NORTHERN & CENTRAL DELTA-MENDOTA

Final Draft
Groundwater Sustainability Plan

For the Northern and Central Delta-Mendota Regions

November 2019

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Appendix D
Water Budget Model Documentation

Groundwater Sustainability Plan for the Northern and Central Delta-Mendota Regions

Appendix D

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NORTHERN & CENTRAL DELTA-MENDOTA REGION GSP WATER BUDGETS DEVELOPMENT

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1. INTRODUCTION

This technical memorandum (TM) describes the required historic, current and projected water budgets for the Northern & Central Delta-Mendota Region (N-C DM) Groundwater Sustainability Plan (GSP) and is intended to document the development process, assumptions, and data sources used to create the GSP water budget spreadsheet (analytical) model. The methodologies used to develop the GSP water budgets were selected after consideration of multiple options. A numerical groundwater flow model (CVHM2) was original considered for use in developing the water budgets, but due to calibration limitations and a lack of time in which to correct the shortfalls (e.g. improve calibration), a spreadsheet model was developed to meet the GSP Emergency Regulations requirement for use of a model to support GSP development (Section 352.4. Data and Reporting Standards and Section 354.18. Water Budget of the Emergency Regulations).

The N-C DM spreadsheet model was developed in order to quantify the following:

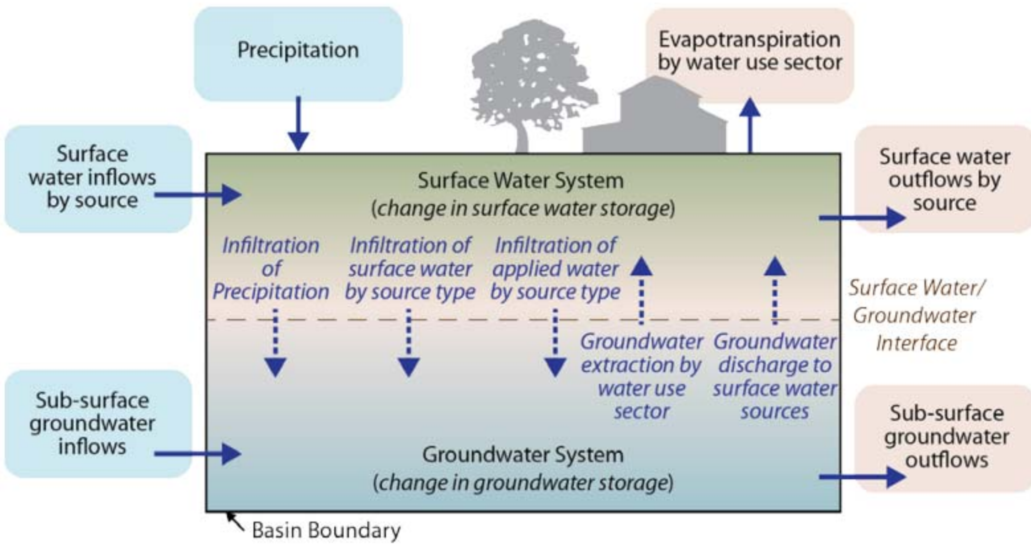
- Total surface water entering and leaving the Northern & Central Delta-Mendota Region GSP Plan area (Plan area) by water source type
- Inflow to the groundwater system by water source type
- Outflows from the groundwater system by water use sector
- Change in annual volume of groundwater in storage (by principal aquifer)
- Overdraft conditions compared to a period of years with average water supply conditions
- Water year types associated with the annual water budgets
- Sustainable yield (by principal aquifer) for the Delta-Mendota Subbasin

The development of the N-C DM spreadsheet model is described in detail herein.

2. WATER BUDGETS PURPOSE AND OBJECTIVES

Water budgets were developed as an accounting and assessment tool to evaluate the volume of water entering and leaving the GSP Plan area through either the surface or the subsurface. Water enters and leaves naturally, such as through precipitation and streamflow, and through human activities, such as groundwater pumping and recharge from irrigation. Source: California Department of Water Resources, 2016

Figure 2-1 presents a simplified vertical slice through the land surface and underlying aquifer system to show the water budget components used in this TM.



Source: California Department of Water Resources, 2016[1]

Figure 2-1: Generalized Water Budget Diagram

Water budgets were developed for historic, current, and projected conditions as they relate to regional hydrology. Water demand, water supply, land use, population, climate change (CC), groundwater and surface water interaction, and subsurface groundwater flow were incorporated directly or indirectly in the water budget tables. The water budgets were then used in development of the GSP to assess potential future shortfalls or overdraft conditions, and to identify the number and types of projects and/or management actions that should be implemented to address future potentially adverse conditions.

Water budgets can be developed at different spatial scales. When evaluating irrigation techniques, water budgets may be developed for the root zone by estimating the inflows and outflows of water from the upper portion of the soil accessible to plants (otherwise referred to a land surface system). In a groundwater study, water budgets may be developed for groundwater flow in the subsurface (otherwise referred to a groundwater system). Water budgets discussed in this TM were developed for the combined land surface and groundwater systems in the GSP Plan area.

Water budgets can also be developed at various temporal scales. Daily water budgets may be used to demonstrate how evaporation and transpiration increase during the day and decrease at night. Monthly water budgets may be used to demonstrate how groundwater pumping increases in dry, hot summer months and decreases in the cool, wet winter months. Water budgets discussed in this TM are annual, representing a full water year (i.e., October of the previous year to September of the current year) and cover the SGMA-required 10-year historic water budget period and 50+ year future projected water budget period.

3. WATER BUDGETS DEVELOPMENT

Water budgets developed for the GSP Plan area were based on a hybrid combination of a numerical groundwater flow model and an analytical spreadsheet model. The numerical model, called CVHM2, was developed by the United States Geological Survey (USGS) and was used during the early stages of water budgets development. However, following

[1] California Department of Water Resources (DWR). December 2016. *Best Management Practices for the Sustainable Management of Groundwater – Water Budget*. https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf. Accessed on November 28, 2018.

an evaluation of the accuracy of the model relative to regional data for the GSP Plan area, the Groundwater Sustainability Agencies (GSAs) of the Northern and Central Delta-Mendota Regions decided alternatively to develop a spreadsheet-based water budget that used key assumptions and datasets from CVHM2. Figure 3-1 shows the area that these water budgets encompass. Development of this hybrid model is described below.

3.1 Numerical Model

At the onset of GSP development, the Central Valley Hydrologic Model Version 2 (CVHM2) was considered as a candidate for developing the required water budgets for the GSP Plan area. The Central Valley Hydrologic Model (CVHM) Version 1 (released in 2009) was developed by the USGS to aid water managers in understanding how water moves through the aquifer system, predict water-supply scenarios, and address issues related to water competition. CVHM2 is intended to update certain aspects of CVHM, including updating the model to the newest version of the MODFLOW-OWHM Farm Process Package (FMP3) and improving representation of the Central Valley aquifer system through added local data sets.

The CVHM2 grid, with uniform one-square mile cell size, covers the entire Central Valley. It consists of 13 layers of varying thickness to simulate the stratigraphy of the Central Valley aquifers. The top 5 layers of CVHM2 account for the semi-confined upper aquifer; the next 3 layers model the Corcoran Clay layer, a regional aquitard in the Plan area that confines the lower aquifer. The bottom 5 layers of CVHM2 model the lower (sub-Corcoran) confined aquifer.

An evaluation of the calibration status of the July 2018 version of CVHM2 indicated that this version of CVHM2 was not adequately calibrated to the GSP Plan area. Additional groundwater pumping, surface water delivery, and canal seepage data from local entities was provided to USGS for further local calibration in July and August 2018. As of August 2019, the USGS continues with calibration of CVHM2 within the GSP Plan area. Due to differences in the USGS' anticipated timeline for the release of a calibrated CVHM2 and the SGMA-required timeline for development of this GSP, an alternative approach was selected to develop water budgets. Specifically, various aspects of the July 2018 version of CVHM2 was used for development of the final water budgets. The use of CVHM2 results in development of the water budget components is discussed in Chapters 0 and 5 of this TM.

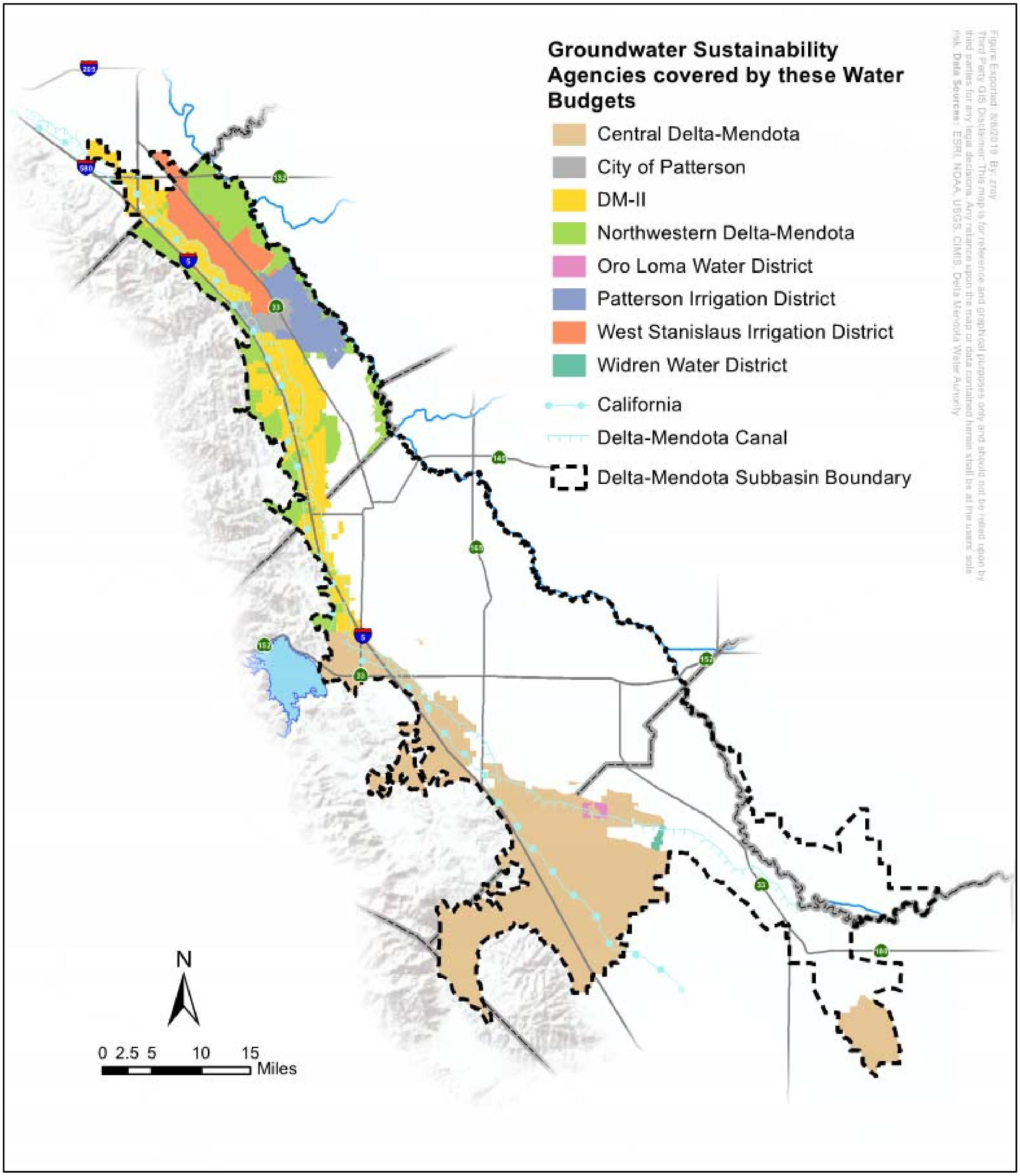


Figure 3-1: Areas Covered by Northern & Central Delta-Mendota Region GSP Water Budgets

3.2 Spreadsheet Model

The selected approach for development of water budgets for the N-C DM Region GSP Plan area is a hybrid approach that combines the use of local data, CVHM2 parameters, standard numerical calculations derived from peer-reviewed literature, and professional judgement. All water budgets presented are based on local land use, water supply, and groundwater observation data received from GSA member agencies, as well as data from publicly available sources including the California Irrigation Management Information System, the Cal Poly Irrigation Training & Research Center (ITRC), and the California Statewide Groundwater Elevation Monitoring Program (CASGEM). Flow data and patterns from CVHM2 were used where local data were unavailable. CVHM2 results were used to apportion runoff and deep percolation volumes, as well as for some surface water delivery and groundwater pumping volumes (again, where data were not otherwise available). Groundwater gradients, underflows, and annual changes in groundwater storage calculations are derived from available groundwater elevation data. Data related to projects and management actions were supplied by GSA member agencies (or project proponents) or derived from planning documents, such as Integrated Regional Water Management Plans (IRWMPs), General Plans and from local knowledge.

Five water budgets were developed for the N-C DM GSP. Due to the different time periods, spatial relationships, and agency operations required to represent the GSP Plan area, the water budgets are presented in eight tables. The water budgets are listed below.

