliance points were frequently moved, often multiple times in a single year, in response to exceedances of water quality criteria. Compared with recent actions discussed below, not much has changed: the compliance point is a floating target that is frequently relocated because it is dependent upon how much water USBR is prepared to provide to comply with water quality criteria and protect fisheries.

The rationale and justification for meeting temperature criteria is described in the OCAP BO at Page 91, Section 4.2.1.2.3.3.4 titled *Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development.* It states:

> Reclamation releases cold water from Shasta Reservoir to provide for adult winter-run migration, spawning, and egg incubation. *However, the extent winter-run habitat needs are met depends on Reclamation's other operational commitments, including those to settlement contractors, water service contractors, D-1641 requirements, and projected end of September storage volume. Based on these commitments, and Reclamation's modeled February and subsequent monthly forecasts, Reclamation determines how far downstream 56ºF can be maintained and sustained throughout the winter-run spawning, egg incubation, and fry development stages. Although WRO 90-05 and 91-1 require Reclamation to operate Keswick and Shasta dams, and the Spring Creek Powerplant, to meet a daily average water temperature of 56ºF at RBDD, they also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. In every year since the SWRCB issued WRO 90-05 and 91-1, operations plans have included modifying the RBDD compliance point to make best use of the coldwater resources based on the location of spawning Chinook salmon* (CVP/SWP operations BA page 2-40). Once a TCP has been identified and established, it generally does not change, and therefore, water temperatures are typically adequate for successful, egg incubation, and fry development for those redds constructed upstream of the TCP. *However, the annual change in TCP has degraded the conservation value of spawning habitat (based on water temperature).* [Emphasis added.]

Regardless of the OCAP BO's description of how USBR views its obligations to deliver water or the process of by which temperature compliance points are selected, it is USBR's ultimate responsibility to comply with the legal water quality criteria in the Basin Plan that was developed pursuant to the federal CWA and approved by USEPA as a condition of operations. USBR is not entitled to operate its project in violation of legal requirements simply because it is the USBR.

The approval of fishery agencies cannot be legally employed as an excuse for USBR's not complying with water quality standards. Nor is the SWRCB's failure to incorporate the full water quality protections in the Basin Plan a defensible excuse. Delivering contracted water and drawing down reservoir levels and depleting cold water storage to the point of not being able to meet temperature requirements is a controllable factor. USBR's contracts for delivering water are predicated on compliance with water quality standards, and USBR's desire to maximize water deliveries and the SWRCB's lack of political will to reduce deliveries to Sacramento Settlement Contractors cannot be used to justify failure to comply with the law.

Yet, over the years, USBR, the fishery agencies and SWRCB have gathered together in secret rooms to determine temperature compliance points. The Sacramento River Temperature Task Group (SRTTG) advises USBR on the best course of action to take regarding temperature compliance, based on fish surveys, real-time data and temperature modeling all functioning within the limits of the quantity of water USBR is willing to provide. The SRTTG is comprised of the USFWS, NMFS, CDFW, SWRCB, Western Area Power Administration and the Hoopa Tribe. A TMP is prepared yearly and submitted to the SWRCB for approval.

In an interesting conflict of interest conundrum, the SWRCB participates in the SRTTG that devises and recommends a TMP and then the SWRCB, as a regulatory agency, evaluates and approves the recommendation that is always less protective than CWA/Basin Plan requirements.

In 2009, the SRTTG set the temperature compliance point at Airport Road (RM 284) in Anderson, thus eliminating 85 miles of spawning habitat protected by the Basin Plan, 41 miles protected by the WR Order 90-05 or 26 miles under the BO. In 2010, Shasta Reservoir received above normal inflow and filled. The SRTTG set the temperature compliance point at Jelly's Ferry (RM 267), eliminating 68 miles of spawning habitat protected by the Basin Plan, 24 miles protected by WR Order 90-05 and 9 miles under the BP.

The SRTTG Annual Report for 2011 revealed that temperature compliance was targeted at Balls Ferry (RM 276) until 1 June and Jelly's Ferry (RM 266) until 31 October. Shasta Reservoir had 3.99 MAF of water, as of 1 April 2011, and inflow was expected to be above average. Yet USBR claimed that 56ºF temperatures could not be met at Red Bluff during a wet year and, with the approval of the fishery agencies, eliminated 61% of spawning habitat from any temperature requirement until 1 June and subsequently eliminated 46% of spawning habitat in the critical spawning period for winter-run Chinook salmon.

The 2011 Independent Panel report, as quoted in the 2012 SRTTG Annual Report observed:

> The TCP at Bend Bridge, which is required to be met only 15% of the time (i.e., 1.5 yrs out of 10), has not been met in either this or the previous year. *If the TCP at this location*

> *was not met in WY2011 –one of the least challenging years in terms of available reservoir storage – it seems unlikely that it can be met in any year*. [Emphasis added.]

In 2012, the temperature compliance point began at Jelly's Ferry (RM 266) was moved up to Balls Ferry (RM 276) and ended the year at Jelly's Ferry. The 2012 SRTTG Annual Report also highlighted another problem: when high releases to meet delivery and temperature requirements are dramatically reduced following the close of the irrigation and temperature control seasons, there is considerable dewatering of fall-run and late-fall-run Chinook salmon redds.

In 2013, the SRTTG recommended and USBR operated to meet an initial temperature compliance point at Balls Ferry (RM 276), but in June it was moved upstream to Anderson (RM 284). The 2013 SRTTG Annual Report demonstrated how relocating temperature compliance points upstream compressed spawning. In 2012, 63.6% of fall-run and 95.9% of late-fall-run Chinook salmon spawned in the 26 miles between Keswick and Balls Ferry and, in 2013, 98.4% of winter-run Chinook salmon spawned in the 3 miles between Keswick and the ACID Dam, with another 22.5% above the Highway 44 bridge. It also reported that 35% of monitored fall-run redds were dewatered when flows were abruptly reduced from 7,000 to 4,000 cfs in WY2013 and that 8,011 fall-run and 650 winter-run salmon were observed stranded by CDFW crews between 7 February 7 and 4 April 2013.

In 2014, the SRTTG established a temperature compliance point at Clear Creek (RM 292), with the approval of the SWRCB Executive Director. This provided 10 miles of spawning habitat but eliminated 34 miles of spawning habitat under the BO, 49 miles of spawning habitat under WR Order 90-05 and 93 miles of spawning habitat protected under the Basin Plan. However, flawed modeling and reckless mismanagement prevented USBR from even protecting this upper 10 miles of spawning habitat. The cold water pool in Shasta Reservoir was depleted because USBR delivered 1.2 MAF of water to Sacramento Settlement Contractors and 119 TAF to the Tehama-Colusa Canal and exported 1.5 MAF via the Jones Pumping Plant in the Delta during 2014, the third year of the drought. Shasta Reservoir was drawn down to 1.05 MAF by January 2015.

