AquAlliance Exhibit 5

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 WaterFix

Testimony of Kit H. Custis

On Behalf of AquAlliance

I Kit H. Custis, do hereby declare:

Introduction

I have a Bachelor's and a Master's Degree in Geology from California State University at Northridge. I have additional graduate studies as a PhD student in Hydrological Sciences at the University of California at Davis. I have worked for 38 years as a professional engineering geologist and hydrogeologist. I hold licenses in California as a Professional Geologist, PG 3942; Certified Engineering Geologist, EG 1219; and Certified Hydrogeologist, HG 254. I have worked in consulting and as an employee of the State of California. As the latter, I've worked for the State Water Resources Control Board, the Central Valley Regional Water Quality Control Board, the California Geological Survey, and the Department of Fish and Wildlife. A copy of my curriculum vitae is attached as Exhibit 6.

Purpose of Testimony

The purpose of my testimony is to provide information on the groundwater in the Sacramento Valley and Delta, the current condition of the groundwater, and the potential impacts to groundwater and surface water resources from the requested change in the point of diversion for California WaterFix (WaterFix Project). The implementation of the WaterFix Project will set up a chain of events that has the potential to significantly impact the groundwater and surface water resources of the Sacramento Valley and the Delta. Alternative 4 of the WaterFix Project will construct an additional cross-Delta water conveyance structure that will increase the capacity to move transfer water from areas upstream of the Delta to the export service areas, and provides a longer transfer window than allowed under current regulatory constraints. My testimony will present information on the condition of groundwater in the areas upstream of the Delta that hasn't been adequately provided in either the November 2013 Draft EIR/EIS for the Bay Delta Conservation Plan (DEIS/EIR) or the 2015 Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS). AquAlliance Exhibit 7 is a pdf file type copy of my testimony presentation.

AquAlliance Exhibit 5

Statements in the WaterFix Project Environmental Documents About Water Transfers

The implementation of the WaterFix Project and the potential impacts to areas upstream of the Delta are discussed in a number of sections of the November 2013 DEIS/EIR and the 2015 RDEIR/SDEIS. Statements made in those documents indicate that the WaterFix Project will increase the timing and the amount of water transferred across the Delta from the Sacramento Valley to users in the export service areas. The following are examples of the statements regarding the timing and amount of Sacramento Valley water available for transfer through the WaterFix tunnels:

- The 2015 RDEIR/SDEIS provides additional discussion of the potential environmental effect to groundwater in Section 7.1. In Section 7.3.3.9 in the discussion on Alternative 4, the 9,000 cfs Operational Scenario H, the NEPA effects analysis on page 7-16 states that the *[t]otal long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 4 Scenario H3 would be higher than under the No Action Alternative, as described in Chapter 5, Water Supply, and Table 7-7.* In the CEQA conclusion section on page 7-16, the RDEIR/SDEIS concludes that *[m]odeling predicts that groundwater pumping under Alternative 4 Scenario H3 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.*

- In the Water Supply Chapter 5 of the RDEIR/SDEIS on Water Supply the discussion of cumulative change in Delta exports on page 5-43, Section 5.2.2.1, Impact WS-4, states that *[i]mplementation of the cumulative projects and programs and the action alternatives (which includes non-SWP and CVP projects that are included in the No Action Alternative) could modify stream flows in the Sacramento and/or San Joaquin Rivers . . . . Overall, there could be changes in diversion patterns throughout the year for SWP and CVP water users in the Sacramento Valley, other water rights water users located in the Sacramento River and in the Delta, and Delta exports. The changes could differ by water year type.*

- In the Water Supply Chapter 5 of the RDEIR/SDEIS on Cumulative Effects of Water Transfers on page 5-45, Section 5.2.2.1, Impact WS-6, the WaterFix Project, it states that *[t]o the extent that implementation of the cumulative projects reduces SWP and CVP Delta exports, there would be a cumulative effect on cross-Delta water transfers evidenced as an increase in the frequency of water transfer demands and an increase in the average annual cross-Delta transfers.*

- In the section on Environmental Setting/Affected Environment in Chapter 30 of the November 2013 DEIR/EIS, Section 30.3.6 Environmental Impacts Relating to Water Transfers on page 30-117 states that . . . . *transfer water* *could potentially be moved at any time of the year that capacity exists in the new BDCP cross-Delta facility and the export pumps, depending on operational and regulatory constraints. If the new north Delta facilities are not restricted to the current July through September transfer export window, crop idling or crop shifting-based transfers may become a more viable source of transfer water for much of the Sacramento Valley.*

- In the section on Environmental Setting/Affected Environment in Chapter 30 of the November 2013 DEIR/EIS, Section 30.3.6.1 Environmental Impacts Relating to Water Transfer Surface Water on page 30-118 states that: (1) *[t]ransfers could lead to decreased reservoir storage levels if additional transfers result in the release of water from a reservoir when it would otherwise have been stored;* (2) *[t]ransfers of water could also change the rate and timing of flows in the Sacramento River and its tributaries;* (3) *[t]he incidence and magnitude of changes in flows would depend on the volume of water transferred and the scheduled release of that water;* (4) *[f]lows could also vary as a result of groundwater substitution-based transfers due to changes in the timing of surface water releases and the interaction between stream flows and groundwater (Bureau of Reclamation 2010); and* (5) *[t]his could result in an increase in groundwater recharge from surface water (i.e. accretion) or a reduction of groundwater that would otherwise have discharged into surface water (i.e. depletion).*

- In the section on Environmental Setting/Affected Environment in Chapter 30 of the November 2013 DEIR/EIS, Section 30.3.6.2 Environmental Impacts Relating to Water Transfer Groundwater on page 30-119 states that: (1) *[g]roundwater pumping could result in the lowering of local groundwater levels, which could create environmental effects including depletion of streamflow or depletion of groundwater flow that would otherwise have caused an increase to streamflow in absence of the transfer*; (2) . . . . *yield from groundwater wells may be reduced while the costs to pump groundwater could increase as a result of declining groundwater levels*; *[g]roundwater drawdown could temporarily exceed historical seasonal fluctuations and dry years could extend the period necessary for recovery of groundwater levels;* (4) *. . . . groundwater pumping could add to the potential for subsidence by decreasing groundwater levels, which could allow consolidation of underlying clay beds*; (5) *while subsidence is a gradual process, in extreme cases it could create problems for flood control, infrastructure, and water distribution systems*; and (6) *[g]roundwater substitution transfers could also result in changes in groundwater quality because pumping can alter local groundwater levels, flow patterns can change and surface water could be drawn into the groundwater.*

- In Appendix 5C of the November 2013 DEIR/EIS, the Historical Background of Cross-Delta Water Transfers and Potential Source Regions, Section 5C.10.2, Groundwater Substitution, on page 5C-15 states that: *[g]roundwater substitution transfers would withdraw more water from the groundwater* *basin below the participating users than without the transfer, so this option is generally only used in basins that are well-managed and not in a state of significant groundwater overdraft, or in areas where the water supplier determines that the water transfer would not contribute to groundwater overdraft.*

- In Chapter 7 of the November 2013 DEIR/EIS, the Delta Watershed Groundwater Setting, Section 7.1.1.3, on page 7-13 states: *[t]herefore, except during drought, the Sacramento Valley groundwater basin is "full," and groundwater levels recover to pre-irrigation season levels each spring. Historical groundwater level hydrographs suggest that even after extended droughts, groundwater levels in this basin recovered to pre-drought levels within 1 or 2 years following the return of normal rainfall quantities. . . . . Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, including the northern Sacramento County area, areas near Chico, and on the far west side of the Sacramento Valley in Glenn County where water demands are met primarily, and in some locales exclusively, by groundwater. These could be early signs that the limits of sustainable groundwater use have been reached in these areas.*

