SOMACH SIMMONS & DUNN
A Professional Corporation
Andrew M. Hitchings (SBN 154554)
Aaron A. Ferguson (SBN 271427)
Kristian C. Corby (SBN 296146)
500 Capitol Mall, Suite 1000
Sacramento, California 95814-2403
Telephone: (916) 446-7979
Facsimile: (916) 446-8199
ahitchings@somachlaw.com
aferguson@somachlaw.com
kcorby@somachlaw.com

Attorneys for Sacramento County Water Agency

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING ON THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX.	**PART TWO TESTIMONY OF STEFFEN MEHL**

I. INTRODUCTION

My name is Steffen Mehl and I submit this testimony on behalf of the Sacramento County Water Agency (SCWA) in Part 2 of the Water Fix petition for change proceeding before the State Water Resources Control Board. I am a professor of Civil Engineering at CSU Chico where I routinely teach courses in fluid mechanics, hydrology, and hydraulics. Previously, I worked as a hydrologist for the USGS National Research Program. I have a BS in Environmental Resources Engineering from Humboldt State, and a MS and a PhD in Civil Engineering from the University of Colorado, Boulder. I have 18 years of experience in groundwater flow and transport modeling in both government and academic sectors. I am part of the development team for MODFLOW-OWHM, an integrated groundwater/surface water modeling tool, and UCODE, a universal code for parameter estimation, sensitivity, and uncertainty analysis. I have applied these methods in situations ranging from regional systems to laboratory scale experiments. Exhibit SCWA-41 contains a true and correct copy of my CV.

II. PURPOSE AND SUMMARY OF TESTIMONY

This testimony is a continuation of what is presented in Exhibits SCWA-50, 51, and 200 and provides technical and critical evaluation of Mitigation Measure GW-1 (MMGW-1) proposed by the California Department of Water Resources (DWR) in the California WaterFix (CWF) Environmental Impact Report (EIR).[1] Specifically, this testimony addresses whether MMGW-1 is sufficient to address SCWA's concerns regarding the potential impact of the CWF on groundwater resources in SCWA's Zone 40 and in the South American Subbasin. It also considers whether temporal duration and spatial extent of MMGW-1 aligns with the groundwater management planning obligations of local agencies under the Sustainable Groundwater Management Act (SGMA), as discussed by Kerry Schmitz in Exhibit SCWA-300.

In the EIR, DWR has proposed MMGW-1 to understand the potential impact of the CWF on the groundwater basin. MMGW-1 consists of:

- DWR determining the location of groundwater wells within the anticipated area of influence of conveyance operations on the Sacramento River above and below the north Delta intakes within an approximately 4-mile wide corridor (about 2 miles on either side of the river). (Exhibit SCWA-303, Ref. p. 7-51:13-19.)
- DWR using groundwater monitoring wells as part of a conveyance operation monitoring program. (Exhibit SCWA–303, Ref. p. 7-51:13-19.)
- DWR monitoring groundwater levels and preparing a monthly and annual reports for up to 5 years after commencement of conveyance operations. (Exhibit SCWA - 303, Ref. p. 7-51:13-19.)

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[1] The DWR revised MMGW-1 in a document titled *Developments after Publication of the Proposed Final Environmental Impact Report*, dated July 21, 2017. The relevant pages from the *Developments* document showing the revisions to MMGW-1 as presented in the EIR at Exhibit SWRCB-102, pp. 7-51 – 7-53 are contained in Exhibit SCWA-303.

- DWR offsetting domestic and agricultural water supply losses attributable to conveyance operations. (Exhibit SCWA-303, Ref. p. 7-51: 24-36.)

This testimony demonstrates that the duration and location of these mitigation strategies seem arbitrary and are not fully supported by existing modeling tools or demonstrated using existing data, such as aquifer tests, combined with analytical approximations. The effectiveness of analytical tools to provide a preliminary characterization of aquifer spatial and temporal response was demonstrated in my first testimony. (See Exhibit SCWA-44.) In this testimony, first, I discuss the theory of groundwater response time and how the proposed 5-years of monitoring is not adequate for an understanding of the long-term impacts of the CWF on groundwater conditions in the South American Subbasin. This will be supported by presenting a summary of a literature review on aquifer response time, and by the analysis of the changes in water budget within the entire South American Subbasin due to different alternatives.