With cold water depleted, the temperature objective was exceeded and 100% of the winter-run Chinook salmon redds were exposed to temperatures above 56ºF. It is estimated that 95% of winter-run, 98% of fall-run and virtually all of the spring-run Chinook salmon brood year was lost because of the USBR's failure to comply with temperature objectives.

On 6 April 2015, the SWRCB Executive Director directed USBR to prepare and implement a 2015 TMP for the Sacramento River for the protection of winter-run, Chinook salmon and other salmonids. USBR submitted a draft TMP in mid-April and an updated plan on 4 May 2015. The Executive Director provisionally approved the TMP on 14 May. USBR subsequently informed the SWRCB that it could not meet the 56ºF temperature requirement at Clear Creek, and the Executive Director suspended his approval of the TMP on 29 May. The SWRCB held a workshop on 24 June, where CSPA, NRDC and the Bay Institute provided highly critical comments on the proposed TMP. USBR submitted a revised TMP on 25 June, the NMFS provide a concurrence letter on 1 July and the Executive Director approved the TMP on 7 July 2015.

The approved TMP set a daily average temperature target of 57ºF at Clear Creek, not to exceed 58ºF. To preserve cold-water storage, the Order limited Keswick releases to 7,250 cfs in June, July and August, 6,500 cfs in September and 5,000 cfs in October, subject to change in accordance with real-time monitoring and decision-making.

So far in 2015, daily average temperatures at the Clear Creek compliance point averaged 57.3ºF in June and 57.1ºF in July. Daily maximum temperatures at Clear Creek averaged 59.6ºF in June and 59.2ºF in July. USBR violated the not-to-exceed 58ºF weakened daily average criterion on June 16 (58.038), 17 (58.42), 18 (58.19) and 24 (58.18). Based upon the scientific literature, significant instantaneous mortality to the 2015 winter-run Chinook salmon brood class has already occurred, and substantial delayed mortality can be expected to occur.

The fishery agencies initially opposed USBR's proposal to increase temperature limits from 56ºF to 58ºF because they believed it was not protective of early Chinook salmon life stages. NMFS' 15 April 2015 *Evaluation of Alternatives for Sacramento River Water Temperature Compliance for Winter-fun Chinook Salmon* is posted on the SWRCB's website. The Evaluation points out, on page one:

> A requirement in NOAA's National Marine Fisheries Service's reasonable and prudent alternative is to provide water temperatures *no greater than a daily average of 56ºF in the upper Sacramento River to provide habitat needs for various life history stages of Sacramento River winter-run Chinook salmon.* [Emphasis added.]
>
> The fish agencies (NMFS, USFWS, and CDFW) have reviewed various alternatives to temperature compliance, including a targeted daily average water temperature Shasta Dam (e.g., 52ºF or 53ºF) and *increasing the temperature target from 56ºF to 58ºF* at the Sacramento River above Clear Creek CDEC monitoring station (CCR) compliance point after the eggs hatch. As a result of their assessment, the fish agencies *do not think that these alternatives would result in negligible impacts and/or little likelihood of adverse impacts to incubating winter-run eggs and alevin in redds compared to a daily average of 56ºF.* [Emphasis added.]
>
> For example, a heat wave in Redding (>105ºF) with these operation could lead to elevated *temperatures above 56ºF at CCR, leading to potentially significant winter-run egg mortality and sublethal effects.* [Emphasis added.]

Having acknowledged that NMFS, USFWS and CDFW believe that an increase of daily average temperatures from 56ºF to 58ºF would result in adverse impacts, the Evaluation observes, on page 5, that <u>violations occur nearly every year because of USBR commitments to water contractors</u>:

> Even though State Water Resources Control Board Orders 90-5 and 91-1 require Reclamation to operate Keswick and Shasta dams to meet a daily average temperature of 56ºF at Red Bluff Diversion Dam (RBDD) [or at a temperature compliance point (TCP) modified *when the objective cannot be met at RBDD based on Reclamation's other operational commitments including those to water contractors*, D-1641 regulations and

> criteria, and projected end of September storage volume], *nearly every year, Reclamation has exceeded the TCP at some point throughout the temperature control season.* Especially last year, 100% of winter-run brood year 2014 redds were exposed to temperatures above 56ºF degrees at the CCR TCP at some time period during the water year (see Figure 3). Emphasis added.

But USBR, with SWRCB acquiescence, did an end run around the fishery agencies and eliminated all possibility of using Shasta storage to meet a 56ºF temperature criterion, even at Clear Creek. In April and May of this year, USBR, despite pleas from CSPA, Bay Institute, NRDC and others to reduce deliveries in order to protect the cold water pool in Shasta Reservoir, delivered 366,794 AF to the Sacramento Settlement Contractors and Tehama-Colusa Canal and exported an additional 312,686 AF of water from the Delta. These deliveries eliminated any possibility that the water would be used to meet water quality standards and fishery needs.

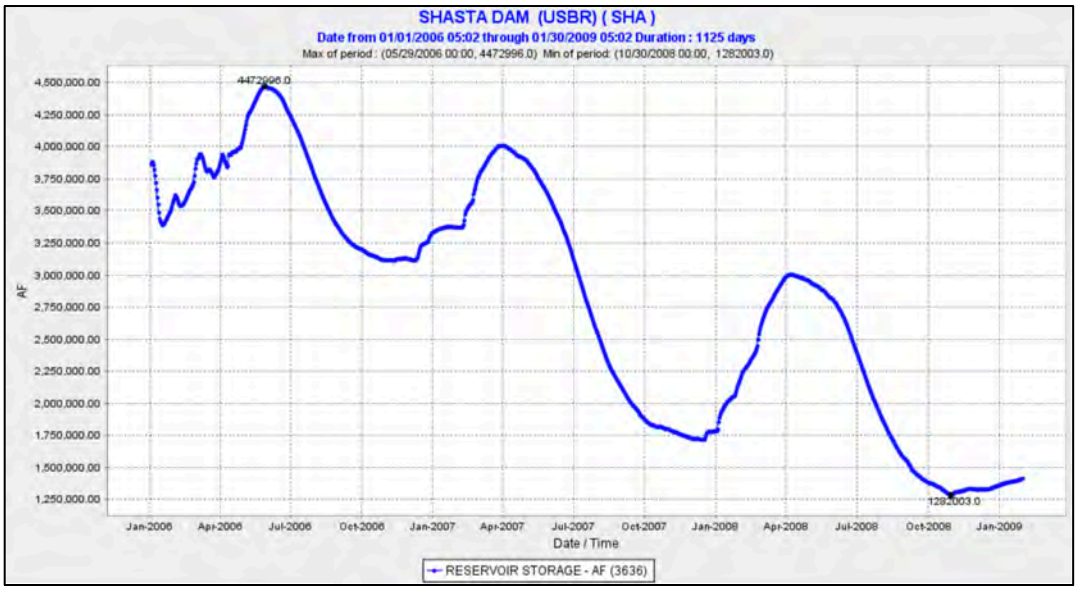
Faced with a *fait accompli* and unwilling to hold their partner accountable for violations of the CWA and ESA, the fishery agencies went along and issued consistency determinations that claimed the TMP was consistent with the BOs. The situation is described in the conclusion of NMFS's 1 July 2015 consistency determination for the TMP:

> NMFS acknowledges that storage in Shasta Reservoir at the beginning of the temperature management season in June, and the quantity and quality of the cold water pool, *will not provide for suitable winter-run habitat needs throughout their eggs and alevin incubation and fry rearing periods*. The base operations plan, including the Keswick release schedule, delayed use of full side gates, and real-time monitoring and decision-making based on winter-run timing, location of redds, air and surface water temperature modeling, and projected versus actual cold water storage conditions and downstream water temperatures, represents the best that can be done with a really bad set of conditions. *We note that these conditions could have been largely prevented through upgrades in monitoring and modeling, and reduced Keswick releases in April and May. Based on extensive analyses of alternative scenarios (6,000 to 8,000 cfs Keswick releases), the plan provides a reasonable possibility that there will be some juvenile winter-run survival this year.* [Emphasis added.]