- In the Appendix 5C of the November 2013 DEIR/EIS, Section 5C.10.2.1, Groundwater Substitution Upstream of the Delta, on page 5C-17 states that: *[t]he Delta pumps are currently unlikely to have available capacity for transfers at the start of the irrigation season under conditions imposed by the Biological Opinions. This constraint may be removed, however, if the transfer water is moved in BDCP facilities.*

- In the Appendix 5C of the November 2013 DEIR/EIS, Section 5C.11, Potential Quantities of Upstream-of-Delta Water Transfer, on page 5C-22 states that*: [b]ased on statewide rice crop acreage of 555,000 acres and an allowable ETAW of 3.3 feet of water, idling 20 percent of the rice crop in California could generate about 366,000 acre-feet of transfer water. Idling 20 percent of all other eligible crops combined would add about another 141,000 acre-feet for a total of about 507,000 acre-feet of crop idling transfer water.*

- In the Appendix 5C of the November 2013 DEIR/EIS, Section 5C.11, Potential Quantities of Upstream-of-Delta Water Transfer, on page 5C-23 states that: (1) *[g[roundwater substitution transfers could approach as much as 400,000 acre-feet in any given year prior to allowance for impacts on streamflows. Groundwater substitution supplies are generally subject to a correction factor to adjust for streamflow depletion effects of water transfers in the current year. As the groundwater basins of the Sacramento Valley are pumped, there will be gradual effects on streamflow as the basins recharge over time. In the past few years, an allowance of 12 percent has been assumed as the amount of impact on Delta inflow in the current year;* and (2) *[if] all of these sources could be*

> *contracted with willing sellers in the same year, about 1,000,000 acre-feet of cross-Delta transfer water might be generated. This estimate is approximately the same as that referenced in Reclamation's Biological Assessment of the OCAP at Page 12-39* [also page 5D-3 in Appendix 5D]*: "Water transfers would increase Delta exports from about 0 to 500,000 acre-feet (af) in the wettest 80 percent of years and potentially more in the driest 20 percent years, and up to 1,000,000 af in the most adverse Critical year water supply conditions."*

<u>Overview of Testimony</u>

From these statements in the WaterFix Project environmental documents on water transfers it is clear that there is a potential for increasing the amount of water transfers from the areas upstream of the Delta to the export service areas. Two of the methods of water transfer that can impact the conditions and the sustainability of the groundwater and the surface water systems in the Sacramento Valley are the use of groundwater substitution and crop idling. My testimony presents information that is specific to these two types of water transfer. My testimony discusses additional data and analysis that's needed to properly evaluate the potential impacts for approving the requested change in point of diversion for the WaterFix Project. My testimony in part summarizes the information that's provided in my five previous letters to AquAlliance (AquAlliance Exhibits 29 through 33). These previous letters should be reviewed for more detailed discussion on potential impacts to the Sacramento Valley groundwater and surface water systems from water transfers.

As part of my testimony, my five previous letters that I prepared for AquAlliance on the potential groundwater impacts from the 10-Year Long Term Water Transfer Program by the Bureau of Reclamation and San Luis & Delta Mendota Water Authority (10-Year BOR/SLDMWA Transfer Program) (my letters are dated November 25, 2014, AquAlliance Exhibit 29; dated April 8, 2015, AquAlliance Exhibit 30), for the Supplemental Water Supply Project by the Glen-Colusa Irrigation District (GCID-SWSP) (my letters are dated July 29, 2015, AquAlliance Exhibit 31; dated August 17, 2015, AquAlliance Exhibit 32), and for the WaterFix Project (my letter dated August 25, 2016, AquAlliance Exhibit 33). The comments and recommendations in those documents are still applicable and relevant to the proposed change in diversion for the WaterFix Project because those upstream area projects are ongoing and will likely utilize the WaterFix tunnels in any cross-Delta transfer of water to the export service areas.

My testimony is divided into four parts: (1) the condition of the groundwater system in the Sacramento Valley; (2) the impacts to well owners in the Sacramento Valley from groundwater and crop idling water transfers; (3) the impact to surface water resources and groundwater recharge from groundwater and crop idling water transfers; and (4) the potential impact to the Delta groundwater system from groundwater and crop idling water transfers.

1. The Condition of the Groundwater System in the Sacramento Valley

On page 5C-15 in Appendix 5C, the November 2013 DEIR/EIS states that: *[g]roundwater substitution transfers would withdraw more water from the groundwater basin below the participating users than without the transfer, so this option is generally only used in basins that are well-managed and not in a state of significant groundwater overdraft, or in areas where the water supplier determines that the water transfer would not contribute to groundwater overdraft.* This statement appears to imply that the groundwater basins of the Sacramento Valley are in good condition and not subject to any overdraft conditions. Information provided by the Department of Water Resources (DWR) CASGEM program suggests that the groundwater basins in the Sacramento Valley require additional management in order to achieve sustainability.

A. AquAlliance Exhibit 8 is a map of the Sacramento Valley that shows the CASGEM Priority ranking for the groundwater basins, with the wells identified in the 10-Year BOR/SLDMWA Transfer Program shown as black dots. These wells and water purveyors will likely be involved in any water transfers involving the WaterFix Project. This map shows that the groundwater basins in the Sacramento Valley that are involved in the 10-Year BOR/SLDMWA Transfer Program have either high or medium priority CASGEM ranking. The 2014 Sustainable Groundwater Management Act (SGMA) requires that high and medium priority ranked basins develop Groundwater Sustainability Plans (GSP). This SGMA process is just beginning, so the feasibility of transfering up to 400,000 acre-feet per year (AFY) of water using groundwater substitution and up to 507,000 AFY crop idling while maintaining a sustainable groundwater system is unknown at this time.

B. AquAlliance Exhibit 9 is a table that lists the changes in groundwater levels in the Sacramento Valley from 2004 to 2015. These data were taken from various Change in Groundwater Elevation maps prepared by the Northern District Office of DWR.[1] The changes in groundwater elevation are separated into shallow, intermediate and deep wells for Butte, Colusa, Glenn and Tehama-south areas, and basin wide. Maximum and average long-term decreases from 2004 to 2014 for spring and fall are then compared to maximum and average decreases for 2014 to 2015. Changes in spring elevation are of particular importance because they're a measure of the ability of the aquifer system to recover from summer extractions. While the average decrease in groundwater elevation isn't a true measure of the change

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[1] Obtained from DWR web site: (http://www.water.ca.gov/groundwater/data_and_monitoring/northern_region/GroundwaterLevel/gw_level_monitoring.cfm).

in aquifer storage, it can be seen as a relative indicator of the direction and rate of change in groundwater storage. The two right-most columns in the table provide the most recent, 2014 to 2015, annual average declines, and compare them to the average 2004 to 2014 decreases. Bold values are those that exceed the 2004 to 2014 annual average. For a more detailed discussion of this table see AquAlliance Exhibit 33. AquAlliance Exhibit 9 shows that:

a. The long-term average decline in groundwater elevation in the listed counties and basin wide typically ranges from 1 to 2 feet per year with some deeper wells as high as 3 to 4 feet per year.
b. The decreases in the 2014 to 2015 groundwater elevation in intermediate and deep wells in the listed counties and basin wide commonly exceed the long-term averages.
c. Changes in groundwater levels were less than the long-term average in Butte, Glenn and basin wide in the spring from 2014 to 2015 and Glenn and basin wide in the fall from 2014 to 2015.