III. DISCUSSION

A. Groundwater Hydraulic response: implication for location and length of monitoring in the EIR

I provide a conceptual discussion of what I would expect for a groundwater hydraulic response for the South American Subbasin considering the effects of the CWF project. I evaluate the MMGW-1 to monitor a 4-mile corridor along the Sacramento River for 5 years after commencement of conveyance operations as a representative temporal and areal coverage to assess the effects of the CWF operations. I do not intend to represent a complete literature review and deem the references used and cited as sufficient depth for the purpose of considering whether the temporal and areal coverage of MMGW-1 is adequate for assessing effects on groundwater wells along the Sacramento River and within SCWA’s Zone 40.

1. Sacramento Valley Groundwater Basin, South American Subbasin

According to the DWR’s Groundwater Bulletin 118, the Sacramento Valley Groundwater Basin South American Subbasin (Subbasin) is bounded on the east by

Sierra Nevada, on the west by the Sacramento River, on the north by the American River, and on the south by the Cosumnes and Mokelumne Rivers. It is comprised of a younger alluvium (consisting of flood basin deposits, dredge tailings and Holocene stream channel deposits), older alluvium, and Miocene/Pliocene volcanics. The maximum combined thickness of all the younger alluvial units is about 100 feet, while thickness of the older alluvium is about 100 to 650 feet and thickness of the Miocene/Pliocene Volcanics is between 200 and 1,200 feet. Aquifer type and hydrogeologic properties of the Subbasin vary spatially and across aquifer layers. According to the EIR, the interaction between surface water and groundwater in the Sacramento Valley also varies spatially and temporally. (Exhibit SWRCB-102, p. 7-4:17-18.) Moreover, groundwater levels in the South American Subbasin have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. (Exhibit SWRCB-102, p. 7-9:5-6.)

2. Groundwater Hydraulic Response Time in Large Aquifers

Aquifer system response time is generally defined as the time that it takes for water level and storage changes throughout the aquifer system to become negligible after a change in the withdrawals (Walton, 2011). Response time depends on many factors including but not limited to hydrogeological properties such as transmissivity and storativity, which are the aquifer's ability to transmit and store water, respectively, as well as aquifer dimensions, boundary conditions, and layer types. The scientific literature indicates that response time can vary based on these parameters ranging from days to centuries with a key relationship for response time characterized by:

$$t = L^2/(T/S)$$

In this equation, t is the response time, L is distance over which the response propagates, and T and S are the aquifer transmissivity and storativity, respectively. For multidimensional systems, long response times occur with large systems (large L), high storativity, and low transmissivity.

Changes in recharge, withdrawal, or hydraulic parameters can result in the groundwater system being in disequilibrium, which will initiate a transient groundwater response. Transient responses propagate through the aquifer starting from the origin of the change. (See Exhibit SCWA-305.) In areas with surface water/groundwater interaction, variations in the surface water patterns can also initiate transient responses in the groundwater. (See Exhibit SCWA-306.) A major challenge in studying these types of interactions is the fact that there is a considerable difference in the response times of the surface water systems and groundwater systems. Understanding groundwater response times in such settings helps make informed decisions about the supply and resource management.

There are three inclusive approaches in the literature for estimating the aquifer response time: (1) numerical computation and hydrogeological modeling, (2) laboratory experiments, and (3) analytical solutions with mathematical approximations. Numerical models are appropriate if set up and calibrated accurately. However, they can be computationally intensive and not suitable for initial evaluations. Laboratory experiments are not considered here. Analytical solutions can provide sufficient initial approximations for the response times; they are limited, however, due to the mathematical simplifications.

3. Literature Review of Aquifer Response Time

Both analytical and numerical solutions for evaluating response time have been proposed by multiple researchers. This testimony examines the appropriate methods qualitatively and avoids mathematical complexity.