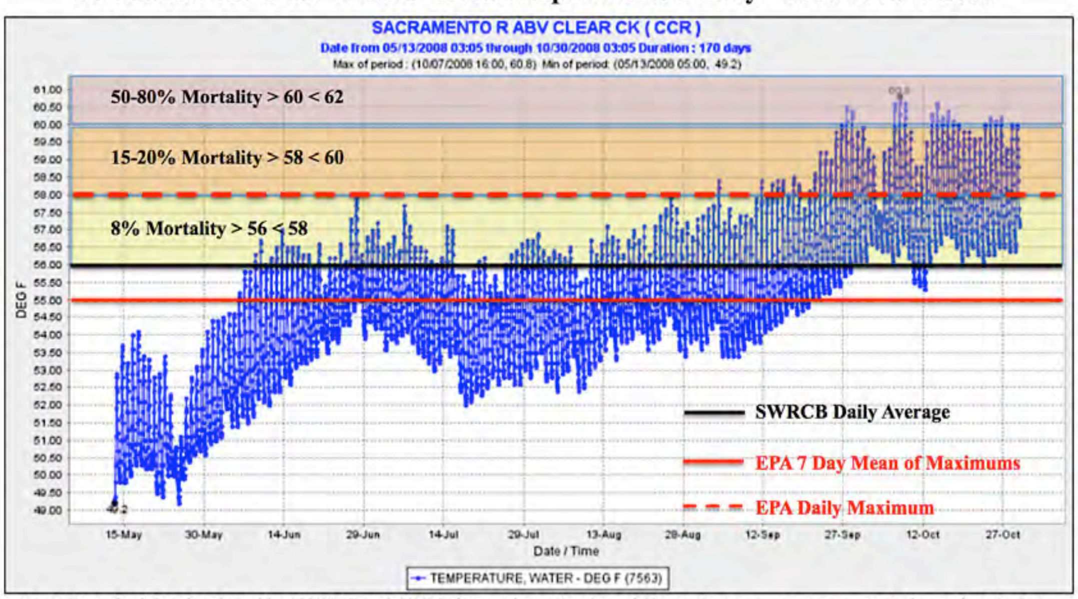
And that's the best that can be hoped for this year, "a reasonable possibility that there will be some juvenile winter-run survival this year." Had USBR and the SWRCB heeded the pleas to not deliver 2.8 MAF of water and draw down Shasta by 1.05 MAF of water last year in the third year of drought, had they heeded the pleas to not deliver 374,237 AF of water to Sacramento Settlement Contractors and the Tehama-Colusa Canal in April and May of this year, had they heeded pleas to not continue to further deplete cold water storage by delivering more than 500,000 AF in June and July to water agencies along the Sacramento River, there might be more than mere hope that some winter-run might survive this year.

But reserving water needed to meet water quality standards and public trust fishery needs has never been a part of USBRs operating protocols. The pattern and practice of draining reservoirs in the initial years of a drought sequence and then either violating water quality and fishery standards or turning to the SWRCB to bail them out of having to comply with water quality standards is deeply ingrained in USBR's operations. The last two drought sequences illustrate the pattern.

During the drought of 2007-2009, USBR delivered 100% of the contracted water to water contractors along the Sacramento River. Deliveries to Sacramento Settlement Contractors and Tehama-Colusa Canal in 2006, 2007, 2008 and 2009 totaled 1.7, 1.9, 1.9 and 1.8 MAF, respectively. CVP Delta Exports in 2006, 2007, 2008 and 2009 were 2.6, 2.6, 1.8 and 1.9 MAF, respectively. Shasta Reservoir was drawn down from 4.47 MAF in April 2006 to 1.28 MAF in November 2008, leaving insufficient cold water remained to comply with temperature criteria.



Sacramento River Above Clear Creek Temperatures: 15 May – 30 November 2008



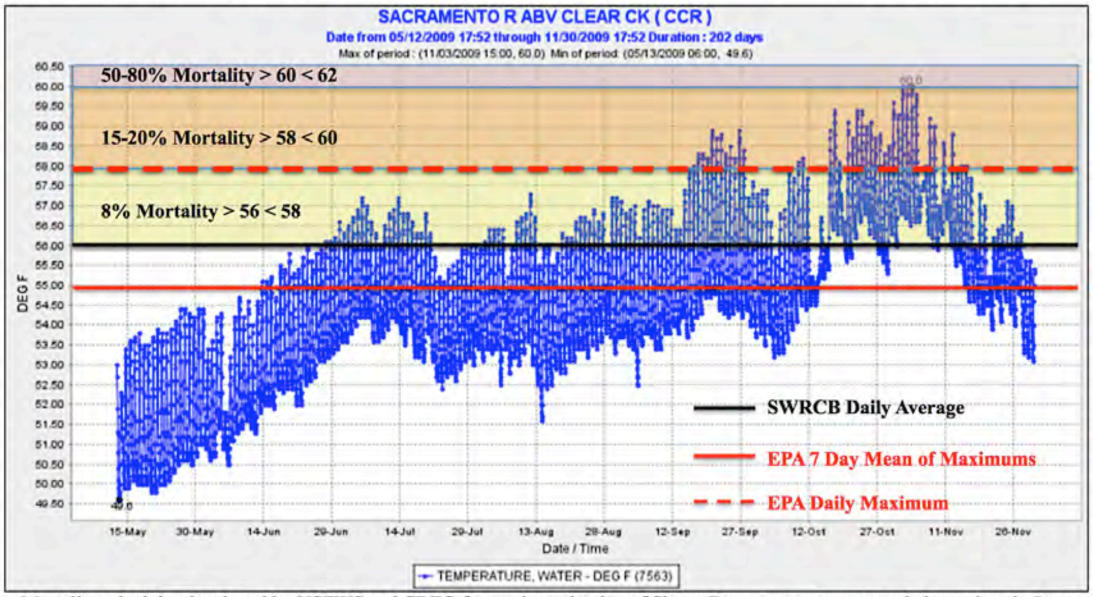
Mortality schedules developed by USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson et al. 1990).