- Historic Water Budget (Table 6-1 and Table 6-2)
- Current Water Budget (Table 6-1 and Table 6-2)
- Baseline Projected Water Budget (Table 6-3 and Table 6-4)
- Projected Water Budget with Climate Change Factors (Table 6-5 and Table 6-6)
- Projected Water Budget with Climate Change Factors and Projects & Management Actions (Table 6-7 and Table 6-8)

The water budget tables were prepared using two different methods, depending on the time period the budget is tabulating. Each method produced two water budget tables: a Land Surface Water Budget and a Groundwater Budget. These two tables represent different spatial portions of the basin.

Three different scenarios were considered for the projected water budgets. The same method was used for each of these water budgets which varied only by the application of the California Department of Water Resources (DWR)-provided climate change factors and the addition of impacts resulting from projected implementation of identified projects and management actions. The methods are discussed below and are summarized in Figure 3-2.

Water Budget Tabulation Methods

Two different methods were used to develop the water budgets using the same modelling tools. The historic and current water budgets were developed using a combination of actual data (for all flow terms except runoff and deep percolation) and assumptions derived from CVHM2 (specifically, the percentage of runoff and deep percolation). As the historic and current water budgets were calculated using the same methods, the results are presented in the same water budget table. The projected water budget was developed using projections and assumptions, and the assignment of historic hydrologic water year types to project future hydrology. Because of inherent differences in the assumptions used in each water budget (e.g. with or without climate change impacts; with or without applied projects and management actions), the three projected water budgets are presented in different tables but are calculated using the same methods.

Land Surface vs Groundwater Water Budgets

Each water budget is split into two parts or systems: a Land Surface Water Budget and a Groundwater Budget. The Land Surface Water Budget accounts for flows that interact with land surface and the root zone. The Groundwater Budget accounts for flows that interact with groundwater below the root zone. Flow terms are repeated between the two water budgets where the flows interact with (interact between) both the land surface and groundwater (such as with deep percolation).

In the land surface system, it is assumed that there is no long-term water storage so the inflows and the outflows for each year in the budget should be equal in magnitude. Differences between the calculated inflows and outflows in the Land Surface Water Budget are a result of inaccuracies in the estimation of flow terms and are presented in the Land Surface Water Budget as "Land Surface Water Budget Balance". The following formulas describe this calculated error.

In theory: $Inflow_{System} - Outflow_{System} = 0$

In reality: $Inflow_{Budget} - Outflow_{Budget} = Land\ Surface\ Water\ Budget\ Balance$

In the groundwater system, long-term water storage exists within the aquifers and the difference in inflows and outflows should be equal to the change in groundwater in storage. Annual changes in groundwater storage were calculated independent of the inflow and outflow accounting using hydrographs from wells around the Plan area. This independently-calculated change in groundwater storage is presented as a part of the Groundwater Budget. The difference between this independently-calculated change in storage (based on hydrographs) and the estimated (accounted) value is a result of inaccuracies in both the calculated change in groundwater storage and inaccuracies in inflow and outflow estimations. This difference is presented in the Groundwater Budget as "Groundwater Budget Balance". The following formulas describe this calculated error.

In theory: $Inflow_{System} - Outflow_{System} = Change\ In\ Storage_{System}$

In reality: $Inflow_{Budget} - Outflow_{Budget} = Change\ In\ Storage_{Budget} + Groundwater\ Budget\ Balance$

Agency-Level Sub-budgets

In addition to the above separations of budget tabulations (between the land surface and groundwater systems), each of the GSP Plan area water budgets were calculated using at least 27 different sub-budgets. These were required in order to organize and combine agency-supplied data. These sub-budgets were then combined into one budget to describe the GSP Plan area. These sub-budgets are not presented in this TM. The methods described in Chapters 0 and 5 apply to these sub-budgets as well as the combined GSP Plan area budgets presented in this TM.

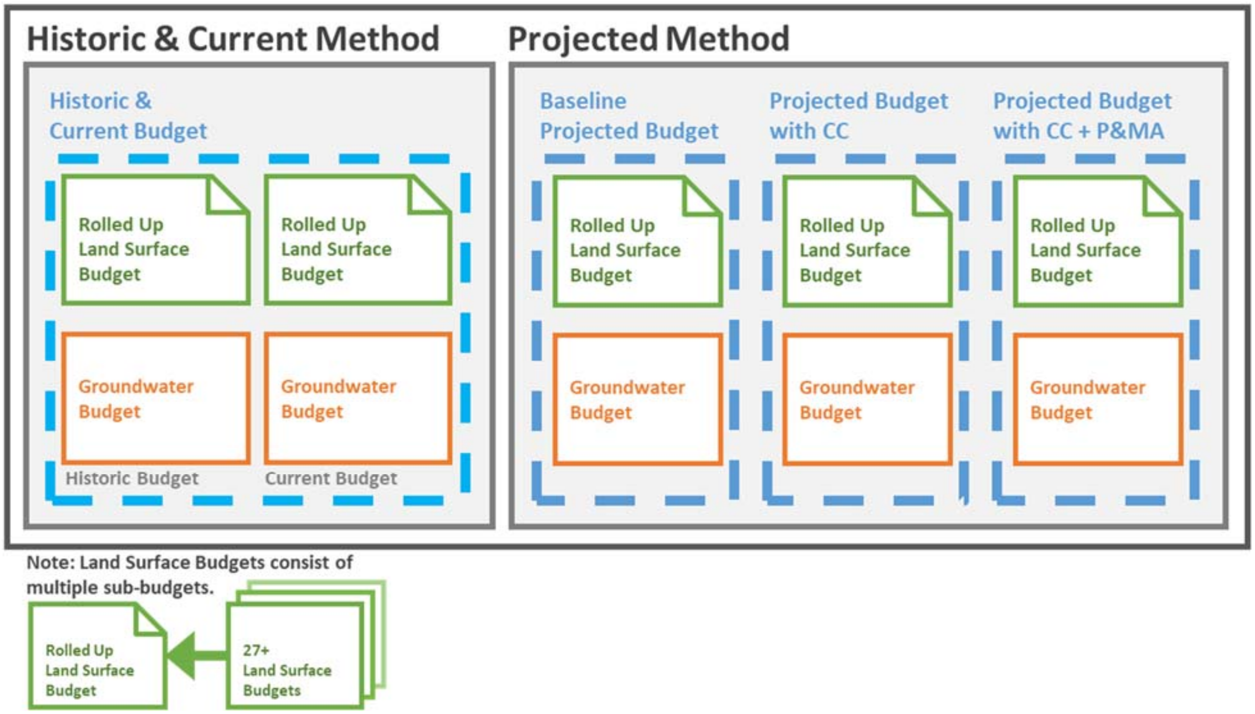


Figure 3-2: Water Budget Organization

The following sections describe the water budgets as described above. The historic water budget and current water budget are referred to collectively as the Historic & Current Water Budget. The Baseline Projected Water Budget, Projected Water Budget with Climate Change Factors (Projected Water Budget with CC), and Projected Water Budget with Climate Change Factors and Projects and Management Actions (Projected Water Budget with CC + P&MA) are referred to collectively as the Projected Water Budgets.

Historic & Current Water Budget data sources, assumptions, and methods are discussed separately from all of the Projected Water Budgets sources, assumptions, and methods. The Projected Water Budgets are related to each other with the Projected Water Budget with CC building on the Baseline Projected Water Budget and the Projected Water Budget with CC + P&MA building on the Projected Water Budget with CC. Because of this, many of the data sources, assumptions, and methods are identical between the three Projected Water Budgets. Additional and differing data sources, assumptions, and methods are described in Chapters 0 and 5.

4. HISTORIC & CURRENT WATER BUDGET

The Historic & Current Water Budget represents Water Year (WY) 2003-2013, where the historic period is WY 2003-2012 and the current year is WY 2013. As described in the N-C DM GSP, WY 2013 was selected as the current water budget year. While "current water budget conditions" are defined in the GSP Emergency Regulations §354.18(c)(1) as the year with "the most recent population, land use, and hydrologic conditions," WY 2015, WY 2016 and WY 2017 were not thought to be representative of the Delta-Mendota Subbasin under "normal" or "average" conditions. Response to the most recent drought began in WY 2014 with some initial fallowing of lands. By WY 2015 and WY 2016, which are both classified as dry years, more lands were fallowed throughout the Subbasin in response to multiple dry year conditions. Agricultural production was higher in WY 2017, compared to WY 2015 and WY 2016, but the delivery allocations from the Central Valley Project (CVP) came late in the season, so a considerable amount of land was still fallowed. By WY 2018, agricultural land production increased and was similar to conditions in WY 2013, however complete datasets were not yet available for use in the water budgets. Therefore, WY 2013 represents the most recent water year with a complete data set representing typical demands and supplies.

The selected historic and current water budget periods capture a range of both wet and dry conditions prior to the most recent drought. This allows for the Historic & Current Water Budgets to more accurately describe the baseline operations and current status of the GSP Plan area.

4.1 Data Sources, Assumptions, and Methods

Many of the flow categories volumes reported in the Historic & Current Water Budgets were directly recorded by the GSA member agencies. Other flow categories were calculated using a combination of publicly available data sets and peer-reviewed estimations. In addition to these data sets, runoff and deep percolation volumes still required an estimating approach in order to quantify these parameters. For these flow categories, CVHM2 results were analyzed, and used where appropriate to estimate the portion of flow attributed to each parameter. Table 3-1 describes the availability of recorded data for each water budget flow category.

Table 3-1: Flow Calculation Methods for Historic & Current Water Budget

Flow Category	Budget	Calculation Method
Surface Water Deliveries	Land Surface	Sum of recorded volumes
Pumping	Land Surface, Groundwater	Sum of recorded volumes
Tile Drainage	Land Surface, Groundwater	Sum of recorded volumes
Precipitation	Land Surface	Sum of recorded rates over the GSP Area
Runoff	Land Surface	Calculated portion of applied water resulting in runoff, using evaluated rates from CVHM2 results
Deep Percolation	Land Surface, Groundwater	Calculated portion of applied water resulting in deep percolation, using evaluated rates from CVHM2 results
Evapotranspiration	Land Surface	Sum of recorded rates over the GSP Plan area
Underflows	Groundwater	Sum of calculated rates at the subbasin boundary
Change in Storage	Groundwater	Sum of calculated volumes

Each of the methods and assumptions used to quantify the water budget flow categories in the Historic & Current Water Budgets are descried in more detail below.

Surface Water Deliveries

GSA member agencies provided delivery data as it was available for their service areas for each year in the Historic & Current Water Budgets. It was assumed that the data reported by the agencies described all of the surface water being applied within their service areas. Deliveries from the Central Valley Project, State Water Project, the San Joaquin River, and other local streams and rivers were included. If no data were available, CVHM2 model results were considered and used if the values were considered sufficiently accurate for the area. Accuracy of the CVHM2 model results was evaluated using professional judgement and local knowledge. The surface water deliveries volume reported in the Historic & Current Water Budgets is the sum of all agency delivery data and applicable CVHM2 results. CVHM2 results represent less than 1% of the total surface water delivery volumes reported in the Historic & Current Water Budgets.

Pumping

GSA member agencies provided groundwater pumping volumes as available for their service areas for each year in the Historic & Current Water Budgets. It was assumed that the data available to the agencies described all significant pumping occurring within their service areas. If no pumping data were available for an agency's service area, CVHM2 model results were considered. Accuracy of the CVHM2 model results was evaluated using professional judgement and local knowledge. The groundwater pumping volume reported in the Historic & Current Water Budgets is the sum of the water removed from the aquifer through pumping. CVHM2 results represent less than 10% of the total pumping volumes reported in the Historic & Current Water Budgets.

Tile Drainage

GSA member agencies provided annual tile drainage volumes for each year in the Historic & Current Water Budgets as available and applicable for their service areas. It was assumed that the data available to the agencies described all of the significant tile drainage occurring within their service areas. The tile drainage volume reported is the sum of the water removed from the groundwater aquifer through drains in the upper aquifer. If no data were available for an agency's service area, it was assumed no tile drainage occurred in that area.

Precipitation

Seasonal data were collected from various California Irrigation Management Information System (CIMIS) Stations in the GSP Plan area for each year in the Historic & Current Water Budgets. The data from these stations were applied across the GSP area according to proximity to each station, as well as the applicability of each station to a particular area. The applicability was determined by each GSA member agency. Figure 3-3 shows how the local stations were applied across the GSP Plan area. Note that the Kesterson CIMIS station was not used as it did not collect both precipitation and reference evapotranspiration (ET_0) data.

Runoff

Runoff rates were evaluated from CVHM2 results based on the estimated volume of applied water that contributes to runoff. This analysis was performed on an annual basis for each GSA member agency service area. For each year in the water budgets, the total volume of water applied as precipitation, surface water deliveries, and groundwater pumping in CVHM2 was compared to the total volume of water that becomes runoff and return flows in that area. The resultant proportion was then applied to the non-modeled volume of applied water that was reported in the Historic & Current Water Budgets. Proportions were determined for each year in the Historic & Current period and applied to the corresponding years observed data. The GSP Plan area effective runoff proportions for each year are reported below in Table 3-2.