Walton (2011) indicates while the supply management planning time frames are usually constrained to 50 years or less partly due to the difficulty and uncertainty surrounding the projection of future development, response time may exceed 50 years especially if the aquifer is multilayered. He claims that accounting for inflows, storage changes, and outflows in all layers is necessary in assessing supply change impacts. Models based on management planning time frames and stress period lengths shorter than response times may underestimate such impacts. (See Exhibit SCWA-304)

Rousseau-Gueutin et al. (2013) estimated the response times for multiple large groundwater basins in the world with different hydrogeological properties. Their estimates showed the response times to be between thousands to millions of years. These are estimates from representative aquifers, and claimed response times should not be interpreted as the aquifer response to local changes and specific analysis should be performed to seek such results. (See Exhibit SCWA-305)

Jazaei et al. (2014) presented a framework to estimate aquifer response time and found that that aquifer systems have three fundamental time scales: (1) a time scale that depends on the intrinsic properties of the aquifer (2) a time scale that depends on the intrinsic properties of the boundary conditions, and (3) a time scale that depends on the properties of the entire system. (See Exhibit SCWA-306.)

Finally, Bredehoeft (2011) uses numerical models of hypothetical systems and data from aquifer properties in Nevada to illustrate how hydraulic responses are propagated through the aquifer. A key result is that monitoring the responses can be challenging in alluvial systems that typically have higher storativity and longer response times. (See Exhibit SCWA-307.)

4. Analysis

These cited works demonstrate that there is scientific literature related to aquifer response time and is relevant to the CWF project mitigation strategy in the following ways:

1) Response times can have large variability (from days to centuries to millennia).
2) In systems with substantial stream aquifer interactions, characterizing the response time is especially important because of the different time scales between surface water and groundwater.
3) Developing appropriate monitoring should account for aquifer response time and how changes are propagated through the aquifer. This is particularly true for alluvial systems that typically have longer response times.

MMGW-1, as proposed, is not justified by analytical approximations, numerical simulations, or SGMA requirements. Therefore, based on the areal extent of the aquifer, its properties, the variability in stream aquifer interaction, and location of supply wells in SCWA's Zone 40, DWR's proposed 4-mile corridor and 5-year duration for monitoring in the EIR seems arbitrary and unjustified.

B. WATER BUDGET ANALYSIS

Similar to the approach of previous testimony (Exhibit SCWA-200), results will not be presented as absolute results, but in a comparative way, using two of the alternatives for the CVHM model provided by the Petitioners. I have used the CVHM NAA and Alt4 models provided by the Petitioners to demonstrate 1) the groundwater impacts of the CWF not only in the vicinity of the Sacramento River but in the entire South American Subbasin, and 2) the need to increase the monitoring time proposed by DWR in MMGW-1 to a time period greater than 5 years.

Without making any modifications to the CVHM NAA and Alt4 models, water budget results for the South American Subbasin and for the Sacramento River specifically were extracted, post-processed, and water budget terms were compared between the NAA and Alt4. As presented in Figure 1 (below), the implementation of CWF could affect the water budget of the entire South American Subbasin and not just the area in the vicinity of the diversion. As mentioned in previous testimony, I am aware that there are issues with DLEAK that can cause erratic model results (Exhibit SCWA-200, paragraph 17.) These results should not be considered as absolute numbers but an indication of the possible relative changes caused by the CWF operations. Conclusions include:

1) Differences in leakage on the Sacramento River adjacent to the South American Subbasin may reach up to 200k acre-ft when looking at the cumulative differences between CVHM-NAA and CVHM-Alt4. Although the models used by the Petitioners were not developed to focus on stream-aquifer interaction, the area around the Sacramento River has substantial stream-

aquifer interactions that can be significantly affected by CWF operations.

2) The cumulative difference in stream leakage along the Sacramento River is negative for the first 5 or so years and then the difference becomes positive. I previously noted that the years 1968-69 and 1998-99 are affected by possible numerical errors. Besides these critical changes in the cumulative difference in the leakage, there are other years with significant variation and this supports the conclusion that 5 years of monitoring data is not enough in the sense that there is a lot of variability in this system and in California hydrology in general. For example, in terms of California hydrology, 2013 was one of the driest years on record while this year was the wettest. Long-term monitoring should be done in conjunction with modeling to support and test model accuracy and to separate out what is natural variability versus the impacts due to CWF operations.