Winter-run Chinook salmon spawning generally begins in late April and extends into early

August, eggs hatch between late June and middle-to-late September, and fry emerge between late July and late October. Spawning through incubation to emergence are critical life stages.

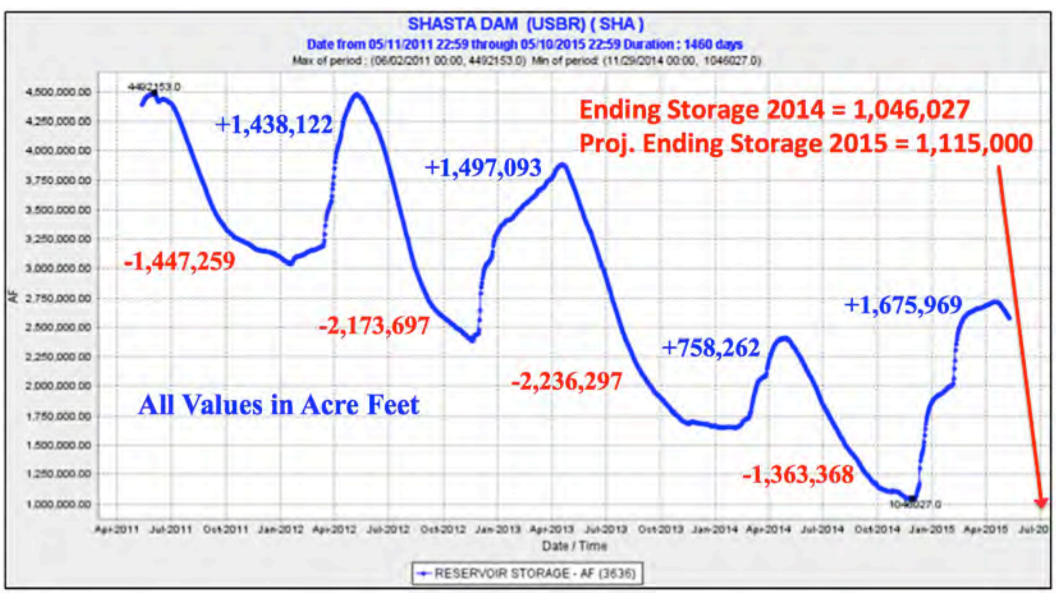
Temperatures at Clear Creek in 2008 ranged into lethal zones during spawning and egg incubation and exceeded even the SWRCB's inadequate daily averages during fry emergence. Temperatures in the 90% of identified spawning habitat below Clear Creek were much higher.

Sacramento River Above Clear Creek Temperatures: 15 May – 30 November 2009



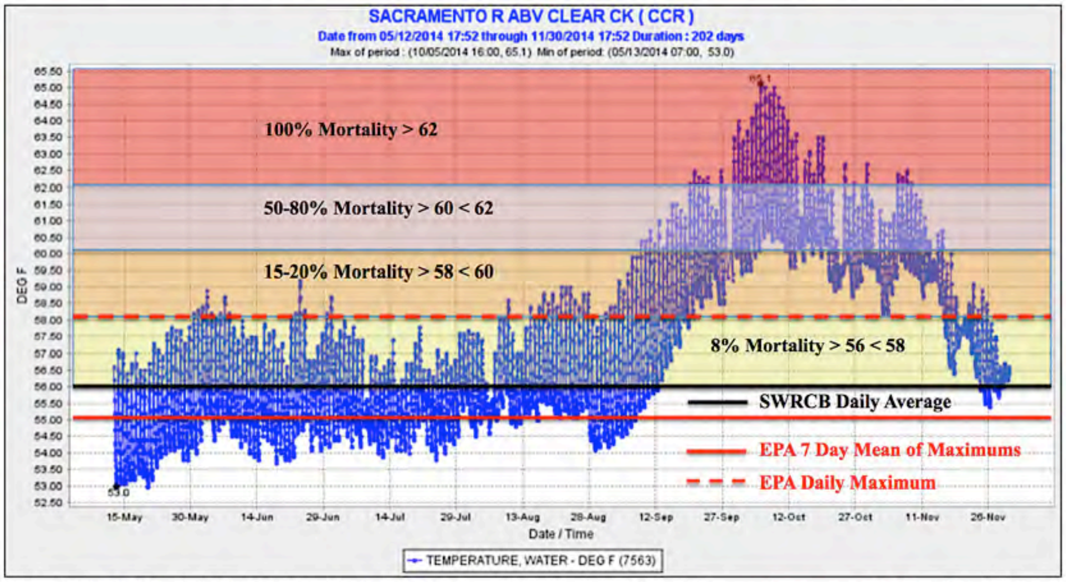
Mortality schedules developed by USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson et al. 1990).

The pattern repeated itself in 2009 as shown above.



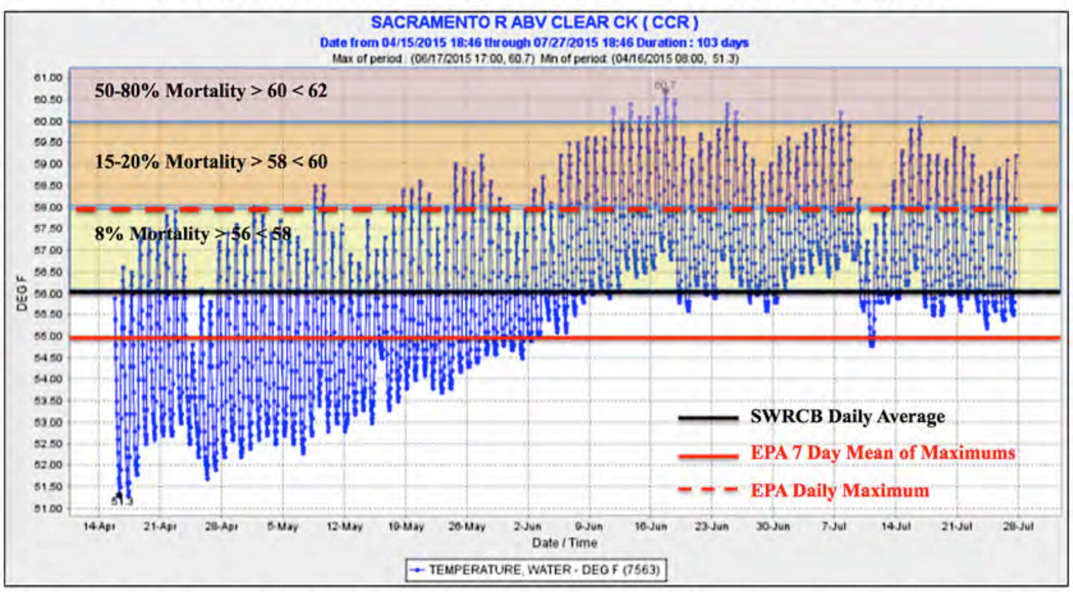
During the present drought, USBR scheduled deliveries of 100% of contracted water to Sacramento Contractors in 2012 and 2013 and 75% in 2014 and 2015. Deliveries to contractors along the Sacramento River in 2012, 2013 and 2014 totaled 1.8, 1.99 and 1.3 MAF, respectively. In 2012, 2013, 2014 and 2015 CVP Delta Exports were 2.1 MAF, 1.5 MAF, 874 TAF, and 334 TAF so far this year. Consequently, end-of-year storage in Shasta Reservoir plummeted.