Deep Percolation

Deep Percolation rates were evaluated based on the volume of applied water that contributed to seepage into the groundwater system based on CVHM2 results. This analysis was performed on a seasonal basis for each GSA member agency's service area for each year in the Historic & Current Water Budgets. The total volume of water applied as precipitation, surface water deliveries, and groundwater pumping in CVHM2 was compared to the total volume of water that becomes deep percolation. The resultant proportion was then applied to the non-modeled volume of applied water that is reported in the water budget. Proportions were determined for each year in the Historic & Current period and applied to the corresponding years data. The GSP Plan area effective deep percolation proportions for each year is reported in Table 3-2.

Table 3-2: Runoff and Deep Percolation
Effective Proportions of Inflow Volume in the GSP Area

Water Year	Runoff Proportion of Total Inflow	Deep Percolation Proportion of Total Inflow
2003	8.5%	8.9%
2004	7.3%	8.0%
2005	7.3%	8.9%
2006	7.8%	8.4%
2007	5.0%	7.2%
2008	8.6%	7.2%
2009	4.6%	7.0%
2010	6.8%	8.3%
2011	7.5%	8.5%
2012	4.2%	7.1%
2013	7.4%	7.3%

Evapotranspiration

ET_0 data was collected from various CIMIS Stations in the GSP Plan area. Data from these stations were applied across the GSP Plan area according to proximity to the station, as well as the applicability of each station to particular areas. The applicability was determined by each GSA member agency.

Figure 3-3 shows how the local stations were applied across the GSP Plan area. Note that the Kesterson CIMIS stations was not used due to the fact that it did not collect both precipitation and ET_0 data.

Crop acreage data was collected from each of the GSA member agencies. If data were not available, CVHM2 data were used. Crop data were separated by each year in the Historic & Current Water Budgets. The average Historic & Current crop coverages are presented in Table 3-3. The land use categories were simplified in order to apply crop coefficient data. The relationship between the supplied data categories and the crop coefficient categories is presented in Table 3-4.

Crop coefficient data was collected from the Cal Poly ITRC Crop Coefficient data for Zone 14. These crop coefficients were analyzed by crop type, irrigation type, and water year type in order to determine the appropriate crop coefficient to use for each GSA member agency's service area in a specific year. GSA member agency service areas with multiple crops types used an area weighted average of the applicable Cal Poly crop coefficients. These crop coefficients were combined with the CIMIS ET_0 data to determine total evapotranspiration volume. The crop coefficients are presented in Table 3-5.

Evapotranspiration volumes were limited in non-crop and non-irrigated areas to avoid having evapotranspiration volumes exceed precipitation volumes. This was enforced to ensure that evapotranspiration volumes alone didn't exceed inflows into any control volume where irrigation was not occurring.

Table 3-3: Crop Type Acreage during Historic & Current Period

Crop Category	Historic Average Acreage	Current Acreage	Crop Category	Historic Average Acreage	Current Acreage
Water	0	0	Grain and hay crops	17,475	15,737
Urban	2,637	2,637	Semiagricultural	268	287
Native grasses	63,027	60,600	Deciduous fruits and nuts	50,180	62,743
Orchards, groves, and vineyards	11,669	17,697	Rice	942	589
Pasture/Hay	1,696	2,703	Cotton	19,094	7,839
Row Crops	0	0	Developed	6,980	6,773
Small Grains	8,873	14,959	Cropland and pasture	198	3
Idle/fallow	13,048	14,418	Cropland	0	0
Truck, nursery, and berry crops	5,051	3,568	Irrigated Row and Field Crops	41,105	32,412
Citrus and subtropical	514	608	Native grasses - Phreatophytes	403	659
Field crops	23,740	21,982	Non-irrigated crops	48	0
Vineyards	940	1,585	Double Cropped	3,394	6,419
Pasture	4,968	4,863	Gravel Quarry	537	594

Table 3-4: Reported Land Use and Cal Poly Crop Coefficnet Category Cross Reference

Reported Land Use	Cal Poly Category Used	Reported Land Use	Cal Poly Category Used
Water	Idle/fallow	Grain and hay crops	Grain and hay crops
Urban	Urban	Semiagricultural	Grass Reference ET
Native grasses	Idle/fallow	Deciduous fruits and nuts	Deciduous fruits and nuts
Orchards, groves, and vineyards	Orchards, groves, and vineyards	Rice	Rice
Pasture/Hay	Pasture	Cotton	Cotton
Row Crops	Irrigated Row and Field Crops	Developed	Urban
Small Grains	Grain and hay crops	Cropland and pasture	Pasture
Idle/fallow	Idle/fallow	Cropland	Field crops
Truck, nursery, and berry crops	Truck, nursery, and berry crops	Irrigated Row and Field Crops	Irrigated Row and Field Crops
Citrus and subtropical	Citrus and subtropical	Native grasses - Phreatophytes	Idle/fallow
Field crops	Field crops	Non-irrigated crops	Idle/fallow
Vineyards	Vineyards	Double Cropped	Grass Reference ET
Pasture	Pasture	Gravel Quarry	Idle/fallow

Table 3-5: Cal Poly IRTC Crop Coefficient Summary

Crop Category	Wet Year	Average Year	Dry Year	Shasta Critical Year
Idle/fallow	25.0%	12.3%	14.2%	14.2%
Urban	50.0%	50.0%	50.0%	50.0%
Orchards, groves, and vineyards	85.6%	75.5%	78.1%	78.1%
Pasture	94.0%	89.3%	89.5%	89.5%
Irrigated Row and Field Crops	50.1%	45.4%	45.1%	45.1%
Grain and hay crops	61.4%	59.0%	57.8%	57.8%
Truck, nursery, and berry crops	73.9%	61.6%	63.8%	63.8%
Citrus and subtropical	74.9%	66.6%	67.8%	67.8%
Field crops	62.5%	49.6%	50.6%	50.6%
Vineyards	68.1%	56.8%	58.6%	58.6%
Grass Reference ET	100.0%	100.0%	100.0%	100.0%
Deciduous fruits and nuts	85.4%	74.0%	76.3%	76.3%
Rice	87.7%	81.0%	78.7%	78.7%
Cotton	79.7%	61.7%	65.7%	65.7%

Underflows

Observation well data were collected and groundwater elevation maps were created for each year during the historic and current water budget period using average water surface elevation values from October through March. These data were used in this analysis because elevation data available during these months was most consistent across wells. These maps were then used to estimate the groundwater gradient at the boundary of the GSP Plan area. Simplified boundaries were also used to calculate underflows. These simplified boundaries are presented in Figure 3-4.

Due to the limited spatial distribution of observation well data, other sources of information were gathered to estimate the groundwater gradients along the Plan area boundaries with the Westside and Kings Subbasins as well as the boundary to the west of the GSP Plan area (Coast Range foothills). The Westside Groundwater Model results were used to determine groundwater gradients along the Westside and Kings Subbasins. Additionally, it was assumed that a fixed portion of precipitation became recharge to the Delta-Mendota Subbasin as underflows from the foothills. Groundwater gradients between the GSP Plan area and the Modesto and Turlock Subbasins to the east were estimated to be zero due to the limited observed well data available in the area.

The soil transmissivity at the boundaries of the GSP Plan area were determined using professional judgement and local knowledge. Transmissivity data for the boundary between the GSP Plan area and the San Joaquin River Exchange Contractors (SJREC) GSP Plan area was estimated by SJREC using a local database. Those values were evaluated and generalized for use at other boundaries. Soil transmissivity data were combined with groundwater gradient data in order to estimate underflows for each year during the Historic & Current water budget period.

Change in Storage

Observation well data were collected and analyzed in order to create groundwater surface elevation data for the GSP Plan area. The GSP Plan area was split into seven areas for this analysis due to the spatial distribution of the observed well data. The seven areas are shown in

Figure 3-5. This separation ensures the water surface elevation trends in areas with many wells is not over-weighted as compared to areas that have fewer observations. The average change in surface water elevation was determined for each of these seven areas for each principal aquifer, then combined to get the total change in storage of the GSP Plan area for each year.

Storativity values were determined using the CVHM2 data sets. The change in water surface elevations and the storativity values were combined to determine the change in storage for the upper aquifer. The lower aquifer had even fewer observation wells, so the change in storage in the lower aquifer was assumed to be a fixed portion of the upper aquifer change in storage. This portion was determined by evaluating the proportion predicted by CVHM2 and confirmed using professional judgement and local knowledge.