The groundwater basins of the Sacramento Valley have areas where groundwater levels are depressed and the basins have medium to high CASGEM priority ranks. Since 2004, the changes in the elevations of shallow, intermediate and deep aquifer zones in Butte, Colusa, Glenn Tehama-south and Basin Wide have decreased. The maximum change in groundwater levels from 2004 to 2014 ranges from -15.5 feet to -79.7 feet, average 10-year changes range from -5.3 feet to -40.5 feet, and the annual average change ranged from -0.84 feet to -4.05 feet. Recent groundwater levels from 2014 to 2015 have generally continued to decline with rates of decline in most of the basin exceeding the 2004-2014 long-term averages. The ongoing decrease in groundwater levels in most of the Sacramento Valley indicates that these basins are not "full" and that the proposed transfer of water using groundwater substitution or crop idling will likely have a significant impact on water users in the valley.

C. AquAlliance Exhibits 10, 11 and 12 are a series of maps that combine the DWR Spring 2004 and 2014 Groundwater Change maps for the Sacramento Valley with the simulated changes in groundwater head as a result of the 10-Year BOR/SLDMWA Transfer Program. This transfer program proposes to export from the Sacramento Valley up to 290,495 acre-feet per year (AFY) through groundwater substitution transfers and up to 177,362 AFY by crop idling. These composite maps show that areas that experienced significant drawdown since 2004 will experience additional lowering of groundwater elevation by the 10-Year BOR/SLDMWA Transfer Program. The water agencies that are participation in the 10-Year BOR/SLDMWA Transfer Program are likely part of the WaterFix Project water transfer agencies and may participate in water tranfers that exceed those analyzed for the 10-Year BOR/SLDMWA Transfer Program.

The impacts to the Sacramento Valley groundwater and surface water systems from the WaterFix proposal to transfer up to 400,00 AFY using groundwater substitution and up to 507,000 AFY using crop idling have not been evaluated. However, the potential impacts on the magnitude and extent of the area of decreasing groundwater levels will likely be significantly greater than with the 10-Year BOR/SLDMWA Transfer Program. The 38% increase in pumping from groundwater substitution transfers, and 186% increase in crop idling will reduce the groundwater storage. Note that the simulation of drawdown for the 10-Year BOR/SLDMWA Transfer Program stopped in 2003 and thus didn't include the decrease in groundwater levels tabulated in Exhibit 9 and shown in Exhibits 10, 11 and 12. For a more detailed discussion of these composite maps and the potential impacts to groundwater resources see AquAlliance Exhibits 29 to 30. Exhibits 10, 11 and 12 show the following:

a. The areas of greatest impact to shallow groundwater, Exhibit 10, are in the southern portion of the transfer program area. Decreases in groundwater are greatest in Sacramento, Placer and Colusa counties and along the Sacramento and Feather rivers. There are a number of domestic and small agriculture wells that extract from the shallow groundwater zone. I'll discuss this below in my testimony of impact to shallow wells.
b. The areas of greatest impact to intermediate groundwater, 200 to 300 feet deep, Exhibit 11, are similar to shallow groundwater only broader. One additional area that will have impact above those of the shallow zone is along the Sacramento River between Butte and Glenn counties. The proposed transfer program extractions in western Glenn County may result in a joining of the two areas of groundwater depression to the east and west, and align with the area of depression in the 700 to 900 foot aquifer zone, Exhibit 12.
c. The areas of greatest impact to deeper groundwater, 700 to 900 feet deep, Exhibit 12, are similar in extent to the intermediate shallow groundwater zone except for Glenn County. The depth and extent of the drawdown of the deep aquifer zone widens in Glenn County in alignment with the existing area of depression.

D. AquAlliance Exhibits 13 and 14 are water balance tables taken from the 2013 DWR report on the C2VSim Model Development, Version 3.02-CG (Brush and others, 2013a). AquAlliance Exhibit 13 provides annual model calculated water budget values for the different C2VSim subregion in the Central Valley from 1922 to 2009. The subregions 1 to 7 are in the Sacramento Valley, subregion 8 covers the eastside streams in Sacramento and northern San Joaquin counties, and subregion 9 is the Delta. AquAlliance Exhibit 14 tabulates the 2000 to 2009 model water balance values. Comparison of the long-term 1922 to 2009 water balance values to the 2000 to 2009 shows that:

a. The 2000 to 2009 annual average change in groundwater storage in the Sacramento Valley is greater than the 1922 to 2009 long-term average by approximately 140,000 AFY, a storage loss of approximately 186% (-303,425 – (-163,417) = -140,008).
b. The annual volume of groundwater discharging to rivers has changed significantly from a gaining river system to a losing river system. The river system has gone from gaining 358,541 AFY of groundwater discharge to losing 370,162 AFY, an approximate minus 729,000 AFY change. Again it should be noted that this model doesn't include groundwater level declines from the last 15 years.

E. AquAlliance Exhibits 15, 16 and 17 provide another set of water balance values for the Sacramento Valley that were developed for the Northern California Water Association (NCWA) in 2014. AquAlliance Exhibit 15 tabulates the water balance values, using fewer categories than AquAlliance Exhibits 13 and 14. AquAlliance Exhibit 16 provides graphs and decade interval bar charts for deep percolation and estimated annual diversion that provides a better understanding of the annual changes. AquAlliance Exhibit 17 provides graphs and decadal bar charts for estimated annual groundwater pumping and annual river accretion. Note that the meaning of the sign for accretion reflects the system. For example, a negative net accretion value for streams and rivers is the same as a positive value for groundwater streams and rivers. That is, when the stream/river system is losing water, accretion is a negative value, while the groundwater system is gaining water, so accretion is a positive value. AquAlliance Exhibits 15, 16 and 17 show the following:

a. The values for simulated stream and river depletion from 2000 to 2009 for groundwater systems in AquAlliance Exhibit 15 are similar to AquAlliance Exhibit 14, loss to groundwater of approximately 358,000 AFY vs 370,162 AFY.
b. AquAlliance Exhibit 15 shows that from the 1920s to the 2000s simulated stream and river depletion changed from gaining 953,000 AFY to losing 358,000 AFY, a shift of approximately 1,311,000 AFY away from the rivers and into groundwater.
c. The annual simulated groundwater pumping increased from 451,000 AFY in the 1920s to 2,253,000 AFY in the 2000s, an increase of 1,802,000 AFY, almost a 500% increase.
d. Simulated deep percolation to groundwater increased from 779,000 AFY in the 1920s to 1,174,000 AFY in the 2000s, an increase of 395,000 AFY.
e. The increases in simulated deep percolation and infiltration from rivers and streams sum to 1,706,000 AFY and almost makeup for the increase in simulated groundwater pumping.

  f. The change in simulated groundwater storage from a loss of 188,000 AFY in the 1920s to a loss of 303,000 AFY in the 2000s, a difference of minus 115,000 AFY
  g. AquAlliance Exhibit 16 shows that simulated deep percolation has generally ranged from 1,000,000 to 1,250,000 AFY since the 1940s.
  h. AquAlliance Exhibit 16 shows that simulated annual diversion began to increase in the 1940s and has equaled or exceeded 3,000,000 AFY since the 1950s.
  i. AquAlliance Exhibit 17 shows that total simulated annual groundwater pumping began to increase in the 1940s and exceeded 1,000,000 AFY by the mid 1950s. Simulated pumping continued to increase and reached 2,000,000 AFY briefly in the mid 1970s and continuously after the late 1980s. By 2010, total simulated annual groundwater pumping had exceeded 2,500,000 AFY.
  j. AquAlliance Exhibit 17 shows on the other side of the water balance that simulated stream and river accretion (groundwater discharge to the river being a positive value) decreased from the 1920s to 2010 at a rate similar but opposite to the simulated pumping. In the 1920s, rivers accreted approximately 1,000,000 AFY of groundwater discharge. From the mid 1970s to early 1990s river accretion oscillated between gaining and losing. Since the mid 1990s, the simulated river systems have generally been losing water to the groundwater system. At times, the total simulated losses since the 1920s was as great as 2,000,000 AF. This is consistent with the tabulated 1920s to 2000s average total simulated loss of approximate 1,300,000 given in AquAlliance Exhibit 15.