Sacramento River Above Clear Creek Temperatures: 15 May – 31 October 2014



Mortality schedules developed by USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson et al. 1990).

Sacramento River Above Clear Creek Temperatures: 15 April – 27 July2015



Mortality schedules developed by USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson et al. 1990)

Excessive water deliveries in the initial drought years depleted cold water pools in Shasta. Water temperature intruded well into lethal zones during spawning and egg incubation and soared during late incubation are fry emergence. The entire brood years of winter-run, spring-run and fall-run Chinook salmon were devastated.

CSPA has been unable to find a single example of the SWRCB taking an enforcement action against USBR for violations that occur “nearly every year,” including the 2014 violations that destroyed an estimated 95% of winter-run, 98% of fall-run and virtually all of the spring-run brood class. Perhaps the SWRCB’s participation in the closed-door meetings that recommends TMPs that fail to comply with CWA/Basin Plan requirements precludes it from taking an enforcement action against a fellow SRTTG member for violations of the TMP. This exhibits all of the characteristics of classic “conflict of interest” and “regulatory capture.”

Average Temperature Requirements are Not Protective of Chinook Salmon

Following a long extensively peer-reviewed court ordered proceeding, USEPA Region 10 issued *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (Region 10 Guidance) in 2003. The Guidance establishes a recommended criterion of 13ºC (55ºF), as a 7 day average of the daily maximums (7DADM), for Chinook salmon, steelhead and trout spawning, egg incubation and fry emergence, 16ºC (61ºF) for salmon and steelhead “core” juvenile rearing and 18ºC (64ºF) for salmon and steelhead migration plus non-core juvenile rearing. The states of Washington, Idaho and Oregon have established temperature criteria for Chinook salmon spawning through fry emergence as 7DADM 13ºC (55.4ºF, 16ºC (60.8ºF) for salmonid core summer habitat and 17.5ºC (63.5ºF) for salmonid rearing and migration.

The 7DADM protects against not only the lethal effects of elevated temperatures but also the chronic and sublethal impacts that frequently occur in waters that meet weekly average temperatures. High daily maximum temperatures can lead to excessive mortality in waters that still meet weekly averages. Chronic and sublethal effects include reduce juvenile growth, increased incidence of disease, reduced viability of gametes in adults prior t spawning, increased susceptibility to predation and competitions and suppressed or reversed smoltification.

In 2011, USEPA Region 9, in disapproving the SWRCB’s 2008-2010 306(d) list of impaired waterbodies, added the San Joaquin, Merced, Tuolumne and Stanislaus Rivers to the 303(d) list as impaired by temperature based partly on the Region 10 guidance and partly on recommendations by the California Department of Fish and Wildlife (CDFG) and the Regional Board, both of which used the Region 10 Guidance and other studies. The USEPA Region 9 letter stated,

> Additionally, EPA believes that EPA’s Temperature Guidance values are appropriate for use in the Central Valley. The criteria have been used by California in their 303(d) list recommendation as well as selected as targets in Total Maximum Daily Loads (TMSLs) in the North Coast Regional of California (Carter 2008). They have also been used by National Marine Fisheries Service (NMFS”) to analyze the effects of the long term operations of the Central Valley Project and State Water Project, and to develop the reasonable and prudent alternative actions to address temperature-related issues in the Stanislaus River (NMFS 2009a). Reviews of appropriate temperature criteria for use in

> the Stanislaus have yielded findings consistent with the EPA Temperature Guidance values (Deas (2004) and Marston (2003)).

The USEPA Region 9 letter also quoted a 2010 letter from Maria Rea, NMFS, to Alexis Straus (USEPA) that also supports the use of the Region 10 Guidance:

> The use of the US EPA 2003 criteria for listing water temperature impaired water bodies in the San Joaquin River basin is scientifically justified. It has been recognized that salmonid stocks do not tend to vary much in their life history thermal needs, regardless of their geographic location. There is not enough significant genetic variation among stocks or among species of salmonids to warrant geographically specific water temperature standards (US EPA 2001). Based upon reviewing a large volume of thermal tolerance literature, McCullough (1999) concluded that there appears to be little justification for assuming large genetic adaptation on a regional basis to temperature regimes.
>
> Although many of the published studies on the responses of Chinook salmon and steelhead to water temperature have been conducted on fish from stocks in Oregon, Washington, and British Columbia, a number of studies were reported for the Central Valley salmonids. Myrick and Cech (2001, 2004) performed a literature review on the temperature effects on Chinook salmon and steelhead, with a focus on Central Valley populations…
>
> It is evident that the difference in thermal response is minimal in terms of egg incubation, growth, and upper thermal limit. Healey (1979, as cited in Myrick and Cech 2004) concluded that Sacramento River fall-run Chinook salmon eggs did not appear to be any more tolerant of elevated water temperature than eggs from the more northern races. Myrick and Cech (2001) concluded that it appears unlikely that there is much variation among races with regard to egg thermal tolerance because data from studies on northern Chinook salmon races generally agree with those from California. They further concluded that fall-run Central Valley and northern Chinook salmon growth rates are similarly affected by water temperature.

In fact, the Myrick and Cech’s 2004 study titled *Temperatures effects on juvenile anadromous salmonids in California’s central valley: what don’t we know?* noted that a recent study on Sacramento River Chinook salmon by the US Fish and Wildlife Service (1999) concurred that fall-run egg mortality increased at temperatures greater than 12ºC (53.6ºF), that winter-run egg mortality increased at temperatures over 13.3ºC (55.8ºF), and that temperatures between 6 and 12ºC appear best suited to Chinook salmon egg and larval development.

Chapter 6, page 2 of USBR’s Biological Assessment (BA) for the 2008 Long-Term Operational Criteria and Plan for Coordination of the Central Valley Project and State Water Project (OCAP) contains Table 6-1 titled *Recommended water temperatures for all life stages of Chinook salmon in Central Valley streams as presented in Boles et al. (1988).* Recommended temperatures for Chinook salmon are migrating adult (<65ºF), holding adult (<60ºF), spawning (53-57.5ºF), egg incubation (<55ºF), juvenile rearing (53-57.5ºF) and smoltification (<64ºF). Table 6-2 (page 6-3) titled *Relationship between water temperature and mortality of Chinook salmon eggs and pre-*

emergent fry used in Reclamation egg mortality model shows that instantaneous daily salmon egg mortality begins at 57ºF and instantaneous daily pre-emergent fry mortality begins at 59ºF.