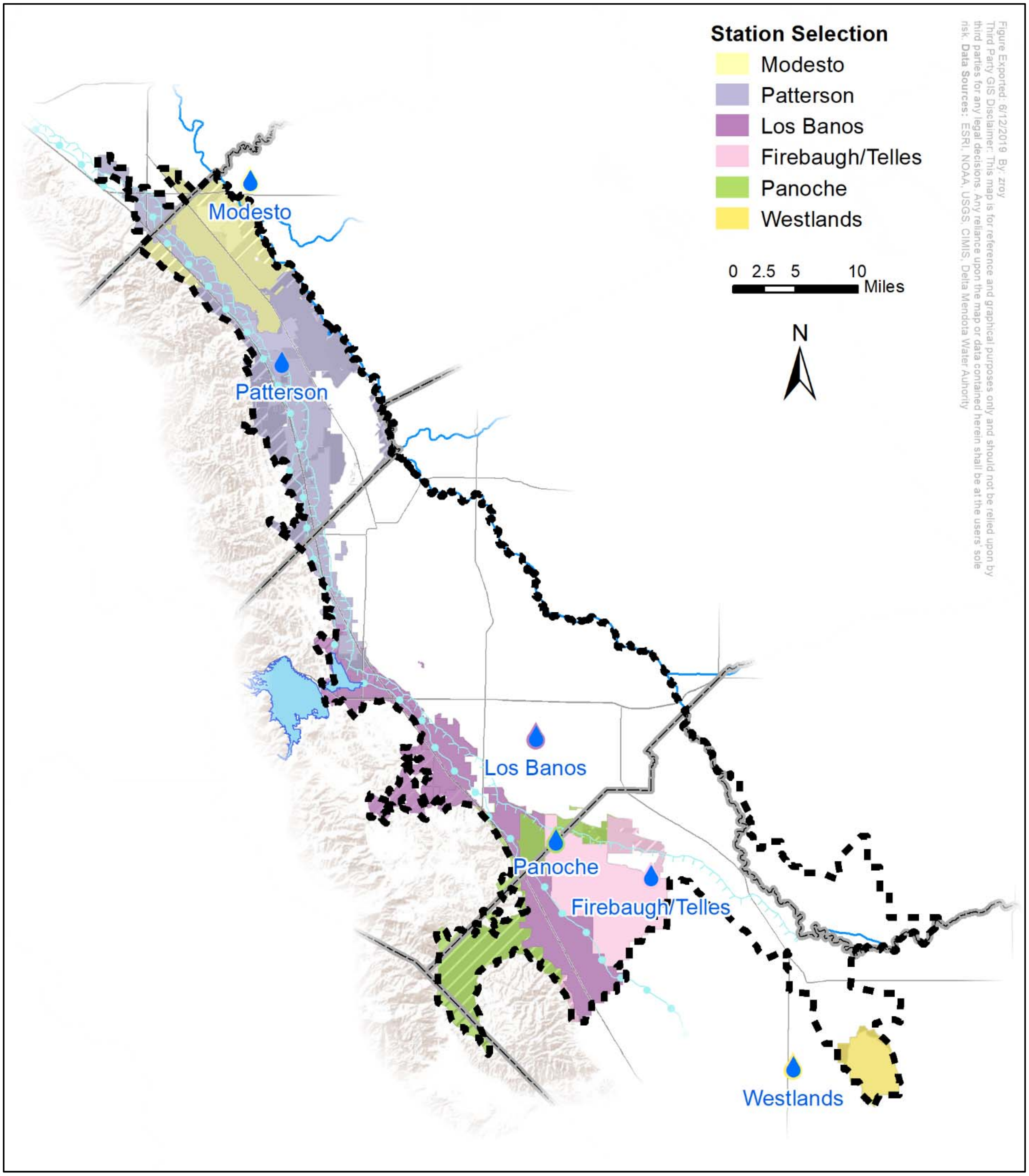


Figure 3-3: Applicable CIMIS Stations

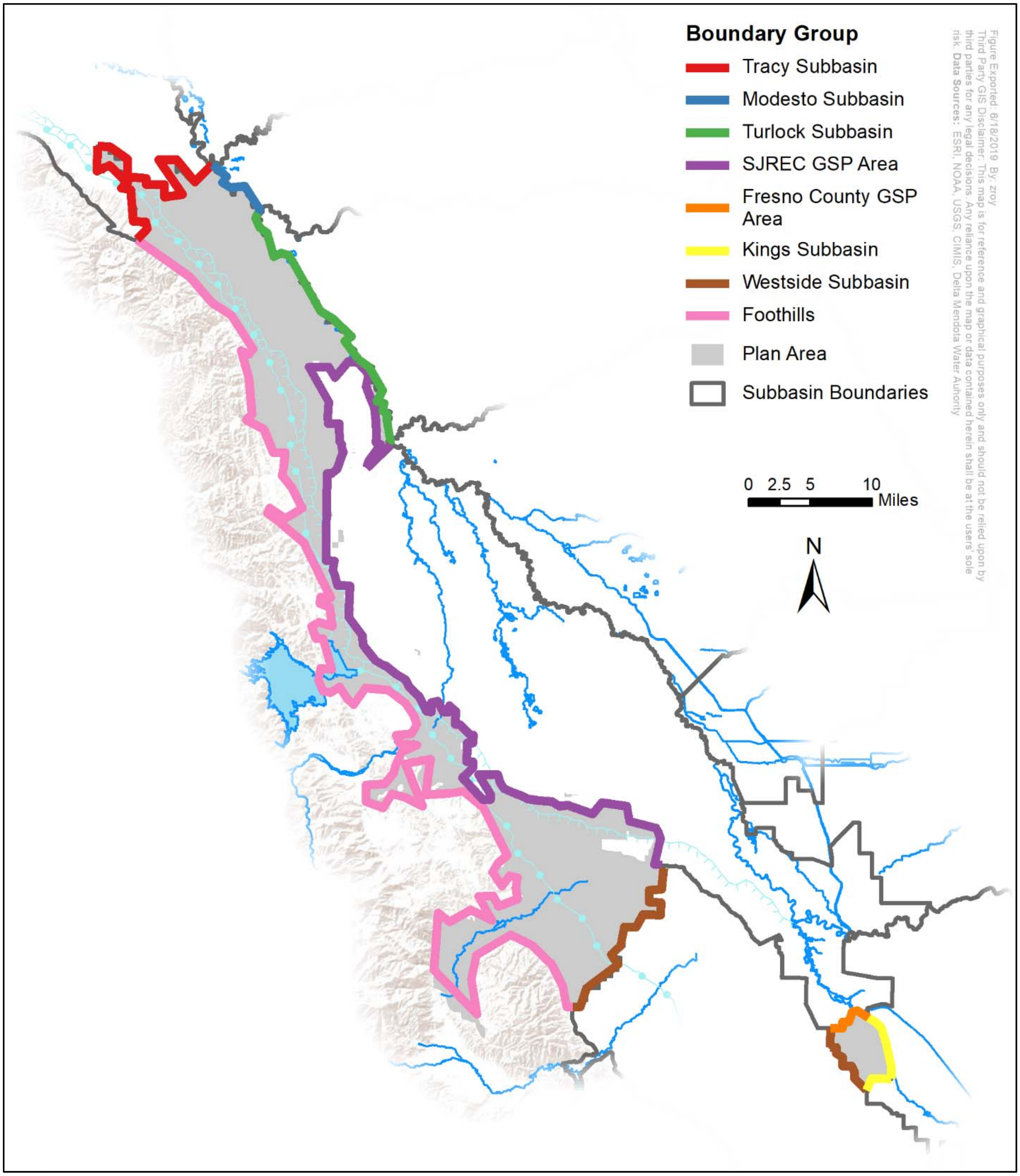


Figure 3-4: Simplified Boundaries for Underflow Calculation

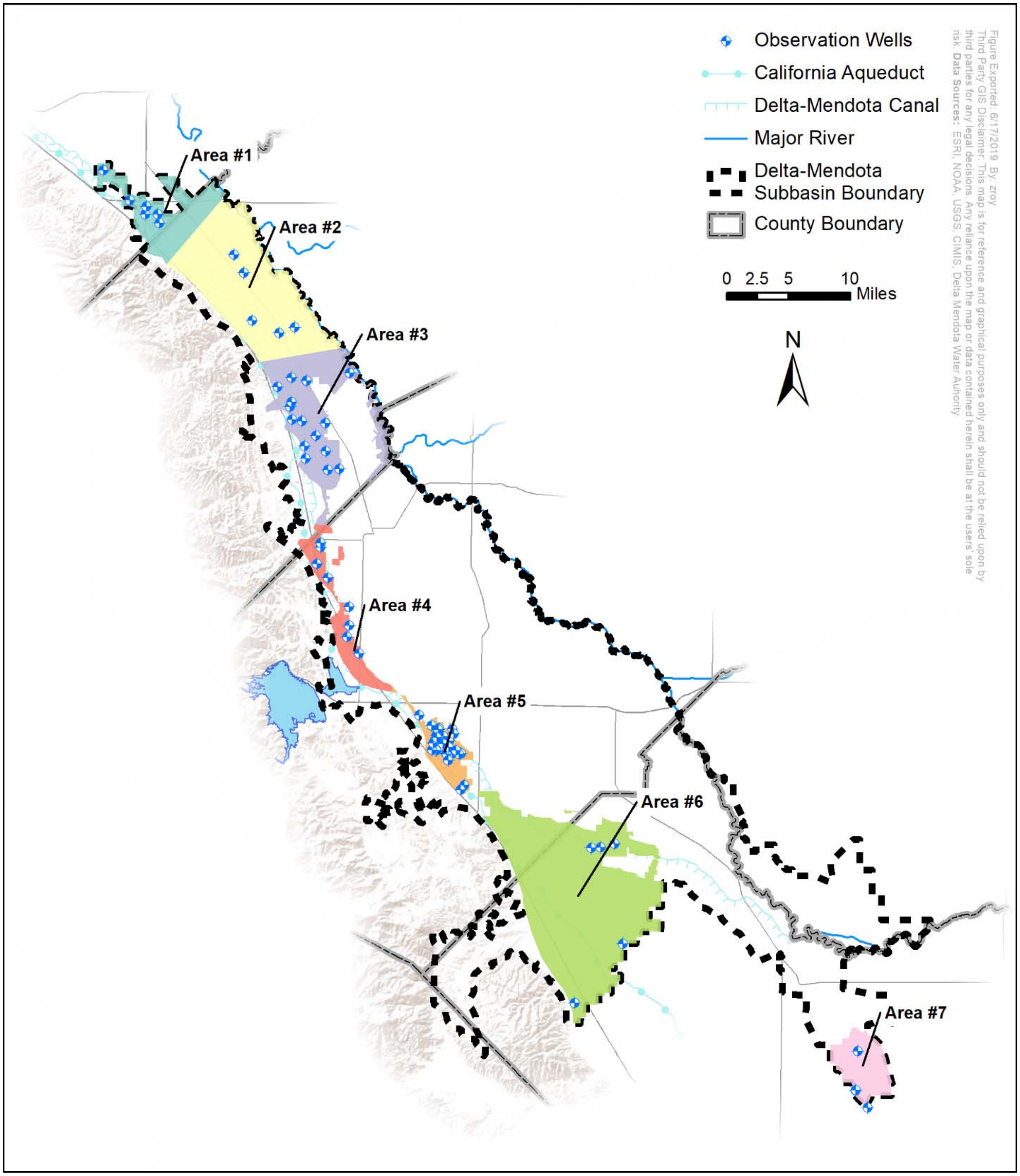


Figure 3-5: Change in Storage Areas

5. PROJECTED WATER BUDGETS

The projected water budgets represent WY 2014-2070. The selected period for the projected water budgets meets SGMA requirements by establishing a 50-year period, where the timeframe is continuous between the historic, current, and projected water budgets. The historic hydrologic period for simulating the projected water budget hydrologic schema was chosen as WY 1979-2017, then wrapping around to include WY 1965-1978 hydrology. Actual data and hydrology were used for WY 2014 through 2017 with the representative water years simulating WY 2018 and beyond (e.g. WY2018 is represented by the hydrology from WY1979; WY2019 is represented by the hydrology from WY1980, and so forth). Each modeled year type is described in

Table 5-1, along with its representative year type.

Three projected water budgets were prepared and are described below:

- **Baseline Projected Water Budget** - Water budget tabulating predicted flows into and out of the GSP Plan area during WYs 2014 through 2070. This is an accounting of annual predicted flows based on the existing climate scenario, without the influence of additional projects or management actions for the purposes of SGMA and for establishing changes in the system as a result of projected future land use and water use patterns.
- **Projected Water Budget with Climate Change (Projected Water Budget with CC)** - Water budget tabulating predicted flows into and out of the GSP Plan area during WYs 2014 through 2070 with the DWR climate change factors (CCFs) applied to Delta-Mendota Subbasin hydrology. This is an accounting of annual predicted flows based on the climate change scenario, without the influence of additional projects or management actions, for the purposes of SGMA and evaluating the impacts of CCF application to the water budget.
- **Projected Water Budget with Climate Change and Projects & Management Actions (Projected Water Budget with CC + P&MA)** - Water budget tabulating predicted flows into and out of the GSP Plan area during WYs 2014 through 2070. This is an accounting of annual predicted flows based on the climate change scenario with the additional influence of additional projects and management actions for the purposes of SGMA and evaluating the impacts of future projected conditions on the GSP Plan area.

Table 5-1. Modeled Water Year by Water Year Type

Modeled Year	Hydrologic Year	Water Year Type	Modeled Year	Hydrologic Year	Water Year Type
2003	2003	Average	2037	1998	Wet
2004	2004	Dry	2038	1999	Average
2005	2005	Wet	2039	2000	Average
2006	2006	Wet	2040	2001	Dry
2007	2007	Dry	2041	2002	Dry
2008	2008	Dry	2042	2003	Average
2009	2009	Average	2043	2004	Dry
2010	2010	Average	2044	2005	Wet
2011	2011	Wet	2045	2006	Wet
2012	2012	Dry	2046	2007	Dry
2013	2013	Dry	2047	2008	Dry
2014	2014	Shasta Critical	2048	2009	Average
2015	2015	Shasta Critical	2049	2010	Average
2016	2016	Dry	2050	2011	Wet
2017	2017	Wet	2051	2012	Dry
2018	1979	Average	2052	2013	Dry
2019	1980	Wet	2053	2014	Shasta Critical
2020	1981	Dry	2054	2015	Shasta Critical
2021	1982	Wet	2055	2016	Dry
2022	1983	Wet	2056	2017	Wet
2023	1984	Average	2057	1965	Wet
2024	1985	Dry	2058	1966	Average
2025	1986	Wet	2059	1967	Wet
2026	1987	Dry	2060	1968	Dry
2027	1988	Dry	2061	1969	Wet
2028	1989	Dry	2062	1970	Average
2029	1990	Dry	2063	1971	Average
2030	1991	Shasta Critical	2064	1972	Dry
2031	1992	Shasta Critical	2065	1973	Average
2032	1993	Wet	2066	1974	Wet
2033	1994	Dry	2067	1975	Wet
2034	1995	Wet	2068	1976	Dry
2035	1996	Wet	2069	1977	Dry
2036	1997	Wet	2070	1978	Wet

5.1 Data Sources, Assumptions, and Methods for the Baseline Projected Water Budget

Many of the volumes reported in the projected water budgets are calculated or based on projections provided by GSA member agencies. Other flow categories were calculated based on volumes from the Historic & Current Water Budgets (adjusted appropriately according to the methods discussed below). Many of the calculation methods that were used for the Historic & Current Water Budgets were used or adjusted slightly, for the Baseline Projected Water Budget. Each of the methods and assumptions used to quantify the projected water budget flow categories in the Baseline Projected Water Budget are descried in more detail below. Changes made to the Baseline methods and assumptions in order to accommodate climate change factors, as well as projects and management actions, are discussed in more detail in Sections 5.2 and 5.3.

Surface Water Deliveries

GSA member agencies provided delivery data as it was available for their service areas for WY 2014-2018. GSA member agencies also provided estimates for anticipated future deliveries by WY type to be used for WY 2019-2070. If data were not available for any year during the projected time period, available data for the GSA member agency's service area was averaged by water year type. Available data used included data from the Historic & Current Budgets.

It was assumed that the projections provided by the agencies described all of the surface water being applied within their service areas. The volume reported in the Baseline Projected Water Budget is the sum of all agency projected delivery data. Deliveries from the Central Valley Project, State Water Project, the San Joaquin River, and other local streams and rivers were included.

Pumping

Pumping for the projected time period is a derived flow volume. Agricultural pumping rates are estimated to be the volume of water needed to meet crop demands after precipitation, surface water deliveries, and tile drainage are accounted for. This calculation is done seasonally and at the GSA member agency-level for each year in the projected time period. Crop demands were calculated first by determining the volume of evapotranspiration in a given area (not including the ET that occurs on native and non-irrigated lands). Crop demands were then reduced by the amount of applied water (withholding losses due to runoff and deep percolation from these sources). If the supplies exceed demands prior to agricultural pumping, the agricultural pumping volume is assumed to be zero. The following formula calculates the agricultural pumping requirement for a given season in a given year for GSA member agency's service area:

$$Ag\ Pumping = max\{0, ET_{crop} - P_{eff} - SWD_{eff} - TD_{eff}\}$$

Where each P_{eff}, SWD_{eff}, and TD_{eff} are calculated using the formula below, substituting each term in for $source$:

$$source_{eff} = (source - R_{source} - DP_{source})$$

And

ET = evapotranspiration
P = precipitation
SWD = surface water deliveries
TD = tile drainage

R_{source} is runoff originating from $source$, and DP_{source} is deep percolation originating from $source$. Note that the total volume of runoff and deep percolation reported in the projected water budgets includes volumes from these sources, as well as additional volumes calculated after the application of pumped water is accounted for.

Urban pumping rates were calculated based on existing urban pumping demands and were adjusted (increased) to account for additional future demands using data from urban growth projections and expectations for the rate of groundwater consumption in these growth areas. Growth projections were supplied by GSA member agencies. These volumes are in addition to agricultural pumping demands.