F. AquAlliance Exhibit 18 is a graph that combines the graphs from AquAlliance Exhibits 16 and 17 for changes in the Sacramento Valley groundwater system from the early 1920s to 2010. The graph is visually busy, but it reflects an attempt to show the relationship between changes in simulated groundwater pumping and river accretion, along with a graph from the C2VSIM User's Manual (Brush and others, 2013b) that shows the simulated change in groundwater storage (see footnote on graph for source). AquAlliance Exhibit 18 shows that:

  a. Starting in the 1940s when simulated groundwater pumping increased, simulated river/stream accretion began to decrease. The straight green lines drawn through the accretion and pumping graphs were mirrored across the accretion-equals-zero (0) horizontal line. This suggests that the long-term average rate of accretion decreased is in step with the long-term increase in groundwater pumping. This issue will be discussed further below in my discussion on stream depletion.

b. Prior to the mid-1970s, the simulated river and stream system in the Sacramento Valley was generally gaining water from groundwater discharge. From the mid-1970s to approximately 1990 the simulated exchange of surface water and groundwater oscillated.
c. After 1990 the simulated river accretion was always negative and the rate of loss increased at a rate similar to that of simulated groundwater pumping increase. The simulated river and stream system in the Sacramento Valley since 1990 has generally been losing water to the groundwater system.
d. The graph that shows simulated groundwater change in storage is almost the mirror image of the simulated groundwater-pumping graph. The yellow line through the storage change graph is drawn at a slope of minus 163,417 AFY, the 1920s to 2009 long-term value for simulated groundwater storage loss given in AquAlliance Exhibit 13. The change in simulated storage graph was placed so that the storage in the 1920s is approximately zero (0), right hand axis. Since the 1920s, the total simulated change in groundwater storage in the Sacramento Valley is approximately 1,200,000 to 1,400,000 AFY.

Why is this number crunching exercise relevant to the WaterFix Project? It is important because it demonstrates that there is a lot of existing information about the condition of the groundwater system in the Sacramento Valley. This information shows that the Sacramento Valley is already impacted by historical groundwater pumping with a decrease in the level of groundwater, the decrease in groundwater storage, and loss of flow in surface waters. These negative historical impacts to groundwater are consistent with the medium to high CASGEM ranks for the groundwater basins and the need to develop Sustainable Groundwater Management Plans. The construction of the WaterFix Project tunnels will only increase these historical impacts because it will allow for more transfer of groundwater from the Sacramento Valley across the Delta to export to the service areas. The WaterFix Project environment assessment should acknowledge, evaluate, monitor and mitigate the potential impact to groundwater levels, groundwater storage, and surface flow from increasing the transfer of Sacramento Valley across the Delta.

2. <u>Impacts to Well Owners in the Sacramento Valley from Groundwater and Crop Idling Water Transfers</u>

My testimony above has shown that the groundwater and surface water systems in the Sacramento Valley have declined over the past 80 years. The negative impact on the public from continued decrease in groundwater levels, and loss in surface water flow are well known. As water levels drop, the distance a well has to lift water increases. This costs dollars and can cause the pump to lose efficiency. If the well is deep enough, the pump can be lowered and maybe changed to accommodate the greater lift. Eventually, as the water level continues to drop, the well goes dry. Replacing a well is costly, and there may be a delay in getting a new well drilled. Water quality may change with lowering of the water levels, making treatment necessary, which is an added cost. All of these impacts are negative for the well owner and, given that many are small groundwater producers that likely don't obtain any economic benefit from the water transfers, the increase in water transfers facilitated by the WaterFix Project will create a potential significant economic and social impact on groundwater users in the Sacramento Valley. These impacts to well owners should be acknowledged, evaluated, monitored and mitigated by the WaterFix Project's environmental impact assessment.

One question that arises is how many wells are potentially impacted by continued declines in groundwater levels as a result on increase in groundwater substitution and crop idling transfers? In order to answer that question, I made an estimate of the number of shallow domestic wells, depths less than 150 feet, which might be impacted by a drop in groundwater levels in aquifers less than 200 feet below the ground surface.

A. AquAlliance Exhibit 19 is a map made by combining maps published by DWR (2014a) for the Sacramento Valley that show the distribution and range of the number of domestic wells in each square mile of the valley. Overlaid on that are the contours of 2004 to 2014 Change in Groundwater Elevation map published by DWR (2014b). The well count maps have a color scheme that gives a range of information on the numbers in each square-mile box and the minimum, maximum and average well depths. I tabulated the minimum and maximum number of wells that fell within each 5-foot drawdown contour interval in Butte, Colusa, Glenn, and Tehama counties and the Redding area. AquAlliance Exhibit 20 is a table of the results of that well inventory.

B. AquAlliance Exhibit 20 shows that there are a significant number of domestic wells within the area of 2004 to 2014 groundwater change. The number of wells ranges from a low of 444 wells in Colusa County to a high of 6,395 wells in Butte County. The groundwater level change in most of the wells varies from 0 feet to -25 feet. The total number of domestic wells for the Sacramento Valley within the 2004 to 2014 groundwater change contours ranged from 10,520 to 24,622, with an average of 17,571 wells.

The impacts of the groundwater substitution and crop idling transfers occurs on top of the ongoing depression in groundwater levels caused by localized overpumping. When combined with the WaterFix Project's proposal to expand water transfers up to 907,000 AFY (400,000 AFY by groundwater substitution and 507,000 AFY by crop idling), there is a potential for significant negative economic and environmental impacts to hundreds perhaps thousands of domestic well owners. The WaterFix Project environment assessment should acknowledge, evaluate, monitor and mitigate the potential impact these thousands of well owners from increasing the transfer of Sacramento Valley across the Delta.

3. Impacts to Surface Water Resources and Groundwater Recharge from Groundwater Substitution and Crop Idling Water Transfers

Implementation of groundwater substitution transfers requires that additional groundwater be pumped to replace the surface water being transferred. This pumping reduces groundwater storage, lowers the water table and as a result can cause impacts to adjacent well owners that are not participating in the transfers. Crop idling water transfers reduces the overall amount of applied irrigation, which results in a reduction in deep percolation and thus reduces the amount of groundwater recharge. When the crop idling reduction in recharge is combined with the increase drawdown from groundwater substitution pumping the impact is compounded.

The pumping with groundwater substitution transfers also causes impacts to surface water resources by; (1) increasing infiltration through an increase in hydraulic gradient between the surface water and groundwater; (2) intercepting groundwater before it can discharge to a surface water body; (3) lowering the water table to the detriment of vegetation and ecosystems; and (4) expanding the area of drawdown. These negative impacts are collectively called "capture."