The NMFS 8 March 2012 Biological Opinion for DWR's proposed construction and operation of the South Delta Temporary Barriers Program acknowledges, at page 12, that the "upper preferred water temperature for spawning Chinook salmon is 55ºF to 57ºF (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, and Snider 2001)" and the "optimal water temperature for egg incubation ranges from 41ºF to 56ºF (44ºF to 54ºF [Rich 1997], 46ºF to 56ºF [NMFS 1997 Winter-run Chinook salmon Recovery Plan], and 41ºF to 55.4ºF [Moyle 2002]). It noted a "significant reduction in egg viability occurs at water temperatures above 57.5ºF and total embryo mortality can occur at temperatures above 62ºF (NMFS 1997)."

The NMFS 4 June 2009, Chinook Salmon/Sturgeon Biological Opinion for OCAP establishes, on page 621, an RPA for specific temperature criteria to protect steelhead adult migration of (< 56ºF at Orange Blossom Bridge [OBB], 1 Oct – 31 Dec), smoltification (< 52ºF at Knights Ferry and < 57ºF at OBB, 1 Jan – 31 May), spawning and incubation (< 55ºF at OBB), 1 Jan - 31May) and juvenile rearing (< 65ºF, 1 June – 30 September). It states, "Temperature compliance shall be measured based on a seven-day average daily maximum temperature. While NMFS requires USBR to meet specific temperature criteria specified as a 7DADM on the Stanislaus River, it fails to require USBR to meet any specific temperature criteria on the Sacramento River; leaving it to the SRTTG to develop an annual flexible TMP based upon water available after USBR meets its contractor obligations.

The North Coast Regional Water Quality Control Board developed a Klamath River TMDL in 2010. As part of the process, staff conducted an extensive literature review to evaluate temperature needs of the various life stages of steelhead trout, coho salmon and Chinook salmon. The purpose of the review was to identify temperature thresholds that are protective of salmonids by life stage, as a basis for evaluating stream temperatures in California temperature TMDLs within the North Coast region. The results were reported in Appendix 4, Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids of the Final Klamath River TMDL Staff Report. Table 13, on page 25 of Appendix 4 identifies life stage temperature thresholds for salmonid spawning, egg incubation and fry emergence as 13ºC (55.4ºF), expressed as a MWMT, which is the same as a 7DADM.

The Pacific Fishery Management Council, in a 29 May 2015 letter from its Executive Director Dr. D. O. McIsaac, to SWRCB Executive Director Tom Howard, recommended that the SWRCB insist that USBR actively manage to meet a 56ºF maximum temperature, rather than a 56ºF daily average.

The 2013 SRTTG annual report revealed that NMFS had broached the subject of switching to a 7DADM. It stated on page 12:

> NMFS expressed the idea of tracking the 7-day maximum (7DADM) water temperature in order to determine whether sub-lethal effects on salmonid life history stages (spawning, egg incubation and fry emergence) exist, despite the current temperature requirement metric of a daily average (Appendix B). *The*

> *7DADM metric is recommended by EPA as of 2003 and has been used in other Central Valley rivers (e.g., Stanislaus, Tuolumne, and Merced rivers).* NMFS looked at the 7DADM and what that might mean to the current daily average criterion (Figures 3-6). *7DADM can exceed daily average temperatures by as much as 4ºF at Balls Ferry and as much as 3ºF at Airport Road.* [Emphasis added.]

The report then observed that:

> *SRTTG indicated that a change in compliance metric would require considerable time and effort in negotiations among all of the agencies and the State Water Resources Control Board and a change to decision 90-5.* Emphasis added.

The SRTTG 2013 report then posed the question:

> *How does the Panel view using 7DADM as a measurement to consider potential sub-lethal effects on salmonid life history stages in lieu of daily average temperature?* Emphasis added.

CSPA poses two additional questions: has the SWRCB abdicated its regulatory and public trust responsibilities to the SRTTG and ceded its authority to those it is required to regulate and to the fishery agencies that have chaperoned the continued decline of Chinook salmon in the Sacramento River? Where in the CWA, ESA or the California Water Code is authority granted to USBR, NMFS, USFWS, CDFG, the Western Area Power Administration and the Hoopa Tribe to secretly decide what are the appropriate water quality criteria to protect beneficial uses?

The 2014 SRTTG annual report reiterated NMFS' recommendation but did not mention any discussion or decision related to pursuing a change to a 7DADM temperature standard from the present daily average. It stated on page 16:

> In 2013, NMFS expressed to the SRTTG the idea of tracking 7-day average of daily maximum water temperature in order to determine whether sub-lethal effects on salmonid life history stages (spawning, egg incubation, and fry emergency) exist, despite the current temperature requirement metric of daily average. As explained in Appendix B of the 2013 SRTTG Annual Report of Activities, daily average temperature does not consider the impacts of diurnal temperature changes and daily maximum temperature. The stressful impacts of higher water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival. Sub-lethal effects from high water temperature can lead to delayed mortality due to reduced fry and smolt sizes from sub-optimal growth. These effects could result in reduced productivity of a stock and reduced population size. As the term suggests, 7-day average of daily maximum (7DADM) reflects an average of maximum temperatures that fish are exposed to in a week long period. Since this metric is oriented to daily maximum temperatures, it can be used to protect against acute and sub-lethal or chronic effects.

It then observed that:

> *7DADM was monitored for WY2014 and it was found that the reported 7DADM temperature was as much as 3ºF higher in the Sacramento above Clear Creek than was shown by the SWRCB's 56ºF average temperature criterion.* Emphasis added.

Violations of the Endangered Species Act

In enacting ESA, Congress stated that the purpose of the ESA is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." 16 U.S.C. § 1531(b). As part of conserving endangered or threatened species, ESA prohibits the "taking" of any such listed species. 16 U.S.C. § 1538(a)(1)(B). A "take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." 16 U.S.C. § 1532(9). To "harm" a listed species in the context of a "take" includes "[any] act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." 50 C.F.R. § 17.3 (1994). An indirect injury to a listed species through habitat modification also constitutes a "take." *Babbitt v. Sweet Home Chapter of Communities for A Great Oregon*, 515 U.S. 687 (1995). The 9th Circuit Court of Appeals ruled that "under Sweet Home, a habitat modification which significantly impairs the breeding and sheltering of a protected species amounts to 'harm' under the ESA." *Marbled Murrelet v Pacific Lumber Company*, 83 F.3d 1060 (9^{th} Cir. 1996).

USBR has operated to a pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards. The SWRCB has operated to a pattern and practice of weakening water quality standards and thereby significantly degrading the habitat and impairing essential behavioral patterns, breeding, feeding, or sheltering of listed species. The SWRCB and USBR are in violation of the ESA.

As discussed at length above, USBR does not have discretion to curtail water deliveries to Sacramento Settlement Contractors to meet ESA requirements to comply with temperature requirements. The SWRCB has the authority but has refused to use it reduce water deliveries to Settlement Contractors in order to retain sufficient cold water storage necessary for temperature compliance. Both the SWRCB and USBR have failed to ensure compliance with the terms and conditions in the incidental take statement, i.e., that the reasonable and prudent measures in the RPAs and, consequently, are no longer in compliance with the ESA.