Tile Drainage

GSA member agencies provided estimated tile drainage volumes for each WY type. It was assumed that the data provided by the agencies described all of the significant tile drainage occurring within that agency's service area. Estimated volumes were applied through the entire projected time period based on representative WY types. The volume reported is the sum of the water removed from the water table aquifer through drains in the shallowest portion of the upper aquifer. If no data were available for an agency's service area, it was assumed no tile drainage occurred.

Precipitation

Seasonal data were collected from various CIMIS Stations in the GSP Plan area. Data were collected for WY 1965-2018. These data were aggregated by season for each station in order to get the total volume of precipitation in that season of that year. Two seasons were considered: a dry season from April through September and a wet season from October through March. These seasons align with the beginning and end of each WY. If the CIMIS Station did not have data for a season in a particular year, the average value (by WY type) was used from that station's available data. For example, if a station did not have data for the dry season of 1966, which was an "average" water year type, dry season data were used from other "average" water years. The data availability for each station is listed in Table 5-2.

Table 5-2: CIMIS Station Data Availability

Station Name	Precipitation Data Availability	Evapotranspiration Data Availability
Modesto	1988 - 2018	1988 - 2018
Patterson	2000 - 2016	2000 - 2016
Los Banos	1989 - 2018	1989 - 2018
Panoche	1997 - 2018	1996 - 2018
Firebaugh/Telles	1997 - 1028	1983 - 1028
Westlands	1993 - 2018	1993 - 2018

The data from these stations were applied across the GSP Plan area in the same spatial manner as the Historic & Current Water Budgets (Figure 3-3).

Runoff

Runoff in the projected water budgets was calculated in two parts: crop runoff and non-crop runoff. Crop runoff rates were evaluated from CVHM2 based on the volume of applied water that contributes to runoff in the model. This analysis was performed on a WY type basis for each GSA member agency's service area. For each year in the Historic & Current period, the total volume of water being applied as precipitation, surface water deliveries, and groundwater applications was compared to the total volume of water that became runoff and return flows in that area. These proportions were used with the volume of water applied to crops in order to determine crop runoff in the projected water budgets.

Non-crop runoff was estimated by the following formula:

$$Runoff_{volume} = Precipitation_{eff} \cdot \left(\frac{Runoff_{rate}}{Deep\ Percolation_{rate} + Runoff_{rate}} \right)$$

Where the $Runoff_{rate}$ and $Deep\ Percolation_{rate}$ were determined from CVHM2 results for cropped areas, and effective Precipitation for non-cropped areas was calculated as follows:

$$Precipitation_{eff} = Precipitation_{total} - Evapotranspiration_{total}$$

The formulas ensure that non-crop runoff is only a portion of precipitation and that the sum of runoff and deep percolation in non-crop areas does not exceed the effective precipitation in a specified area.

Deep Percolation

Deep percolation in the projected water budgets was calculated in two parts: crop deep percolation and non-crop deep percolation. Crop deep percolation rates were evaluated from CVHM2 based on the modeled volume of applied water that contributed to deep percolation in the model. This analysis was performed on a WY type basis for each GSA member agency. For each year in the Historic & Current period, the total volume of water being applied as precipitation, surface water deliveries, and groundwater applications was compared to the total volume of water that became deep percolation in that area. These proportions were used with the volume of water applied to crops in order to determine crop deep percolation in the projected water budgets.

Non-crop deep percolation was estimated by following formula:

$$Deep\ Percolation_{volume} = Precipitation_{eff} \cdot \left(\frac{Deep\ Percolation_{rate}}{Deep\ Percolation_{rate} + Runoff_{rate}}\right)$$

Where the $Runoff_{rate}$ and $Deep\ Percolation_{rate}$ were determined from CVHM2 results for cropped areas. Effective precipitation in the non-cropped areas was calculated as follows:

$$Precipitation_{eff} = Precipitation_{total} - Evapotranspiration_{total}$$

This formula ensures that non-crop deep percolation is only a portion of precipitation and that the sum of runoff and deep percolation in non-crop areas does not exceed the effective precipitation in a specified area.

Evapotranspiration

ET_0 data were collected from various CIMIS Stations in the GSP Plan area. The data from these stations were applied across the GSP Plan area according to proximity to the station, as well as the applicability of each station to particular areas. The applicability was determined by each GSA member agency. Figure 3-3 shows how the local stations were applied across the GSP Plan area. The Kesterson CIMIS station was not used due to the fact that it did not collect both precipitation and ET_0 data.

Crop data were collected from each of the GSA member agencies. The total number of acres for each crop type was supplied from reported data, and if data were not available, CVHM2 data were used. Crop acreage data were separated by winter and summer seasons and for each WY type. The average projected crop coverages are presented in

Table 5-3. The land use categories are simplified in order to apply crop coefficient data. The correlation between the supplied data categories and the crop coefficient categories is presented in Table 3-4.

Crop coefficient data were collected from the Cal Poly ITRC Crop Coefficient data for Zone 14. These crop coefficients were analyzed by crop type, irrigation type, and WY type in order to determine the appropriate crop coefficient to use for each GSA member agency service area in a specific year. GSA member agency service areas with multiple crops used an area weighted average of the applicable Cal Poly crop coefficients. These crop coefficients were combined with the CIMIS ET_0 data. The crop coefficients are presented in Table 3-5.

Evapotranspiration volumes were limited in non-crop areas to not exceed precipitation volumes. This was enforced to ensure that evapotranspiration volumes alone did not exceed inflows into any control volume where irrigation was not occurring.

Table 5-3: Crop Type Acreage during the Projected Period

Crop Category	Average Projected Acreage	Crop Category	Average Projected Acreage
Water	100	Grain and hay crops	14,362
Urban	2,577	Semiagricultural	442
Native grasses	61,206	Deciduous fruits and nuts	67,827
Orchards, groves, and vineyards	25,239	Rice	0
Pasture/Hay	2,546	Cotton	6,516
Row Crops	4,191	Developed	7,142
Small Grains	9,418	Cropland and pasture	1,193
Idle/fallow	18,259	Cropland	0
Truck, nursery, and berry crops	2,182	Irrigated Row and Field Crops	20,281
Citrus and subtropical	453	Native grasses - Phreatophytes	19
Field crops	22,588	Non-irrigated crops	60
Vineyards	1,530	Double Cropped	3,915
Pasture	4,641	Gravel Quarry	594

Underflows

The underflows used in the Historic & Current Water Budgets were averaged by WY type and used throughout the Projected Water Budget period. See the Underflows discussion in Section 4.1 for details on the data sources, assumptions, and methods used.

Change in Storage

The change in storage volumes used in the Historic & Current Water Budgets were averaged by water year type and used throughout the projected water budgets period. See the Change in Storage discussion in Section 4.1 for details on the data sources, assumptions, and methods used.

5.2 Additional Data Sources, Assumptions, and Methods in the Projected Water Budget with Climate Change Factors

For the Projected Water Budget with CC (climate change), one additional data set was used in addition to those discussed in Section 5.1. The Gridded Statewide Precipitation and ET Change Factors were developed for the Water Storage Investment Program (WSIP) using the Variable Infiltration Capacity (VIC) Macroscale Hydrology Model (CA DWR, 2018). This data set was applied to applicable flow data categories to account for adjustments due to climate change. This data set includes multipliers for precipitation and ET_0 data for the 2030 climate model and the 2070 climate model prepared by DWR for the WSIP. Table 5-4 describes which climate model factors were applied during each year of the Projected Water Budget with CC.

Table 5-4: Climate Change Model Used by Model Year

Modeled Year	VIC Model Data Used	Modeled Year	VIC Model Data Used
2014	2030	2043	2030
2015	2030	2044	2030
2016	2030	2045	2070
2017	2030	2046	2070
2018	2030	2047	2070
2019	2030	2048	2070
2020	2030	2049	2070
2021	2030	2050	2070
2022	2030	2051	2070
2023	2030	2052	2070
2024	2030	2053	2070
2025	2030	2054	2070
2026	2030	2055	2070
2027	2030	2056	2070
2028	2030	2057	2070
2029	2030	2058	2070
2030	2030	2059	2070
2031	2030	2060	2070
2032	2030	2061	2070
2033	2030	2062	2070
2034	2030	2063	2070
2035	2030	2064	2070
2036	2030	2065	2070
2037	2030	2066	2070
2038	2030	2067	2070
2039	2030	2068	2070
2040	2030	2069	2070
2041	2030	2070	2070
2042	2030		

Many of the calculation methods that were used for the Baseline Projected Water Budget were used or adjusted slightly for the Projected Water Budget with CC. Each of the methods and assumptions used to quantify the water budget flow categories in the Projected Water Budget with CC are described in more detail below. The unchanged flow categories are discussed first, followed by the flow categories directly affected by the climate change factors. These changes indirectly affected some flow categories, which are discussed last.

5.2.1 Unchanged Flow Categories

Surface Water Deliveries

Projected surface water deliveries were based on volumes provided by the GSA member agencies. These volumes represent their anticipated future supplies. The climate change factors provided by DWR were not applied to projected surface water deliveries as they are based on an outdated model. These climate change factors, when applied, result in projected future surface water deliveries that do not represent anticipated future conditions.

Tile Drainage

Climate change factors were not expected to affect the groundwater levels enough to change tile drainage volumes for the GSP Plan area.

Underflows

Climate change factors and their expected effect on land surface operations were not expected to change the average annual gradient of groundwater at the boundary of the GSP Plan area. Any future changes to the underflows are beyond the accuracy of this spreadsheet model. Due to this, the underflows between adjacent areas were assumed to remain constant between scenarios. Change in storage is evaluated separately from underflows in the projected water budgets.

5.2.2 Directly-Affected Flow Categories

Precipitation

Precipitation rates were adjusted according to multipliers from the VIC hydrological gridded data set. Precipitation was scaled according to the spatial overlap of the gridded data set and the GSP Plan area.

Evapotranspiration

ET_0 rates were adjusted according to multipliers from the VIC hydrological gridded data set. ET_0 was scaled according to the spatial overlap of the VIC hydrological gridded data set and the GSP Plan area. Evapotranspiration volumes were not adjusted above the adjusted precipitation volumes for non-crop areas. Land use operations and trends were not changed as a part of this climate analysis.

5.2.3 Indirectly Affected Flow Categories

Pumping

Pumping volumes were adjusted due to the changes in precipitation and evapotranspiration. No changes were made to the calculation methods for pumping volumes.

Runoff

Runoff volumes were adjusted due to the changes in precipitation and evapotranspiration. No changes were made to the calculation methods for runoff volumes.

Deep Percolation

Deep percolation volumes were adjusted due to the changes in precipitation and evapotranspiration. No changes were made to the calculation methods for deep percolation volumes.

Change in Storage

Change in storage calculations were adjusted slightly in order to accommodate for the changes in operations in the Land Surface Water Budget. Additional pumping volumes were split between the upper and lower aquifer change in storage volumes. Additional deep percolation volumes, however, were applied to the upper aquifer change in storage volume.

5.3 Additional Data Sources, Assumptions, and Methods in the Projected Water Budget with Climate Change Factors and Projects & Management Actions

For the Projected Water Budget with CC + P&MA, GSA member agencies identified projects and management actions that were in various stages of planning and implementation. These projects were evaluated against their effects on the groundwater and land surface systems. Specifically, impacts from the projects were considered in the flow categories that they effect - the total volumes of water the projects generate in excess of the Baseline water budget (which did not contain the projects or management actions) and the timing of the project or management action. A list of projects and management actions that were modeled and the flow categories that they effected is included in Table 5-5.

Many of the calculation methods that were used for Projected Water Budget with CC were used or adjusted slightly for the Projected Water Budget with CC + P&MA. Each of the methods and assumptions used to quantify the water budget flow categories in the Projected Water Budget with Climate CC + P&MA are described in more detail below. The unchanged flow categories are discussed first, followed by the flow categories directly affected by the projects & management actions. These changes indirectly affected some flow categories, which are discussed last.