The capture of surface water by groundwater pumping can create a significant impact to surface-water-user's water rights both, riparian and appropriated, by decreasing the flow and shortening the time that surface water is available for diversion. Decreases in surface flows can negatively impact the health, reproduction capability, and extent of groundwater dependent vegetation, wildlife and ecosystems. Decreases in riparian vegetation can alter flood plains and reduce channel stability, which in turn can require costly artificial means to control channel migration or erosion. Reductions in surface flow can result in negative changes to water quality, i.e., increased temperature, reduced oxygen, and algal blooms. A reduction in surface flow can negatively impact the quality of riverine habitat by allowing non-native invasive species, i.e., tamarisk, which requires costly and repeated efforts to eradicate. All these negative impacts from a reduction in surface water can reduce recreational uses of river and wildlife habitats such as parks, wildlife areas and fisheries. A reduction in the quality and quantity of a recreation area can in turn result in an economic impact to the local economy as a result of fewer users and visitors to the area. The following is a discussion on the measures proposed to mitigate the impacts of streamflow depletion from water transfers.

A. The WaterFix Project as well as the 10-Year BOR/SLDMWA Transfer Program assert that the impacts to surface water "*in the current year*" from groundwater substitution transfers can be mitigated by holding back 12% of the transfer volume for later release into the impacted rivers (Appendix 5C of the November 2013 DEIR/EIS, Section 5C.11 on page 5C-23; see Mitigation Measures WS-1 and GW-1; and the October 2013 *Draft Technical Information for Preparing Water Transfer Proposals* in the 10-Year BOR/SLDMWA Transfer Program DEIS/EIR). I should be noted that the Final EIS/EIR for the 10-Year BOR/SLDMWA Transfer Program uses a streamflow depletion factor (SDF) of 13% as part of mitigation measure WS-1 that accounts for the potential water supply impacts to the CVP and SWP (Section 3.1.4.1 on page 3.1-44 in the Final EIR, March 2015). The 12-13% SDF is the default mitigation unless available monitoring data analyzed by Project Agencies demonstrate a more appropriate value. The 10-Year BOR/SLDMWA Transfer Program relies on mitigation measure GW-1 to ensure flows in the river aren't impacted. For additional comments on the use of a 12-13% SDF and mitigation measures WS-1 and GW-1, see my comment nos. 1, 2, 3, 5, 6, 15, 16, 18 21, and 22 in AquAlliance Exhibit 29). The WaterFix Program reliance on a one-value-fits-all 12% *"correction factor"* to mitigate streamflow depletion in only the *"current year"* doesn't agree with the science of stream flow depletion and other documents submitted in support of groundwater substitution transfers.

B. The effects on groundwater levels and stream flow from groundwater substitution transfer pumping were documented in a technical memorandum by CH2MHill (2010) that presented the results of a SACFEM groundwater model simulations of the transfers using the well distribution associated with the 2009 Drought Water Bank Program. Results of the stream depletion simulations were presented in graphs for three groundwater substitution transfer periods, 1976, 1987 and 1994. AquAlliance Exhibit 21 presents four graphs of the streamflow impacts from the simulated extraction of 82,000 AF in 1976 by pumping for groundwater substitution transfer. Graphs (a) to (c) show streamflow depletion for various scenarios at times after the start of pumping that extend to 2004. These graphs show that streamflow depletion peaks shortly after pumping starts and gradually decays following the cessation of pumping. Graph (d) gives the cumulative streamflow depletion as a percentage of the total volume (yield) of the transfer pumping. I have identified on graph (d) several points on the curve along the top of the shaded area and matched the percent depletion with the time since the start of pumping. One point of the curve that is particularly important is the time of 2.4 years when depletion is 28%. That point is equivalent to the stream depletion factor of Jenkins (1968), and can be used to compare the 1976 simulation to ideal stream depletion curves.

C. AquAlliance Exhibit 22 is a graph showing two ideal response curves for streamflow depletion (Miller and Durnford, 2005), and a third dashed curve showing the points taken from graph (d) in AquAlliance Exhibit 21. On the logarithmic x-axis of the graph, the time since pumping started is divided by the Jenkin's stream depletion factor, SDF, which produces a unitless value because the unit of the Jenkin's SDF is time. Note that the Jenkin's SDF is not the same as the BOR's SDF. Jenkin's SDF is equal to the square of the distance between the pumping well and the water body divided by the aquifer diffusivity (aquifer transmissivity/aquifer storage coefficient). Therefore the value of 1 on the x-axis is when the duration of pumping equals the Jenkin's SDF time. The y-axis is a percent of either the total pumping volume or the maximum pumping rate. The upper solid curve, equation 1, gives the streamflow depletion rate as a percentage of the maximum pumping rate. The lower solid curve, equation 2, gives the streamflow depletion volume as a percentage of the total volume pumped. It should be remembered that although these curves express the rate of streamflow depletion, that depletion is the recharge that allows for the recovery of the groundwater system from the pumping extractions. These ideal response curves for streamflow depletion have some interesting properties:

a. At an x-value of 1, where the time since pumping equals the value of the Jenkin's SDF, the cumulative volume of streamflow depletion is equal to 28% of the total volume pumped. This is the reason that I determined the time at 28% depletion in graph (d) in AquAlliance Exhibit 21.
b. At the same x-value of 1, the instantaneous rate of streamflow depletion is 48% of the maximum pumping rate.
c. The time that it takes from the start of pumping for the streamflow depletion rate, or aquifer recovery rate, to equal 95% is approximately 127 times the value of Jenkin's SDF. This is an observation that Wallace and others (1990) made in a paper on stream depletion by cyclic pumping wells.

D. The third curve on AquAlliance Exhibit 22 is a dashed line that goes through the five points identified by the time since the start of pumping divided by an SDF of 2.4 years (x-axis) and percentage depletion values (y-axis) identified in graph (d) in AquAlliance Exhibit 21. The extension of the dashed curve beyond the 60% depletion values is interpreted. This dashed line is a streamflow depletion response curve for the 1976 simulated groundwater substitution transfer pumping event. There are several important features of this simulated response curve.

a. The curve deviates from the ideal response curves as would be expected because the aquifer system is layered, is likely anisotropic, and represents the combined streamflow depletion from a number of wells, which likely don't all have the same Jenkin's SDF value.
b. At the time of 4 months after the start of pumping, the first point on the curve, the peak rate of streamflow depletion is approximately 10 percent of the maximum pumping rate.
c. At approximately 25 years after the start of pumping, the volume of streamflow depletion is approximately 60% of the total volume pumped. The time to achieve 60% depletion for the ideal curve is

approximately 13 years (5.5 x 2.4 years), approximately half the time it takes for the 1976 simulation.

d. At the time when the ideal response curves reach 95% depletion, the 1976 simulation is only at approximately 82%. The actual time it takes to reach 95% recovery on the ideal response curves for a well with a Jenkin's SDF equal to 2.4 years is approximately 300 years (127 x SDF of 2.4 years = 305 years). For the 1976 simulation, the time to 95% recovery is significantly greater.

The WaterFix Project qualifies the 12% streamflow depletion correction factor with the phrase "*in the current year.*" There's no discussion of a correction factor for the ongoing streamflow depletion; Jenkin's called this "*residual depletion.*" The residual depletion from a pumping event will be added to the depletion from the next pumping event. If pumping events continue for a number of years the summation of the streamflow depletion from the current year's pumping with the past residual depletions will eventually peak as the earliest pumping event's residual depletions decay. Wallace and others (1990) discussed the issue of streamflow depletion from cyclic pumping and provided tables that allow for the estimation of the peak stream flow depletion rate from ongoing cyclic pumping events.