3) This concern needs to be aligned with the acknowledgement that the Groundwater Sustainability Agencies (GSAs) implementing SGMA must show sustainability over a 20-50 year period. The CWF has the potential to impact aquifer sustainability and therefore should monitor for at least 20 years.

4) As previously demonstrated using analytic solutions of stream-aquifer interaction (Exhibit SCWA-44) Zone 40 within the South American Subbasin could be affected by changes in flow patterns from multiple directions because the South American Subbasin is bounded by the Sacramento River to the west and the American River to the north, and stream flows will change under operation of the CWF. Therefore, groundwater monitoring data (such as groundwater levels) should be collected in a more distributed way around the Sacramento River, but also within Zone 40.

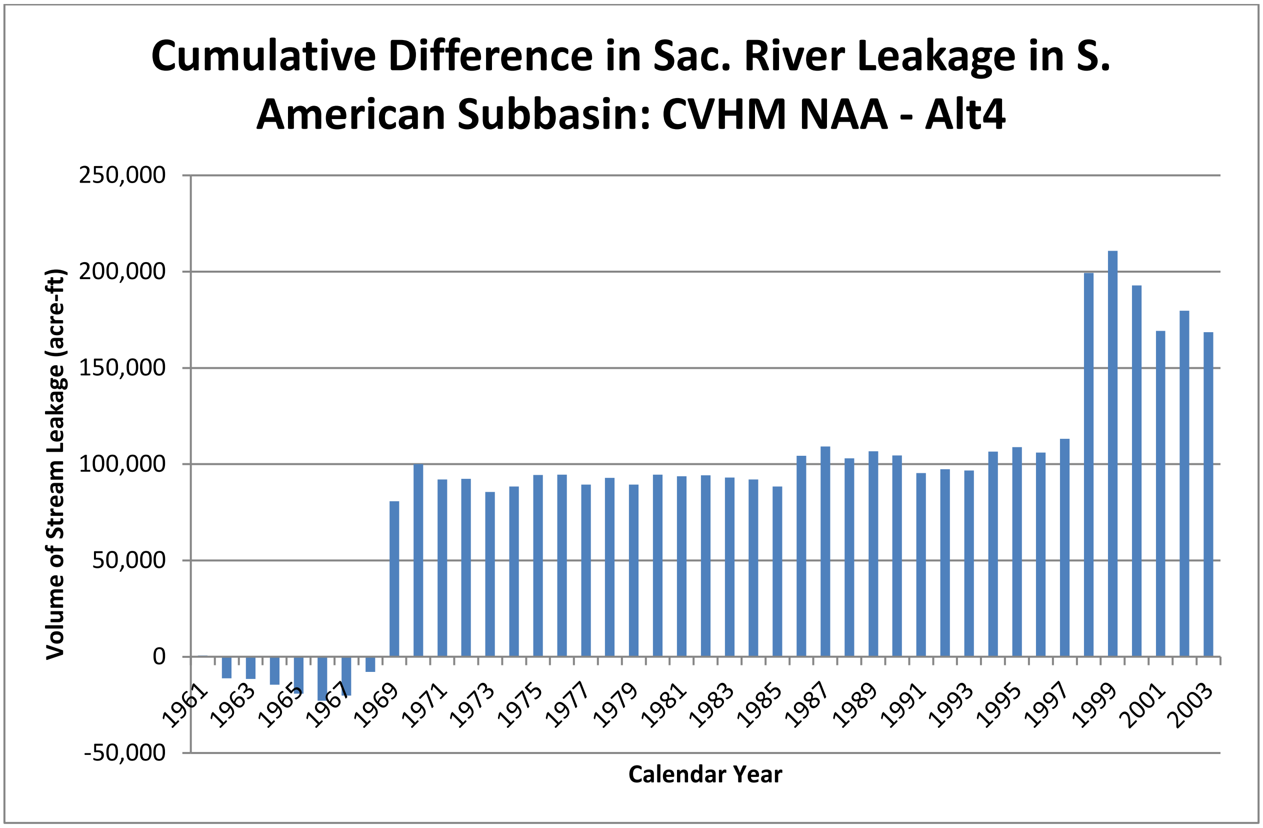

Figure 1. Cumulative difference in Sacramento River leakage volume within the South American Subbasin: CVHM No Action Alternative minus Alternative 4