Table 5-5: Modeled Projects & Management Actions

Project Name	Inflow			Outflow			Modeled Start Year
	Category	Description of Influence	Volume or Volume Pattern	Category	Description of Influence	Volume or Volume Pattern	
City of Patterson Percolation Ponds for Stormwater Capture and Recharge	Surface Water Deliveries	Percolations ponds are sourced from the Del Puerto Creek, the increase in this category is applied directly in the percolation ponds	1,700 AFY	Deep Percolation	Increases based on the Percolation Pond study	1,700 AFY	2020
North Valley Regional Recycled Water Program (Turlock Part)	Surface Water Deliveries	Increased Supply, increasing from 9,700 AFY in 2020 to 28,400 in 2040 and onward. Not using the total 48,000 value since a portion of the project has already been implemented	Growing from 14,100 AFY in 2026 to 28,400 AFY in 2045	Runoff; Deep Percolation	Increased surface water deliveries changes runoff and deep percolation patterns	Approximately 15% of increased Surface Water Deliveries.	2026
Orestimba Creek Recharge and Recovery Project	N/A			Pumping	In withdrawal years, the allowed pumping value is at least the withdrawal amount	Sets a minimum pumping amount in below normal, dry, and critical water years (San Joaquin River Index)	2020
Los Banos Creek Recharge Project	Surface Water Deliveries	Added inflows from the Los Banos Creek, applied to recharge basin	200 AFY	Deep Percolation	Increased due to the capture of surface water flows	200 AFY	2020
Kaljian Drainwater Reuse Project	Surface Water Deliveries; Pumping	Added inflows from the SJR and Kings flood waters, applied to recharge basin; Additional inflows reduces pumping need	2,700 AFY	Runoff; Deep Percolation	Increased surface water deliveries changes runoff patterns; Increased due to the capture of surface water flows	Approximately 15% of increased Surface Water Deliveries	2020
West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	N/A			Deep Percolation	Increased deep percolation due to recharge basin location	270 AFY	2020
West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	N/A			Deep Percolation	Increased deep percolation due to recharge basin location	270 AFY	2026
Tranquillity Irrigation District Revision to Lower Aquifer Pumping	Pumping	Reduction of average pumping volumes	In normal and wet years, limit lower aquifer pumping to 1,000 AFY, and in dry years limit lower aquifer pumping to 8,000 AFY.	, Runoff, Deep Percolation	Decreased average pumping reduces runoff, and deep percolation volumes	Approximately 15% of changes in Pumping Volumes	2017
Del Puerto Canyon Reservoir	Surface Water Deliveries; Pumping	Increased supplies in every year; Reduced average pumping due to the increased supply of surface water	3,000 AFY; Varies	N/A			2030
Little Salado Creek Groundwater Recharge and Flood Control Basin	N/A			Deep Percolation	Increased deep percolation via recharge basins	489 AFY in Wet years	2032
Patterson Irrigation District Groundwater Bank and/or Flood-MAR-type Project	N/A			Deep Percolation	Increased deep percolation via applications to fallow lands	3,000 AFY in Wet and Average years	2032

Project Name	Inflow			Outflow			Modeled Start Year
	Category	Description of Influence	Volume or Volume Pattern	Category	Description of Influence	Volume or Volume Pattern	
Ortigalita Creek Groundwater Recharge and Recovery Project	N/A			Deep Percolation	Increased due to capture of surface water flows	3,000 AFY	2026
Development of Program to Incentivize Use of Surface Water and Reduce Groundwater Demand	Surface Water Deliveries; Pumping	Decreased Pumping due to the increased availability of Surface Water Deliveries	4,000 – 34,000 AFY	N/A			2026

N/A – Not Applicable

5.3.1 Unchanged Flow Categories

Precipitation

Precipitation rates were not affected by projects and management actions implemented within the GSP Plan area.

Tile Drainage

Projects and management actions were not expected to affect the groundwater levels enough to change tile drainage volumes for the basin.

Evapotranspiration

ET_0 rates were not affected by projects and management actions implemented within the GSP Plan area. Additionally, land use operations and trends were not changed as a part of this climate analysis.

Underflows

Projects and management actions and their expected effect on land surface operations were not expected to change the average annual gradient of groundwater at the boundary of the GSP Plan area. Any changes to the underflows are beyond the accuracy of this spreadsheet model. Due to this, the underflows between adjacent areas were assumed to remain constant between scenarios. Change in storage is evaluated separately from underflows in the projected water budgets.

5.3.2 Directly Affected Flow Categories

Surface Water Deliveries

Additional volume of surface water deliveries in the Projected Water Budget with CC + P&MA is due to the effects of the projects and management actions described in Table 5-5.

Pumping

Additional volume of pumping in the Projected Water Budget with CC + P&MA is due to the effects of the projects & management actions described in Table 5-5.

Deep Percolation

Certain projects are aimed at increasing the deep percolation into the Upper Aquifer. Those projects are listed in Table 5-5. Additional volume of deep percolation in the Projected Water Budget with CC + P&MA is due to the effects of anticipated increases in applied surface water resulting from the projects and management actions.

5.3.3 Indirectly Affected Flow Categories

Runoff

Additional volume of percolation in the Projected Water Budget with CC + P&MA is due to the effects of anticipated increases in applied surface water resulting from the projects and management actions.

Change in Storage

Change in storage calculations were adjusted slightly in order to accommodate for the changes in operations in the Land Surface Water Budget. Additional pumping volumes were split between the upper and lower aquifer change in storage volumes. Additional deep percolation volumes, however, were applied to the upper aquifer change in storage volume.

6. WATER BUDGET TABLES

The water budgets developed for the GSP Plan area are presented below. Data sources, assumptions and methods for each of the tables are discussed in prior sections of this TM. The annual flow volumes are estimated in the following tables in acre-feet per year (AFY):

- Historic Water Budget
  - Land Surface Water Budget (Table 6-1)
  - Groundwater Budget (Table 6-2)
- Current Water Budget
  - Land Surface Water Budget (Table 6-1)
  - Groundwater Budget (Table 6-2)
- Baseline Projected Water Budget
  - Land Surface Water Budget (Table 6-3)
  - Groundwater Budget (Table 6-4)
- Projected Water Budget with CC
  - Land Surface Water Budget (Table 6-5)
  - Groundwater Budget (Table 6-6)
- Projected Water Budget with CC + P&MA
  - Land Surface Water Budget (Table 6-7)
  - Groundwater Budget (Table 6-8)

Table 6-1: Historic & Current Land Surface Water Budget

Land Surface Water Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2003	Average	78,000	365,000	4,000	0	3,000	92,000	30	200,000	742,000	63,000	66,000	606,000	736,000
2004	Dry	85,000	359,000	5,000	0	3,000	86,000	30	174,000	711,000	52,000	57,000	580,000	688,000
2005	Wet	79,000	347,000	4,000	0	4,000	102,000	30	312,000	848,000	62,000	75,000	662,000	799,000
2006	Wet	66,000	353,000	4,000	0	4,000	99,000	30	248,000	774,000	60,000	65,000	663,000	788,000
2007	Dry	93,000	344,000	4,000	0	4,000	97,000	30	114,000	656,000	33,000	47,000	560,000	639,000
2008	Dry	97,000	269,000	2,000	0	4,000	140,000	30	142,000	654,000	56,000	47,000	598,000	700,000
2009	Average	109,000	234,000	2,000	0	4,000	128,000	30	125,000	602,000	28,000	42,000	647,000	717,000
2010	Average	105,000	271,000	3,000	0	4,000	112,000	30	227,000	721,000	49,000	60,000	590,000	699,000
2011	Wet	104,000	356,000	3,000	0	4,000	76,000	30	258,000	802,000	60,000	68,000	682,000	811,000
2012	Dry	124,000	316,000	3,000	0	4,000	106,000	30	112,000	665,000	28,000	47,000	559,000	634,000
Historic Average		94,000	322,000	3,000	0	4,000	104,000	30	191,000	718,000	49,000	58,000	615,000	722,000
2013	Dry	127,000	283,000	3,000	0	4,000	119,000	30	149,000	685,000	51,000	50,000	568,000	669,000

[1] Runoff includes return flows to all surface water sources leaving the Plan Area. Return flows were not separated due to model limitations.

Table 6-2: Historic & Current Groundwater Budget

Groundwater Budget													
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2003	Average	66,000	50,000	27,000	143,000	95,000	30	60,000	32,000	186,000	94,000	19,000	113,000
2004	Dry	57,000	56,000	29,000	142,000	89,000	30	65,000	34,000	188,000	(67,000)	(13,000)	(80,000)
2005	Wet	75,000	73,000	39,000	187,000	105,000	30	54,000	29,000	188,000	123,000	25,000	147,000
2006	Wet	65,000	61,000	32,000	158,000	103,000	30	54,000	29,000	186,000	(67,000)	(13,000)	(80,000)
2007	Dry	47,000	35,000	18,000	100,000	101,000	30	67,000	36,000	204,000	(157,000)	(31,000)	(188,000)
2008	Dry	47,000	40,000	21,000	108,000	144,000	30	76,000	40,000	259,000	(211,000)	(42,000)	(253,000)
2009	Average	42,000	36,000	19,000	98,000	132,000	30	67,000	35,000	234,000	(45,000)	(9,000)	(54,000)
2010	Average	60,000	56,000	30,000	146,000	115,000	30	60,000	32,000	207,000	77,000	15,000	92,000
2011	Wet	68,000	63,000	33,000	164,000	80,000	30	61,000	32,000	173,000	(64,000)	(13,000)	(76,000)
2012	Dry	47,000	38,000	20,000	105,000	110,000	30	66,000	35,000	212,000	(105,000)	(21,000)	(126,000)
Historic Average		58,000	51,000	27,000	136,000	108,000	30	63,000	33,000	204,000	(42,000)	(8,000)	(126,000)
2013	Dry	50,000	42,000	22,000	114,000	124,000	0	52,000	27,000	50,000	(73,000)	(15,000)	(88,000)

Table 6-3: Baseline Projected Land Surface Water Budget

Land Surface Water Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	197,000	8,000	127,000	671,000	47,000	61,000	578,000	686,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	198,000	8,000	134,000	615,000	38,000	48,000	542,000	628,000
2016	Dry	80,000	231,000	3,000	0	4,000	136,000	11,000	260,000	724,000	55,000	87,000	572,000	714,000
2017	Wet	74,000	303,000	3,000	0	4,000	123,000	12,000	264,000	784,000	65,000	90,000	648,000	803,000
2018	Average	60,000	320,000	2,000	0	4,000	121,000	10,000	196,000	713,000	51,000	74,000	585,000	710,000
2019	Wet	118,000	332,000	4,000	0	4,000	85,000	12,000	342,000	897,000	76,000	107,000	683,000	867,000
2020	Dry	141,000	272,000	3,000	0	5,000	115,000	11,000	211,000	757,000	50,000	67,000	584,000	700,000
2021	Wet	118,000	332,000	4,000	0	4,000	86,000	12,000	342,000	898,000	76,000	107,000	683,000	867,000
2022	Wet	118,000	332,000	4,000	0	5,000	79,000	12,000	410,000	960,000	81,000	114,000	697,000	893,000
2023	Average	126,000	310,000	3,000	0	5,000	109,000	10,000	327,000	891,000	66,000	93,000	617,000	776,000
2024	Dry	141,000	272,000	3,000	0	5,000	110,000	11,000	320,000	863,000	65,000	89,000	594,000	748,000
2025	Wet	118,000	332,000	4,000	0	5,000	80,000	12,000	461,000	1,012,000	87,000	120,000	695,000	902,000
2026	Dry	141,000	272,000	3,000	0	6,000	111,000	11,000	304,000	848,000	62,000	86,000	593,000	741,000
2027	Dry	141,000	272,000	3,000	0	6,000	110,000	11,000	336,000	879,000	67,000	92,000	585,000	744,000
2028	Dry	141,000	272,000	3,000	0	6,000	112,000	11,000	277,000	823,000	58,000	77,000	601,000	735,000
2029	Dry	141,000	272,000	3,000	0	6,000	115,000	11,000	217,000	764,000	49,000	64,000	575,000	689,000
2030	Shasta Critical	122,000	244,000	2,000	0	6,000	186,000	8,000	155,000	722,000	47,000	59,000	585,000	691,000
2031	Shasta Critical	122,000	244,000	2,000	0	6,000	186,000	8,000	165,000	732,000	48,000	63,000	582,000	694,000
2032	Wet	118,000	332,000	4,000	0	6,000	97,000	12,000	334,000	903,000	76,000	106,000	699,000	881,000
2033	Dry	141,000	272,000	3,000	0	6,000	116,000	11,000	189,000	739,000	48,000	63,000	564,000	676,000
2034	Wet	118,000	332,000	4,000	0	6,000	80,000	12,000	341,000	893,000	76,000	107,000	659,000	842,000
2035	Wet	118,000	332,000	4,000	0	6,000	91,000	12,000	332,000	894,000	74,000	101,000	695,000	870,000
2036	Wet	118,000	332,000	4,000	0	6,000	140,000	12,000	289,000	900,000	72,000	98,000	719,000	889,000
2037	Wet	118,000	332,000	4,000	0	6,000	83,000	12,000	393,000	948,000	85,000	127,000	653,000	866,000
2038	Average	126,000	310,000	3,000	0	6,000	152,000	10,000	196,000	805,000	59,000	84,000	593,000	735,000
2039	Average	126,000	310,000	3,000	0	6,000	167,000	10,000	177,000	800,000	55,000	72,000	615,000	742,000
2040	Dry	141,000	272,000	3,000	0	6,000	141,000	11,000	199,000	773,000	54,000	77,000	573,000	704,000
2041	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	152,000	739,000	48,000	62,000	571,000	682,000
2042	Average	126,000	310,000	3,000	0	6,000	153,000	10,000	200,000	809,000	58,000	81,000	606,000	746,000
2043	Dry	141,000	272,000	3,000	0	7,000	151,000	11,000	174,000	759,000	53,000	73,000	580,000	706,000

Land Surface Water Budget															
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows				
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2044	Wet	118,000	332,000	4,000	0	6,000	110,000	12,000	312,000	894,000	75,000	105,000	662,000	842,000
2045	Wet	118,000	332,000	4,000	0	7,000	121,000	12,000	248,000	841,000	68,000	89,000	663,000	820,000
2046	Dry	141,000	272,000	3,000	0	7,000	156,000	11,000	114,000	704,000	44,000	52,000	560,000	656,000
2047	Dry	141,000	272,000	3,000	0	7,000	170,000	11,000	142,000	746,000	47,000	57,000	598,000	702,000
2048	Average	126,000	310,000	3,000	0	6,000	209,000	10,000	125,000	790,000	53,000	63,000	647,000	762,000
2049	Average	126,000	310,000	3,000	0	6,000	130,000	10,000	227,000	814,000	60,000	90,000	590,000	740,000
2050	Wet	118,000	332,000	4,000	0	7,000	124,000	12,000	258,000	854,000	66,000	84,000	682,000	832,000
2051	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	112,000	699,000	44,000	52,000	559,000	654,000
2052	Dry	141,000	272,000	3,000	0	7,000	143,000	11,000	149,000	726,000	47,000	57,000	568,000	672,000
2053	Shasta Critical	122,000	244,000	2,000	0	7,000	220,000	8,000	128,000	729,000	49,000	62,000	601,000	711,000
2054	Shasta Critical	122,000	244,000	2,000	0	7,000	216,000	8,000	138,000	735,000	40,000	48,000	562,000	650,000
2055	Dry	141,000	272,000	3,000	0	7,000	152,000	11,000	262,000	848,000	56,000	87,000	587,000	730,000
2056	Wet	118,000	332,000	4,000	0	7,000	156,000	12,000	275,000	903,000	68,000	91,000	696,000	855,000
2057	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2058	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2059	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2060	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2061	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2062	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2063	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2064	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2065	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2066	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2067	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2068	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2069	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2070	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
Projected Average		124,000	295,000	3,000	0	6,000	132,000	11,000	246,000	817,000	61,000	83,000	620,000	764,000

[1] Runoff includes return flows to all surface water sources leaving the Plan Area. Return flows were not separated due to model limitations.