E. AquAlliance Exhibit 23 is a graphic example of the impacts of cyclic pumping on streamflow depletion. AquAlliance Exhibit 23 is a simulation of 15 years of groundwater pumping by a group of wells, and the resulting streamflow depletion (Bredehoeft, 2011). The upper graph shows the streamflow depletion oscillating with each pumping event, but the maximum depletion rate decreases with each pumping cycle. The cumulative impact on streamflow depletion from cyclic pumping can be significant. The fact that neither the WaterFix Project nor the 10-Year BOR/SLDMWA Transfer programs provide for a streamflow depletion correction factor for only "*the current year*" without addressing the cumulative impacts of cyclic pumping means the "*correction factor*" is inadequate by design, if not value.

It should be noted that the impacts of cyclic pumping on streamflow depletion are occurring with the pumping of all wells in the Sacramento Valley, and elsewhere. The work by Wallace and others (1990) shows that with repeated cycles of pumping, the long-term cumulative streamflow depletion rate approaches the maximum depletion rate. Thus with repeated pumping events the streamflow depletion rate for one event is nearly equal to the total pumping rate even for short periods of pumping. This fact is likely the reason that in the long-term the decrease in river and stream accretion shown in AquAlliance Exhibit 18 is approximately equal to, but opposite in sign, to the long-term groundwater pumping volume. The cumulative effect of cyclic pumping can build until the long-term average streamflow depletion rate nearly matches the total pumping rate.

F. The June 2015 Draft Environmental Impact Report (DEIR) for the Supplemental Water Supply Project by the Glen-Colusa Irrigation District (GCID-SWSP) provides an example of disagreement between the estimated streamflow depletion and the WaterFix Project's and the 10-Year BOR/SLDMWA Transfer Program's default 12-13% streamflow depletion correction factor.

The proposed GCID Supplemental Water Supply Project calls for installation and operation of five new GCID groundwater production wells along with continued operation of five existing groundwater wells. The proposed project wells are located in the eastern portion of Glenn County along or near GCID's main service canal. AquAlliance Exhibit 24 shows the locations of the wells along with the simulated outer impact boundary overlain on DWR's Domestic Well Count Distribution map (see AquAlliance Exhibit 19). Note that the GCID-SWSP pumping impact area occurs in the same general area between the groundwater depressions in the northern portions of Glenn and Butte counties as with the 10-Year BOR/SLDMWA Transfer Program's simulations (see AquAlliance Exhibits 10, 11 and 12).

The GCID-SWSP DEIR analyzed the impacts of pumping each well at a rate of approximately 2,500 gallons per minute (gpm) with a maximum cumulative total annual pumping volume of 28,500 acre-feet per year (AFY). The DEIR evaluated a number of potential environmental impacts from groundwater pumping of the ten GCID production wells from 1970 to 2010, 41 years, using the groundwater model SACFEM2013. The GCID-SWSP DEIR provided Table 3-6, which summarized the simulated streamflow depletions from cyclic pumping of these 10 wells. AquAlliance Exhibit 25 is a modification of Table 3-6, which provides additional information on the rate of streamflow depletion relative to the pumping rate and volume. My Table 3-6 also provides the number of years to the maximum streamflow depletion rate assuming 6 years of cyclic pumping dates given in GCID-SWSP Table 3-3 started in February 1987. The results of the simulation of streamflow depletion for GCID's Supplemental Water Supply project show that:

a. The maximum rate of streamflow depletion, third column from right, exceeds the default 12-13% correction factor for three of the water bodies. Although the Main Canal isn't a navigable water body, it does function like a natural conveyance structure so the results can be indicative of a river with a similar distance to the wells.
b. The 41-year average streamflow depletion rate, right hand column, is nearly equal to or exceeds the default 12-13% correction factor for three of the water bodies.
c. The time to the maximum streamflow depletion, fifth column from the right, is greater than one year, which conflicts with the default 12-13% correction factor assumption of being applicable only to the *"current year."*

d. The time to maximum streamflow depletion increases while the rate of depletion decreases, third column versus fifth column. This is consistent with the concept that the square of the distance between the well and the surface water body has a significant influence on the rate and duration of streamflow depletion.
e. The 41-year average rate of streamflow depletion is approximately 68.5% of the time-weighted average for pumping for 16 years at 28,600 cfs per year, a time period used in the simulation. This 68.5% 41-year streamflow depletion average greatly exceeds the maximum averages for a 6-year simulation, which is consistent with the cumulative impacts from cyclic pumping. That is, the more years of cyclic pumping, the higher the peak streamflow depletion rate.

My testimony on the impacts from groundwater substitution pumping and crop idling transfers shows from the potential impacts to stream flows and the duration of groundwater recharge from increasing availability of water transfers that construction of the WaterFix Project tunnels will likely cause will have additional and potentially significant impacts on the surface water and groundwater resources in the Sacramento Valley. My testimony on the groundwater pumping simulations used to evaluate the potential impacts on surface waters from groundwater substitution transfers or the increase in the number of GCID production wells shows that the mitigation measure default 12-13% *"current year"* correction factor doesn't account for: (1) long-term residual streamflow depletion, (2) the increases in *"current year"* depletion caused by addition losses from past cyclic pumping events, (3) the impact that the distance between a well and a surface water body has on the rate and duration of depletion and recharge, and (4) the time needed to achieve recovery from a pumping event (95% recovery = 127 x SDF). Given the number and significance of these deficiencies in the WaterFix Projects's environmental analysis on the potential impacts from the groundwater substitution and crop idling transfers of water from the Sacramento Valley, the WaterFix Project DEIR/EIS and RDEIR/SDEIS should be considered inadequate. For additional information and expanded comments on the potential impacts from groundwater substitution transfer pumping see AquAlliance Exhibits 29, 30, 31, 32, and 33.

4. Potential Impact to the Delta Groundwater System from Groundwater and Crop Idling Water Transfers

The Central Valley of California is large alluvial basin with the Sacramento River Basin watershed on the north and the San Joaquin River Basin watershed on the south. These river systems drain towards each other to the Delta. Groundwater models of the Central Valley have been developed by both the U.S. Geological Survey (CVHM, Faunt, ed., 2009) and California Department of Water Resources (C2VSim, Brush and others, 2013). Both of these models break the Central Valley into twenty-one (21) subregions. The subregions in the Sacramento Valley are numbered 1 to 7, subregion 8 consists of a group of Eastside Streams, and the Delta is subregion 9. The groundwater model computations keep track of the subsurface flow between these subregions and the reports for the C2VSim model provide tabulated and graphic information on this interbasin flow (Brush, 2013a and 2013b).

A. AquAlliance Exhibit 26 is a figure that shows the simulated average annual subsurface flow between the Central Valley subregions for the decade of 1960-1969 (Figure 81B in Brush, 2013a). This figure shows that groundwater in the Delta, subregion 9, was flowing towards the Eastern Streams area, subregion 8, at a rate of 56,000 AFY per year, while only minimal groundwater flowed towards the San Joaquin Basin. In the 1960-1969 decade Subregion 8 received annually 65,000 AF groundwater flow from subregion 11, a part of the San Joaquin Basin, and discharged annually 1,000 AF to subregion 7, a part of the Sacramento Valley Basin. The C2VSim groundwater model report also provides the simulation results showing groundwater flow between subregions in the 2000-2009 decade and the interbasin flows between the Delta, Eastern Stream and Sacramento Valley have changed significantly.