The BO does not address ESA section 7(a)(2) compliance for individual water supply contracts and, consequently, delivery of water that is "nondiscretionary" for the purposes of the ESA is not exempt from ESA section 9 take prohibitions. The SWRCB has sanctioned the illegal "take" of endangered species by the USBR and Sacramento Settlement Contractors.

Abundances of anadromous and pelagic species listed pursuant to the ESA have plummeted over the last few years to the point where they are facing the likelihood of imminent extinction. Over this period, the SWRCB has acceded to multiple requests by USBR to weaken basic minimum standards adopted to protect listed species and their habitats and the fishery agencies have acquiesced in issuing concurrence letters, frequently within hours or several days of receiving TUCPs and Reinitiation of Consultation requests. These serial actions have seriously modified and degraded the habitat and impaired the breeding and sheltering of listed species to the point of impending extinction.

For example, a year after violations of temperature criteria had decimated the year classes of Sacramento Chinook salmon, a month and a half after identifying Sacramento winter-run Chinook salmon as one of the eight species in the nation "most at risk of extinction in the near future" and after it had stated than an increase in the temperature compliance target would result in adverse impacts to incubating winter-run eggs and alevin in redds and that 58ºF was identified in the scientific literature as lethal to incubating salmon eggs and emerging fry, the NMFS issued a concurrence letter claiming that that increasing the temperature target was consistent with the BO because "the plan provides a ***reasonable possibility*** that there will be ***some juvenile winter-run survival*** this year." [Emphasis added.] A reasonable possibility that some winter-run might survive is not an acceptable ESA legal standard.

Notwithstanding the letters of concurrence from USFWS, NMFS and CDFW that claim these actions are consistent with existing Biological Opinions, nothing in the ESA legally allows or justifies the SWRCB and USBR to further degrade the habitats of species lingering on the precipice of extinction. Collectively, the excuses, justifications and serial weakening of water quality criteria emanating from the secret SRTTG meetings while the fishery agencies remain embraced in denial as fisheries plummet toward extinction, surely constitute one of the saddest and most wretched spectacles we've ever witnessed and could be easily construed as an illegal conspiracy to defraud the public of public trust resources to the benefit of special interests.

Violations of the Public Trust and Article X of the California Constitution

Article X, Section 2 of the California Constitution provides that:

> The right to water or to the use of the flow of water in or from any natural stream or water course in this state is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.

Because of this Constitutional requirement, the SWRCB must consider the reasonableness of a particular method of diversion of water when evaluating (or reevaluating) all permitted uses of water and the requirements controlling those uses. "The limitations of Art. X, Section 2 … apply to all water users of the state and serve as a limitation on every water right and method of diversion." See *Yuba River D-1644* at p. 29. USBR is a water user subject to Article X, Section 2 in the operation of its respective projects in the Central Valley. The SWRCB's responsibility under the reasonable use doctrine is illustrated in the recent summary of this doctrine by the First District Court of Appeal, in *Light v. SWRCB (2014) 226 Cal.App.4th 1463, 1479–80*:

> Water use by both riparian users and appropriators is constrained by the rule of reasonableness, which has been preserved in the state Constitution since 1928. (Cal. Const., art. X, § 2; hereafter Article X, Section 2.) ... As the Supreme Court recognized soon after Article X, Section 2 was added, the rule limiting water use to that reasonably necessary "appl[ies] to the use of all water, under whatever right the use may be enjoyed." (Peabody v. City of Vallejo (1935) 2 Cal.2d 351, 367–68 (Peabody).) The rule of reasonableness is now "the overriding principle governing the use of water in California." (People ex rel. State Water Resources Control Bd. v. Forni (1976) 54 Cal.App.3d 743, 750 (Forni).)
>
> California courts have never defined, nor as far as we have been able to determine, even attempted to define what constitutes an unreasonable use of water, perhaps because the reasonableness of any particular use depends largely on the circumstances. (Peabody, supra, 2 Cal.2d at p. 368.) "What may be a reasonable beneficial use, where water is present in excess of all needs, would not be a reasonable beneficial use in an area of great scarcity and great need. What is a beneficial use at one time may, because of changed conditions, become a waste of water at a later time." (Tulare Dist. v. Lindsay–Strathmore Dist. (1935) 3 Cal.2d 489, 567.) In this regard, the Joslin court commented, "Although, as we have said, what is a reasonable use of water depends on the circumstances of each case, such an inquiry cannot be resolved in vacuo isolated from statewide considerations of transcendent importance. Paramount among these, we see the ever increasing need for the conservation of water in this state, an inescapable reality of life quite apart from its express recognition in [Article X, Section 2]." ([Joslin v. Marin Municipal Water District (1967) 67 Cal.2d 132, 140 (Joslin)]; see similarly In re Waters of Long Valley Creek Stream System (1979) 25 Cal.3d 339, 354 ["it appears self-evident that the reasonableness of a riparian use cannot be determined without considering the effect of such use on all the needs of those in the stream system [citation], nor can it be made 'in vacuo isolated from statewide considerations of transcendent importance'"].) Few decisions have ruled on the reasonableness of a specific use of water, but in separate cases the Supreme Court has concluded, essentially as self-evident, that the use of water for the sole purpose of flooding the land to kill gophers and squirrels is unreasonable (Tulare Dist., at p. 568), as is the use of floodwaters solely to deposit sand and gravel on flooded land (Joslin, at p. 141.)

And the responsibility and authority of the SWRCB to prevent unreasonable use of water extends to all users, The Board's authority to prevent unreasonable or wasteful use of water extends to all users, regardless of the basis under which the users' water rights are held. ([*California Farm Bureau Federation vs. State Water Resources Control Board (2011) 51 Cal.4th 421, 429].)*

Considering the conditions of drought which are described in the "drought emergency" declared by Governor Brown - the curtailments of water rights, the serial waivers of D-1641 standards to protect fish and wildlife and water quality in the Delta watershed, and the continual weakening of temperature compliance requirements on the Sacramento River - it is time for the SWRCB to declare flood irrigation by agriculture during the drought emergency a waste and unreasonable use until the emergency is over.

If the SWRCB can require urban conservation, it can also require conservation in agriculture. As former SWRCB chief counsel and Delta Watermaster Craig Wilson put it "flood irrigating a field during drought can be considered unreasonable. Flood irrigation in the Sacramento Valley in particular is unreasonable when endangered salmon are facing extinction.

Alfalfa and irrigated pasture alone consumes 8.6 MAF of water in California and provides low net revenue and few jobs. The SWRCB can and must reduce the quantity of water allocated to irrigated pasture and low-value crops like alfalfa that use prodigious amounts of water and have very high "applied water" coefficients relative to other crops during the drought emergency. To continue this use is unreasonable and a waste of water, and must be stopped or reduced until the drought emergency is declared over.