Table 6-4: Baseline Projected Groundwater Budget

Groundwater Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	61,000	45,000	24,000	*131,000*	201,000	8,000	65,000	34,000	*308,000*	(128,000)	(28,000)	(156,000)
2015	Shasta Critical	48,000	45,000	24,000	*117,000*	203,000	8,000	65,000	34,000	*310,000*	(127,000)	(27,000)	(154,000)
2016	Dry	87,000	45,000	24,000	*157,000*	140,000	11,000	65,000	34,000	*251,000*	(102,000)	(14,000)	(115,000)
2017	Wet	90,000	73,000	38,000	*201,000*	127,000	12,000	56,000	30,000	*226,000*	(12,000)	(5,000)	(17,000)
2018	Average	74,000	51,000	27,000	*153,000*	125,000	10,000	62,000	33,000	*230,000*	41,000	8,000	48,000
2019	Wet	107,000	73,000	38,000	*219,000*	89,000	12,000	56,000	30,000	*188,000*	4,000	3,000	7,000
2020	Dry	67,000	45,000	24,000	*136,000*	119,000	11,000	65,000	34,000	*230,000*	(111,000)	(19,000)	(130,000)
2021	Wet	107,000	73,000	38,000	*219,000*	90,000	12,000	56,000	30,000	*189,000*	4,000	3,000	7,000
2022	Wet	114,000	73,000	38,000	*226,000*	84,000	12,000	56,000	30,000	*182,000*	18,000	10,000	28,000
2023	Average	93,000	51,000	27,000	*172,000*	114,000	10,000	62,000	33,000	*219,000*	67,000	22,000	88,000
2024	Dry	89,000	45,000	24,000	*158,000*	115,000	11,000	65,000	34,000	*226,000*	(89,000)	(7,000)	(97,000)
2025	Wet	120,000	73,000	38,000	*232,000*	85,000	12,000	56,000	30,000	*184,000*	28,000	15,000	43,000
2026	Dry	86,000	45,000	24,000	*155,000*	116,000	11,000	65,000	34,000	*227,000*	(93,000)	(9,000)	(102,000)
2027	Dry	92,000	45,000	24,000	*161,000*	116,000	11,000	65,000	34,000	*227,000*	(86,000)	(6,000)	(92,000)
2028	Dry	77,000	45,000	24,000	*146,000*	118,000	11,000	65,000	34,000	*229,000*	(98,000)	(12,000)	(110,000)
2029	Dry	64,000	45,000	24,000	*134,000*	121,000	11,000	65,000	34,000	*231,000*	(110,000)	(18,000)	(128,000)
2030	Shasta Critical	59,000	45,000	24,000	*128,000*	192,000	8,000	65,000	34,000	*299,000*	(123,000)	(25,000)	(147,000)
2031	Shasta Critical	63,000	45,000	24,000	*133,000*	192,000	8,000	65,000	34,000	*299,000*	(121,000)	(24,000)	(144,000)
2032	Wet	106,000	73,000	38,000	*218,000*	103,000	12,000	56,000	30,000	*202,000*	2,000	2,000	4,000
2033	Dry	63,000	45,000	24,000	*133,000*	122,000	11,000	65,000	34,000	*233,000*	(116,000)	(21,000)	(137,000)
2034	Wet	107,000	73,000	38,000	*219,000*	86,000	12,000	56,000	30,000	*185,000*	4,000	3,000	6,000
2035	Wet	101,000	73,000	38,000	*213,000*	97,000	12,000	56,000	30,000	*196,000*	2,000	2,000	4,000
2036	Wet	98,000	73,000	38,000	*209,000*	146,000	12,000	56,000	30,000	*244,000*	(7,000)	(3,000)	(9,000)
2037	Wet	127,000	73,000	38,000	*239,000*	89,000	12,000	56,000	30,000	*188,000*	14,000	8,000	22,000
2038	Average	84,000	51,000	27,000	*162,000*	158,000	10,000	62,000	33,000	*263,000*	41,000	8,000	48,000
2039	Average	72,000	51,000	27,000	*151,000*	173,000	10,000	62,000	33,000	*279,000*	37,000	6,000	43,000
2040	Dry	77,000	45,000	24,000	*146,000*	147,000	11,000	65,000	34,000	*258,000*	(114,000)	(20,000)	(134,000)
2041	Dry	62,000	45,000	24,000	*132,000*	159,000	11,000	65,000	34,000	*270,000*	(123,000)	(25,000)	(148,000)
2042	Average	81,000	51,000	27,000	*160,000*	159,000	10,000	62,000	33,000	*264,000*	41,000	8,000	50,000
2043	Dry	73,000	45,000	24,000	*143,000*	158,000	11,000	65,000	34,000	*269,000*	(119,000)	(23,000)	(141,000)
2044	Wet	105,000	73,000	38,000	*217,000*	116,000	12,000	56,000	30,000	*215,000*	(2,000)	0	(2,000)

Groundwater Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2045	Wet	89,000	73,000	38,000	*201,000*	127,000	12,000	56,000	30,000	*226,000*	(15,000)	(7,000)	(22,000)
2046	Dry	52,000	45,000	24,000	*122,000*	163,000	11,000	65,000	34,000	*274,000*	(131,000)	(29,000)	(160,000)
2047	Dry	57,000	45,000	24,000	*127,000*	177,000	11,000	65,000	34,000	*288,000*	(125,000)	(26,000)	(151,000)
2048	Average	63,000	51,000	27,000	*142,000*	215,000	10,000	62,000	33,000	*321,000*	26,000	0	27,000
2049	Average	90,000	51,000	27,000	*169,000*	137,000	10,000	62,000	33,000	*242,000*	47,000	11,000	58,000
2050	Wet	84,000	73,000	38,000	*195,000*	130,000	12,000	56,000	30,000	*229,000*	(13,000)	(6,000)	(19,000)
2051	Dry	52,000	45,000	24,000	*121,000*	160,000	11,000	65,000	34,000	*271,000*	(131,000)	(29,000)	(160,000)
2052	Dry	57,000	45,000	24,000	*127,000*	150,000	11,000	65,000	34,000	*260,000*	(124,000)	(25,000)	(149,000)
2053	Shasta Critical	62,000	45,000	24,000	*131,000*	227,000	8,000	65,000	34,000	*334,000*	(128,000)	(27,000)	(155,000)
2054	Shasta Critical	48,000	45,000	24,000	*117,000*	223,000	8,000	65,000	34,000	*330,000*	(126,000)	(26,000)	(152,000)
2055	Dry	87,000	45,000	24,000	*156,000*	159,000	11,000	65,000	34,000	*270,000*	(101,000)	(13,000)	(114,000)
2056	Wet	91,000	73,000	38,000	*203,000*	162,000	12,000	56,000	30,000	*261,000*	(9,000)	(4,000)	(14,000)
2057	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
2058	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*	41,000	8,000	49,000
2059	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
2060	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*	(111,000)	(19,000)	(130,000)
2061	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
2062	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*	41,000	8,000	49,000
2063	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*	41,000	8,000	49,000
2064	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*	(111,000)	(19,000)	(130,000)
2065	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*	41,000	8,000	49,000
2066	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
2067	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
2068	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*	(111,000)	(19,000)	(130,000)
2069	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*	(111,000)	(19,000)	(130,000)
2070	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*	4,000	3,000	7,000
Projected Average		83,000	56,000	30,000	169,000	138,000	11,000	62,000	32,000	243,000	(43,000)	(7,000)	(50,000)

Table 6-5: Projected Land Surface Water Budget with Climate Change

Land Surface Water Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	208,000	8,000	131,000	686,000	48,000	63,000	598,000	709,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	196,000	8,000	141,000	620,000	39,000	49,000	543,000	631,000
2016	Dry	80,000	231,000	3,000	0	4,000	130,000	11,000	280,000	738,000	57,000	93,000	574,000	724,000
2017	Wet	74,000	303,000	3,000	0	4,000	125,000	12,000	259,000	781,000	64,000	88,000	649,000	801,000
2018	Average	60,000	320,000	2,000	0	4,000	120,000	10,000	200,000	717,000	52,000	75,000	586,000	712,000
2019	Wet	118,000	332,000	4,000	0	4,000	84,000	12,000	347,000	900,000	76,000	109,000	684,000	869,000
2020	Dry	141,000	272,000	3,000	0	5,000	117,000	11,000	200,000	749,000	48,000	64,000	583,000	695,000
2021	Wet	118,000	332,000	4,000	0	4,000	83,000	12,000	351,000	904,000	76,000	109,000	685,000	870,000
2022	Wet	118,000	332,000	4,000	0	5,000	77,000	12,000	437,000	984,000	84,000	118,000	701,000	902,000
2023	Average	126,000	310,000	3,000	0	5,000	106,000	10,000	342,000	903,000	67,000	97,000	618,000	783,000
2024	Dry	141,000	272,000	3,000	0	5,000	109,000	11,000	325,000	866,000	65,000	89,000	596,000	750,000
2025	Wet	118,000	332,000	4,000	0	5,000	79,000	12,000	460,000	1,010,000	86,000	119,000	696,000	901,000
2026	Dry	141,000	272,000	3,000	0	6,000	108,000	11,000	315,000	856,000	63,000	88,000	595,000	746,000
2027	Dry	141,000	272,000	3,000	0	6,000	108,000	11,000	343,000	884,000	68,000	94,000	587,000	748,000
2028	Dry	141,000	272,000	3,000	0	6,000	110,000	11,000	296,000	839,000	60,000	80,000	604,000	744,000
2029	Dry	141,000	272,000	3,000	0	6,000	113,000	11,000	223,000	768,000	49,000	65,000	577,000	691,000
2030	Shasta Critical	122,000	244,000	2,000	0	6,000	185,000	8,000	156,000	722,000	46,000	59,000	586,000	691,000
2031	Shasta Critical	122,000	244,000	2,000	0	6,000	184,000	8,000	173,000	738,000	49,000	65,000	584,000	697,000
2032	Wet	118,000	332,000	4,000	0	6,000	93,000	12,000	347,000	911,000	77,000	109,000	699,000	885,000
2033	Dry	141,000	272,000	3,000	0	6,000	115,000	11,000	196,000	743,000	49,000	64,000	565,000	679,000
2034	Wet	118,000	332,000	4,000	0	6,000	79,000	12,000	345,000	895,000	76,000	108,000	660,000	843,000
2035	Wet	118,000	332,000	4,000	0	6,000	88,000	12,000	342,000	901,000	75,000	104,000	695,000	874,000
2036	Wet	118,000	332,000	4,000	0	6,000	128,000	12,000	337,000	936,000	78,000	110,000	719,000	908,000
2037	Wet	118,000	332,000	4,000	0	6,000	87,000	12,000	382,000	940,000	83,000	124,000	654,000	861,000
2038	Average	126,000	310,000	3,000	0	6,000	152,000	10,000	199,000	806,000	59,000	84,000	593,000	736,000
2039	Average	126,000	310,000	3,000	0	6,000	169,000	10,000	171,000	796,000	54,000	71,000	615,000	740,000
2040	Dry	141,000	272,000	3,000	0	6,000	139,000	11,000	204,000	777,000	54,000	77,000	574,000	706,000
2041	Dry	141,000	272,000	3,000	0	7,000	151,000	11,000	158,000	743,000	49,000	63,000	573,000	685,000
2042	Average	126,000	310,000	3,000	0	6,000	150,000	10,000	207,000	813,000	58,000	82,000	608,000	748,000
2043	Dry	141,000	272,000	3,000	0	7,000	146,000	11,000	197,000	777,000	55,000	80,000	582,000	717,000