B. AquAlliance Exhibit 27 is a figure that shows recent simulated average annual subsurface flow between the Central Valley subregions for the decade of 2000-2009 (Figure 81C in Brush, 2013a). This figure shows that groundwater in the Delta, subregion 9, is flowing towards the Eastern Streams area, subregion 8, at 112,000 AFY per year, doubling the annual loss of groundwater from the Delta in the 1960-1969 decade. In addition, the Delta is now losing 25,000 AFY to the San Joaquin Basin, which received only minimal flow in the 1960-1969 decade. In the 2000-2009 decade, groundwater flow from subregion 8 to subregion 7 has increased to 17,000 AFY. This is an increase of 1600% over the rate of 1960-1969 decade. It should be noted that the recent net rate of groundwater flow out of the Delta, a combined loss of 133,000 AFY, is greater than any of the interbasin flows in the Sacramento Valley, approximately 2.8 times the next highest interbasin flow between subregion 3 and subregion 4 at 48 AFY.

C. AquAlliance Exhibit 28 is a Spring 2016 groundwater contour map for the area surrounding the Delta. This map is taken DWR's interactive groundwater web site.[2] In addition to the contours, the map also shows the general locations of three WaterFix Project's intakes of Alternative 4. It shows that the direction of groundwater flow on the eastern side of the Delta is towards two areas. The larger and deeper area is in southern Sacramento and northern San Joaquin counties. While the shallower depression occurs east of the city of Sacramento. Both of these depressions appear to lie within the Eastern Stream subregion 8.

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[2] DWR's interactive groundwater web site: https://gis.water.ca.gov/app/gicima/

D. Water purveyors in the Sacramento Valley and northern portion of subregion 8 are participating in groundwater substitution transfers in the 10-Year BOR/SLDMWA Transfer Program (see Table 2.5 in the Final EIS/EIR).[3] It could be assumed that some of these water purveyors will participate in the WaterFix Project water transfers. These purveyors are proposing to transfer an annual combined maximum of 62,000 AFY using groundwater substitutions from the American River and the Yuba River areas, subregions 8 and 7, respectively. Given that the C2VSim simulations show that the greatest volume of interbasin groundwater flow out of the Delta currently goes eastward into the Eastern Stream subregion 8 and that subregion 8 then flows into subregion 7, there is a potential for increased loss to the groundwater system in the Delta from the Sacramento Valley groundwater substitution transfers. This magnitude of this potential impact to the Delta hasn't been evaluated in either the 10-Year BOR/SLDMWA Transfer Program or the WaterFix Project. An evaluation of this potential impact should be done along with mitigation measures to ensure that the water transfers don't create an additionsl impact to the groundwater system of the Delta. For additional information and expanded comments on the potential impacts from groundwater substitution transfer pumping see AquAlliance Exhibits 29, 30, 31, 32, and 33.

E. The long-term impacts on groundwater levels and groundwater storage in the Sacramento Valley from the WaterFix Project water transfers may result in increased groundwater flow away from the Delta due to increased groundwater substitution pumping by water agencies in greater Sacramento area or from increased northward interbasin flow due to water transfer pumping by water agencies in the Sacramento Valley. Increased flow of groundwater away from the Delta may cause saline water to move eastward to fill the void. Increases in groundwater salinity will negatively impact Delta groundwater users by reducing the availability of fresh water suitable for crops and may eventually require development of a costly groundwater injection system to create a hydraulic barrier as is often done in other coastal areas. The potential impact the proposed groundwater substitution and crop idling water transfers on the groundwater system in the Delta hasn't been adequately evaluated by either the WaterFix Project or the 10-Year BOR/SLDMWA Transfer Program. The issue decreasing the amount of fresh water in the groundwater system of the Delta from the water transfers in the Sacramento Valley should be fully evaluated in the WaterFix Project's environment analysis and monitoring and mitigation measures should be provided.

Conclusions

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[3] BOR water transfer web site: http://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=21161

Based on my testimony given above I have the following conclusions:

1. The groundwater basins of the Sacramento Valley have areas where groundwater levels are depressed and the basins have medium to high CASGEM priority ranks. Since 2004, the changes in the elevations of shallow, intermediate and deep aquifer zones in Butte, Colusa, Glenn Tehama-south and Basin Wide have decreased. The maximum change in groundwater levels from 2004 to 2014 ranges from -15.5 feet to -79.7 feet, average 10-year changes range from -5.3 feet to -40.5 feet, and the annual average change ranged from -0.84 feet to -4.05 feet. Recent groundwater levels from 2014 to 2015 have generally continued to decline with rates of decline in most of the basin exceeding the 2004-2014 long-term averages. The ongoing decrease in groundwater levels in most of the Sacramento Valley indicates that these basins are not "full" and that the proposed transfer of water using groundwater substitution or crop idling will likely have a significant impact on water users in the valley.
2. Simulations of Sacramento Valley groundwater basin changes since the 1920s shows that the long-term rate of decline in stream and river accretion is approximately the same as the long-term increase in groundwater pumping.
3. The current, 2000 to 2009, annual rate of change in the Sacramento Valley groundwater basin storage based on DWR's C2VSim simulations is approximately minus 303,000 AFY, which is approximately a minus 140,000 AFY greater than the simulated long-term average annual rate of change of minus 163,417 AFY. The groundwater substitution and crop idling water transfers proposed by the WaterFix Project, up to 907,000 AFY, or the 10-Year BOR/SLDMWA Transfer Program, up to 467,857 AFY could cause a annual decrease in groundwater storage equal to or exceeding the current 303,000 AFY annual average. Doubling the annual loss in groundwater storage should be considered a potentially significant impact and the WaterFix Project's environmental analysis should address the issue, analyze the potential impacts and provide monitoring and mitigation measures.
4. The medium and high CASGEM priority ranking for most of the Sacramento Valley indicates that additional groundwater management is needed for groundwater sustainability. These basins are still in the planning phases for SGMA. Development of sustainable groundwater management plans won't occur for several years, and the demonstration that these plans are effective won't occur for a number of years. A determination that up to 907,000 AFY of water transfers using groundwater substitution (400,000 AFY) and crop idling (507,000 AFY) can occur without significantly impacting groundwater sustainability is premature given that the SGMA required groundwater sustainability plans and the required sustainability actions haven't been created. The issue of groundwater sustainability should be part of the WaterFix Project's environment analysis and monitoring and mitigation measures should be provided.
5. The use of the default 12-13% *"current year"* correction factor to mitigate the impacts from groundwater substitution transfers doesn't account for: (1) long-

AquAlliance Exhibit 5

term streamflow depletion; (2) the increases in *"current year"* depletion caused by additional losses from past cyclic pumping events; (3) the impact that distance between a well and a surface water body has on the rate and duration of depletion and groundwater recharge; and (4) the time needed to achieve recovery from a pumping event (95% recovery = 127 x SDF). Therefore, the default 12-13% correction factor won't protect the beneficial uses of surface water resources and groundwater dependent ecosystems, or maintain groundwater levels. Groundwater and surface water users in Sacramento Valley groundwater basins that don't participate in groundwater substitution or crop idling water transfers will likely be impacted. Impacts such as a reduction in the ability to divert surface water, and increased costs for maintaining or replacing wells should be anticipated. The issue of the applicability of the 12-13% correction factor should be fully evaluated in the WaterFix Project's environment analysis with monitoring and mitigation measures provided to ensure whatever correction factor is use will properly mitigate for streamflow depletion and prevent significant impacts to landowners and the environment.

6. The long-term impacts on groundwater levels and groundwater storage in the Sacramento Valley from the WaterFix Project water transfers may result in increased groundwater flow away from the Delta due to increased groundwater substitution pumping. Increased flow of groundwater away from the Delta may cause saline water to move eastward to fill the void. Increases in groundwater salinity will negatively impact Delta groundwater users by reducing the availability of fresh water suitable for crops and may eventually require development of a costly groundwater injection system to create a hydraulic barrier as is often done in other coastal areas. The issue decreasing the amount of fresh water in the groundwater system of the Delta from the water transfers in the Sacramento Valley should be fully evaluated in the WaterFix Project's environment analysis with mitigation measures and monitoring requirements provided.