The continued killing of threatened and endangered species by obsolete and non-protective export pumping facilities simply because the state and federal water contractors refuse to pay for new state-of-the-art fish screens is an unreasonable method of diversion. This is especially true when water diverted through those facilities deprives listed species of water and primary production necessary for survival. The SWRCB can and must curtail south Delta exports during the drought emergency until D-1641 water quality standards are met.

The SWRCB must also consider public trust issues in proceedings that concern water rights and water quality based on reserved jurisdiction or under the doctrine of reasonable use. The SWRCB may also modify permits of "the projects" that require the appropriator to reduce the quantity of exports. *United States v. SWRCB* (1986) 182 Cal.App. 3d 82, 124-131. The SWRCB has a complaint procedure that can exercise authority over both federal and state water projects by virtue of having state water rights permits issued by the Board.

The State's management responsibilities include broad discretion to promote trust uses, such as the continued survival Chinook salmon in the Sacramento River, provided the discretion is exercised consistent with constitutional and statutory constraints. *People v. California Fish Co.* (1913) 166 Cal. 576, 597. While the State has discretion to promote trust issues, the SWRCB has "an affirmative duty" to protect trust resources. See *Illinois Central Railroad v. Illinois,* 146 U.S. 387; and *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419 (The state may not abdicate its supervisory role any more than the state may abdicate its police power); see also Stevens, The Public Trust: *A Sovereign's Ancient Prerogative Becomes the People's Environmental Right,* 14 U.C. Davis Law Review 195, 223.

Fish and wildlife are natural resources unequivocally protected by state sovereignty, whereby ownership of the resource is reserved to the states. *Geer v. Connecticut,* (1896) 161 U.S. 519. The court in *Audubon v. Superior Court*, (1983) 33 Cal.3d. 419 held that "no one may obtain a vested right to undertake an act that is harmful to the trust." See also *SWRCB D-1644* (Yuba River) at page 29. The supremacy of the public trust over private individuals is reflected in a "judicial presumption against state or legislative alienation of trust resources." *People v. California Fish*; see also *Illinois Central v. Illinois* (1892) 146 U.S. 387; *Montana v. U.S.,* (1981) 450 U.S.544. Historically, state sovereign ownership was limited to "the traditional triad of uses" – commerce, navigation, and fishing.

However, in 1971 the California Supreme Court expanded the protected uses to cover the environment generally. *Marks v. Whitney* (1971) 6 Cal 3d. 251, 259-260. State sovereign ownership imposes restraints on the state's discretion regarding the use of navigable waters. The use of trust resources must be consistent with the general trust purposes or it is invalid. *State of California v. Superior Court* (Lyon) (1981) 29 Cal 3d. 210, 220-230; *Marks v. Whitney*, supra; *City of Long Beach v. Mansell*, (1970) 3 Cal 3d. 462, 482-485. Preservation of a public trust resource such as the Sacramento River and San Francisco Bay/Delta estuary is a legitimate disposition of the public trust resource, and is consistent with general trust purposes. Thus, tidelands and water may be burdened with a negative easement against any active use or disposition of the trust reserve. Id; *National Audubon*, supra; *State of California v. Superior Court* (Fogerty), (1981) 29 Cal 3d. 240, 249-250.

Consequently, the SWRCB has both the authority and responsibility under its reserved jurisdiction in the permits and licenses of the USBR, and under its continuing authority and responsibilities pursuant to the public trust and reasonableness doctrine to protect fisheries, public trust resources and beneficial uses. To protect those resources and uses, it approved, among other things, the Basin Plan and issued WR Order 90-05 to protect the Sacramento River and issued the Bay-Delta Plan and D-1641 to protect the Sacramento-San Joaquin Delta Estuary.

Unfortunately, the SWRCB has ignored reasonable use and public trust considerations in its decision-making. It failed to analyze, discuss or justify its decision to significantly weaken protection for Sacramento River fisheries as opposed to maintaining near 75% deliveries to Settlement Contractors in its 7 July 2015 Order. The Order is devoid of any analysis and discussion weighing the costs and benefits of sending public trust species into extinction versus fallowing cropland that will be replanted when rains return. There is no economic study of Sacramento Valley agricultural beneficial uses to determine which crops provide important employment and economic benefits relative to crops that require large quantities of water but provide low net economic return and few jobs. Nor is there any analysis of “health and safety” needs and urban uses as opposed to agricultural or environmental.

USBR's pattern and practice of delivering near normal water supplies in the early years of drought, depleting carryover storage and then relying on the SWRCB to weaken water quality standards established to protect public trust resources as successive dry years occur has been amply documented in multiple documents and TUCP proceedings over the last several years. The SWRCB has failed to establish minimum reservoir storage levels that ensure compliance with water quality standards protective of public trust resources. When successive dry years occur, it then routinely weakens those standards, with little regard to its public trust and constitutional obligations.

In WR Order 92-02, the SWRCB previously made clear that water necessary to comply with water quality standards is not available for delivery for consumptive purposes. It must now explain or justify why it now chooses to reallocate that water to the Sacramento Settlement Contractors. Weakening water quality objectives and requirements simply because USBR recklessly delivered water that was otherwise necessary to maintain sufficient carryover storage to comply with water quality objectives and to protect public trust resources and agricultural beneficial uses in the Delta is a violation of Public Trust Doctrine. To send fisheries into extinction while continuing to supply water for low value crops like pasture and alfalfa is an unreasonable use of water and a violation of Public Trust Doctrine and the California Constitution.

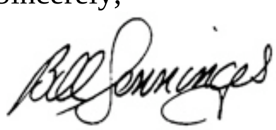
It is not the SWRCB's responsibility or legal right to sacrifice public trust resources and the Sacramento River's beneficial uses in order to absolve USBR of the consequences of egregious mismanagement. If customers of water contractors are now suffering because USBR failed to exercise prudence and due diligence in water management and rashly delivered near normal water supplies in initial drought years with little thought that another dry year might occur, it is USBR and not the SWRCB that has the responsibility to alleviate the suffering it caused.

In Conclusion

We request that the SWRCB immediately use its public trust, constitutional and water rights authorities to reduce water deliveries to low valued crops that are further depleting already inadequate cold water reserves, to require USBR to modify operations to ensure that sufficient carryover reserves of cold water necessary to comply with CWA and Basin Plan temperature criteria remain in Shasta Reservoir, and to issue sanctions against USBR for its willful disregard for public trust resources and beneficial uses. We also request that the SWRCB accelerate the present review of Bay-Delta standards, including a comprehensive balancing of the public trust with competing uses, and provide us a response to our 13 August 2014 complaint regarding illegal diversion by DWR and USBR and petition to adjudicate Central Valley waters.

Thank you for your consideration. If you have questions or require clarification, please don't hesitate to contact us.

Sincerely,



Bill Jennings, Executive Director
California Sportfishing Protection Alliance

Enclosures

Cc: Felicia Marcus
Frances Spivy-Weber
Tam M. Doduc
Dorene D'Adamo
Steven Moore
Tom Howard
Michael George