Executed on 29 of August, 2016 in Fair Oaks, California

Kit H. Custis

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List of AquAlliance Exhibits

AquAlliance Exhibit 6. Curriculum vitae of Kit H. Custis

AquAlliance Exhibit 7. Powerpoint presentation of Kit H. Custis Testimony in pdf file format

AquAlliance Exhibit 8. Map of Sacramento Valley CASGEM Priority Basins, downloaded August 28, 2016, with 10-Year BOR/SLDMWA Transfer Program wells.

AquAlliance Exhibit 9. Table of Changes in Groundwater Levels in Sacramento Valley (2004 to 2015), from Exhibit 1 in AquAlliance Exhibit 33.

AquAlliance Exhibit 10. Composite map of DWR's Northern Sacramento Valley Change in Groundwater Elevation Map Spring 2004 to Spring 2014, Shallow Aquifer Zone, Plate 1S-B, April 2014, and Figure 3-3-29 Simulated Change in Water Table Elevations from Draft EIS/EIR of 10-Year BOR/SLDMWA Transfer Program, date 2014, from Exhibit 3.1 in AquAlliance Exhibit 29.

AquAlliance Exhibit 11. Composite map of DWR's Northern Sacramento Valley Change in Groundwater Elevation Map Spring 2004 to Spring 2014, Intermediate Aquifer Zone, Plate 1I-B, April 2014, and Figure 3-3-29 Simulated Change in Water Table Elevations from Draft EIS/EIR of 10-Year BOR/SLDMWA Transfer Program, date 2014, from Exhibit 3.2 in AquAlliance Exhibit 29.

AquAlliance Exhibit 12. Composite map of DWR's Northern Sacramento Valley Change in Groundwater Elevation Map Spring 2004 to Spring 2014, Deep Aquifer Zone, Plate 1D-B, April 2014, and Figure 3-3-29 Simulated Change in Water Table Elevations from Draft EIS/EIR of 10-Year BOR/SLDMWA Transfer Program, date 20014, from Exhibit 3.3 in AquAlliance Exhibit 29.

AquAlliance Exhibit 13. Table of Average Annual Central Valley Basin Flows from the C2Vsim model for Water Years 1922-2009, from Table 10 in Brush, C.F., Dogrul, E.C., and Kadir, T.N., 2013a.

AquAlliance Exhibit 14. Table of Average Annual Central Valley Basin Flows from the C2Vsim model for Water Years 2000-2009, from Table 13 in Brush, C.F., Dogrul, E.C., and Kadir, T.N., 2013a.

AquAlliance Exhibit 15. Summary Tables of Sacramento Valley Historical Water Balance from C2Vsim R374, Tables 3-6, 3-7 and 3-8 from Northern California Water Association, 2014.

AquAlliance Exhibit 16. Figures 3-19, 3-20, 3-26, and 3-27, showing historical values of estimated deep percolation and estimated annual diversions in the Sacramento Valley, from Northern California Water Association, 2014.

AquAlliance Exhibit 17. Figures 3-22, 3-23, 3-24, and 3-25, showing historical values of estimated annual groundwater pumping and estimated annual accretions in the Sacramento Valley, from Northern California Water Association, 2014.

AquAlliance Exhibit 18. Figure Comparison of Ground Water Pumping and Accretion in Sacramento Valley 1920's to 2009, from Exhibit 10.7 in AquAlliance Exhibit 29.

AquAlliance Exhibit 19. Composite map of domestic wells, < 150 ft. bgs. depth summary maps for northern Sacramento Valley (DWR, 2014a) and traced shallow zone, well depths < 200 ft. bgs., 2004 to 2014 changes in groundwater elevation (DWR, 2014b) from Exhibit 2.1 in AquAlliance Exhibit 29.

AquAlliance Exhibit 20. Table summarizing the range of the number of wells in that lie within the spring 2004 to spring 2014 shallow aquifer zone drawdown contours in northern Sacramento Valley from DWR, 2014a and DWR, 2014b, from Exhibit 7.1 in AquAlliance Exhibit 29.

AquAlliance Exhibit 21. Figure of Stream Impacts From 1976 Groundwater Substitution Transfer Pumping, Figure 4 from CH2MHill, 2010.

AquAlliance Exhibit 22. Figure showing ideal response curves for depletion rate and volume, modified after Figure 1 in Miller and Durnford, 2005, from Exhibit 11.1 in AquAlliance Exhibit 29.

AquAlliance Exhibit 23. Figure showing stream depletion caused by an ensemble of wells, from Figure 6 in Bredehoft, 2011.

AquAlliance Exhibit 24. GCID Wells and outer impact boundary with DWR Domestic Well Depth, Summary Map, January 2014, from Exhibit 30 in AquAlliance Exhibit 30.

AquAlliance Exhibit 25. Modified Table of Glenn-Colusa Irrigation District DEIR Table 3-6, Calculations of Stream Depletion as Percentage of Total Pumping Rate, Table 3-6 taken from the Supplemental Water Supply Project DEIR by the Glen-Colusa Irrigation District, June 2015, from Exhibit 33A in AquAlliance Exhibit 31.

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AquAlliance Exhibit 26. Figure showing simulated average annual subsurface flows between groundwater subregions of the Central Valley, 1960-1969, from Brush, C.F., Dogrul, E.C., and Kadir, T.N., 2013a.

AquAlliance Exhibit 27. Figure showing simulated average annual subsurface flows between groundwater subregions of the Central Valley, 2000-1969, from Brush, C.F., Dogrul, E.C., and Kadir, T.N., 2013a.

AquAlliance Exhibit 28. Spring 2016 Groundwater Contours, Sacramento, San Joaquin and Yolo Counties, from Exhibit 6C in AquAlliance Exhibit 33.

AquAlliance Exhibit 29. Letter from Kit H. Custis to Barbara Valmis, dated November 24, 2014, *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*, 48 pages, 118 total exhibits (exhibits number is groups numbered from 1 to 12).

AquAlliance Exhibit 30. Letter from Kit H. Custis to Barbara Valmis, dated April 8, 2015, *Comments on the U.S. Bureau of Reclamation and San Luis & Delta-Mendota Water Authority March 2015 Final Long-Term Water Transfer EIS/EIR response to my comments on the DRAFT EIS/EIR, dated September 2014*, 13 pages.

AquAlliance Exhibit 31. Letter from Kit H. Custis to Barbara Valmis, dated July 29, 2015, *Comments and Recommendations on Draft Environmental Impact Report for Glenn Colusa Irrigation District's Groundwater Supplemental Supply Project, June 2015*, 23 pages, 55 total exhibits (exhibits number is groups numbered from 1 to 31).

AquAlliance Exhibit 32. Letter from Kit H. Custis to Barbara Valmis, dated August 17, 2015, *Additional Comments and Recommendations on Draft Environmental Impact Report for Glenn Colusa Irrigation District's Groundwater Supplemental Supply Project, June 2015*,6 pages, 7 exhibits.

AquAlliance Exhibit 33. Letter from Kit H. Custis to Barbara Valmis, dated August 25, 2016, Comments and Recommendations on the California Department of Water Resources and U.S. Bureau of Reclamation California WaterFix Project Joint Petition to Add Three New Points of Diversion, 15 pages, 19 exhibits.