Land Surface Water Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2044	Wet	118,000	332,000	4,000	0	6,000	107,000	12,000	320,000	900,000	76,000	106,000	663,000	846,000
2045	Wet	118,000	332,000	4,000	0	7,000	123,000	12,000	241,000	836,000	67,000	86,000	665,000	817,000
2046	Dry	141,000	272,000	3,000	0	7,000	157,000	11,000	112,000	703,000	44,000	51,000	560,000	655,000
2047	Dry	141,000	272,000	3,000	0	7,000	167,000	11,000	158,000	759,000	48,000	60,000	601,000	709,000
2048	Average	126,000	310,000	3,000	0	6,000	210,000	10,000	119,000	786,000	52,000	61,000	648,000	760,000
2049	Average	126,000	310,000	3,000	0	6,000	127,000	10,000	238,000	821,000	61,000	92,000	591,000	744,000
2050	Wet	118,000	332,000	4,000	0	7,000	123,000	12,000	259,000	854,000	65,000	82,000	685,000	832,000
2051	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	112,000	699,000	44,000	51,000	560,000	655,000
2052	Dry	141,000	272,000	3,000	0	7,000	142,000	11,000	149,000	726,000	45,000	55,000	570,000	671,000
2053	Shasta Critical	122,000	244,000	2,000	0	7,000	222,000	8,000	121,000	725,000	48,000	59,000	600,000	707,000
2054	Shasta Critical	122,000	244,000	2,000	0	7,000	216,000	8,000	138,000	735,000	40,000	47,000	563,000	650,000
2055	Dry	141,000	272,000	3,000	0	7,000	155,000	11,000	252,000	841,000	54,000	82,000	590,000	725,000
2056	Wet	118,000	332,000	4,000	0	7,000	154,000	12,000	279,000	905,000	67,000	90,000	699,000	856,000
2057	Wet	118,000	332,000	4,000	0	7,000	97,000	12,000	339,000	909,000	75,000	104,000	687,000	866,000
2058	Average	126,000	310,000	3,000	0	6,000	149,000	10,000	193,000	798,000	55,000	74,000	609,000	738,000
2059	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	345,000	913,000	77,000	107,000	685,000	869,000
2060	Dry	141,000	272,000	3,000	0	7,000	130,000	11,000	198,000	762,000	49,000	63,000	584,000	695,000
2061	Wet	118,000	332,000	4,000	0	7,000	95,000	12,000	347,000	913,000	76,000	106,000	688,000	869,000
2062	Average	126,000	310,000	3,000	0	6,000	150,000	10,000	192,000	798,000	55,000	75,000	609,000	739,000
2063	Average	126,000	310,000	3,000	0	6,000	148,000	10,000	197,000	801,000	56,000	76,000	609,000	740,000
2064	Dry	141,000	272,000	3,000	0	7,000	127,000	11,000	211,000	772,000	50,000	65,000	585,000	700,000
2065	Average	126,000	310,000	3,000	0	6,000	145,000	10,000	206,000	808,000	57,000	78,000	609,000	744,000
2066	Wet	118,000	332,000	4,000	0	7,000	97,000	12,000	340,000	909,000	75,000	105,000	687,000	867,000
2067	Wet	118,000	332,000	4,000	0	7,000	94,000	12,000	349,000	915,000	76,000	107,000	687,000	871,000
2068	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	205,000	765,000	49,000	63,000	586,000	698,000
2069	Dry	141,000	272,000	3,000	0	7,000	125,000	11,000	210,000	770,000	50,000	65,000	586,000	700,000
2070	Wet	118,000	332,000	4,000	0	7,000	95,000	12,000	344,000	911,000	76,000	106,000	687,000	868,000
Projected Average		124,000	295,000	3,000	0	6,000	131,000	11,000	250,000	820,000	60,000	83,000	622,000	765,000

[1] Runoff includes return flows to all surface water sources leaving the Plan Area. Return flows were not separated due to model limitations.

Table 6-6: Projected Groundwater Budget with Climate Change

Groundwater Budget													
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	63,000	45,000	24,000	132,000	*212,000*	*8,000*	*65,000*	*34,000*	319,000	(135,000)	(29,000)	(164,000)
2015	Shasta Critical	49,000	45,000	24,000	118,000	*200,000*	*8,000*	*65,000*	*34,000*	308,000	(123,000)	(26,000)	(148,000)
2016	Dry	93,000	45,000	24,000	162,000	*134,000*	*11,000*	*65,000*	*34,000*	244,000	(87,000)	(10,000)	(97,000)
2017	Wet	88,000	73,000	38,000	199,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000	(17,000)	(6,000)	(23,000)
2018	Average	75,000	51,000	27,000	154,000	*124,000*	*10,000*	*62,000*	*33,000*	229,000	43,000	8,000	52,000
2019	Wet	109,000	73,000	38,000	220,000	*88,000*	*12,000*	*56,000*	*30,000*	186,000	7,000	4,000	11,000
2020	Dry	64,000	45,000	24,000	133,000	*122,000*	*11,000*	*65,000*	*34,000*	232,000	(119,000)	(20,000)	(139,000)
2021	Wet	109,000	73,000	38,000	221,000	*87,000*	*12,000*	*56,000*	*30,000*	186,000	10,000	4,000	14,000
2022	Wet	118,000	73,000	38,000	229,000	*82,000*	*12,000*	*56,000*	*30,000*	180,000	28,000	13,000	41,000
2023	Average	97,000	51,000	27,000	176,000	*111,000*	*10,000*	*62,000*	*33,000*	216,000	76,000	24,000	100,000
2024	Dry	89,000	45,000	24,000	159,000	*115,000*	*11,000*	*65,000*	*34,000*	225,000	(88,000)	(7,000)	(94,000)
2025	Wet	119,000	73,000	38,000	231,000	*84,000*	*12,000*	*56,000*	*30,000*	183,000	28,000	15,000	43,000
2026	Dry	88,000	45,000	24,000	157,000	*113,000*	*11,000*	*65,000*	*34,000*	224,000	(86,000)	(7,000)	(93,000)
2027	Dry	94,000	45,000	24,000	163,000	*114,000*	*11,000*	*65,000*	*34,000*	225,000	(81,000)	(4,000)	(85,000)
2028	Dry	80,000	45,000	24,000	149,000	*116,000*	*11,000*	*65,000*	*34,000*	227,000	(90,000)	(9,000)	(99,000)
2029	Dry	65,000	45,000	24,000	135,000	*118,000*	*11,000*	*65,000*	*34,000*	229,000	(106,000)	(17,000)	(123,000)
2030	Shasta Critical	59,000	45,000	24,000	128,000	*191,000*	*8,000*	*65,000*	*34,000*	298,000	(121,000)	(24,000)	(146,000)
2031	Shasta Critical	65,000	45,000	24,000	134,000	*190,000*	*8,000*	*65,000*	*34,000*	297,000	(115,000)	(22,000)	(138,000)
2032	Wet	109,000	73,000	38,000	221,000	*98,000*	*12,000*	*56,000*	*30,000*	197,000	12,000	4,000	16,000
2033	Dry	64,000	45,000	24,000	134,000	*121,000*	*11,000*	*65,000*	*34,000*	231,000	(112,000)	(20,000)	(132,000)
2034	Wet	108,000	73,000	38,000	219,000	*84,000*	*12,000*	*56,000*	*30,000*	183,000	6,000	3,000	10,000
2035	Wet	104,000	73,000	38,000	216,000	*93,000*	*12,000*	*56,000*	*30,000*	192,000	10,000	4,000	13,000
2036	Wet	110,000	73,000	38,000	222,000	*134,000*	*12,000*	*56,000*	*30,000*	232,000	26,000	4,000	30,000
2037	Wet	124,000	73,000	38,000	235,000	*92,000*	*12,000*	*56,000*	*30,000*	191,000	5,000	7,000	12,000
2038	Average	84,000	51,000	27,000	163,000	*158,000*	*10,000*	*62,000*	*33,000*	263,000	42,000	8,000	50,000
2039	Average	71,000	51,000	27,000	149,000	*175,000*	*10,000*	*62,000*	*33,000*	281,000	33,000	5,000	37,000
2040	Dry	77,000	45,000	24,000	147,000	*146,000*	*11,000*	*65,000*	*34,000*	256,000	(111,000)	(19,000)	(130,000)
2041	Dry	63,000	45,000	24,000	133,000	*158,000*	*11,000*	*65,000*	*34,000*	269,000	(120,000)	(24,000)	(144,000)
2042	Average	82,000	51,000	27,000	161,000	*156,000*	*10,000*	*62,000*	*33,000*	262,000	46,000	9,000	55,000
2043	Dry	80,000	45,000	24,000	149,000	*153,000*	*11,000*	*65,000*	*34,000*	263,000	(103,000)	(19,000)	(122,000)
2044	Wet	106,000	73,000	38,000	218,000	*114,000*	*12,000*	*56,000*	*30,000*	213,000	3,000	1,000	4,000

Groundwater Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2045	Wet	86,000	73,000	38,000	197,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000	(22,000)	(8,000)	(30,000)
2046	Dry	51,000	45,000	24,000	120,000	*164,000*	*11,000*	*65,000*	*34,000*	274,000	(133,000)	(29,000)	(162,000)
2047	Dry	60,000	45,000	24,000	129,000	*174,000*	*11,000*	*65,000*	*34,000*	284,000	(116,000)	(24,000)	(140,000)
2048	Average	61,000	51,000	27,000	140,000	*217,000*	*10,000*	*62,000*	*33,000*	322,000	22,000	(1,000)	21,000
2049	Average	92,000	51,000	27,000	171,000	*133,000*	*10,000*	*62,000*	*33,000*	238,000	54,000	13,000	67,000
2050	Wet	82,000	73,000	38,000	194,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000	(13,000)	(6,000)	(19,000)
2051	Dry	51,000	45,000	24,000	120,000	*160,000*	*11,000*	*65,000*	*34,000*	270,000	(132,000)	(29,000)	(161,000)
2052	Dry	55,000	45,000	24,000	125,000	*149,000*	*11,000*	*65,000*	*34,000*	260,000	(125,000)	(25,000)	(150,000)
2053	Shasta Critical	59,000	45,000	24,000	129,000	*229,000*	*8,000*	*65,000*	*34,000*	336,000	(133,000)	(28,000)	(162,000)
2054	Shasta Critical	47,000	45,000	24,000	117,000	*223,000*	*8,000*	*65,000*	*34,000*	330,000	(126,000)	(26,000)	(153,000)
2055	Dry	82,000	45,000	24,000	151,000	*161,000*	*11,000*	*65,000*	*34,000*	272,000	(110,000)	(15,000)	(125,000)
2056	Wet	90,000	73,000	38,000	201,000	*160,000*	*12,000*	*56,000*	*30,000*	259,000	(8,000)	(3,000)	(12,000)
2057	Wet	104,000	73,000	38,000	216,000	*104,000*	*12,000*	*56,000*	*30,000*	202,000	0	2,000	2,000
2058	Average	74,000	51,000	27,000	153,000	*156,000*	*10,000*	*62,000*	*33,000*	261,000	35,000	7,000	42,000
2059	Wet	107,000	73,000	38,000	219,000	*102,000*	*12,000*	*56,000*	*30,000*	201,000	5,000	3,000	9,000
2060	Dry	63,000	45,000	24,000	132,000	*137,000*	*11,000*	*65,000*	*34,000*	247,000	(122,000)	(21,000)	(142,000)
2061	Wet	106,000	73,000	38,000	217,000	*101,000*	*12,000*	*56,000*	*30,000*	200,000	5,000	4,000	8,000
2062	Average	75,000	51,000	27,000	153,000	*156,000*	*10,000*	*62,000*	*33,000*	261,000	35,000	7,000	42,000
2063	Average	76,000	51,000	27,000	154,000	*154,000*	*10,000*	*62,000*	*33,000*	260,000	38,000	8,000	46,000
2064	Dry	65,000	45,000	24,000	135,000	*134,000*	*11,000*	*65,000*	*34,000*	244,000	(114,000)	(19,000)	(133,000)
2065	Average	78,000	51,000	27,000	157,000	*152,000*	*10,000*	*62,000*	*33,000*	257,000	45,000	9,000	54,000
2066	Wet	105,000	73,000	38,000	216,000	*104,000*	*12,000*	*56,000*	*30,000*	202,000	0	3,000	3,000
2067	Wet	107,000	73,000	38,000	218,000	*101,000*	*12,000*	*56,000*	*30,000*	199,000	7,000	4,000	11,000
2068	Dry	63,000	45,000	24,000	132,000	*133,000*	*11,000*	*65,000*	*34,000*	244,000	(117,000)	(19,000)	(137,000)
2069	Dry	65,000	45,000	24,000	135,000	*132,000*	*11,000*	*65,000*	*34,000*	243,000	(113,000)	(19,000)	(132,000)
2070	Wet	106,000	73,000	38,000	217,000	*102,000*	*12,000*	*56,000*	*30,000*	201,000	3,000	3,000	7,000
Projected Average		83,000	56,000	30,000	169,000	137,000	11,000	62,000	32,000	242,000	(42,000)	(6,000)	(48,000)

Table 6-7: Projected Land Surface Water Budget with Climate Change and Projects & Management Actions

Land Surface Water Budget															
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows				
		Surface Water Deliveries [1]				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [2]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	208,000	8,000	131,000	686,000	48,000	63,000	598,000	709,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	196,000	8,000	141,000	620,000	39,000	49,000	543,000	631,000
2016	Dry	80,000	231,000	3,000	0	4,000	130,000	11,000	280,000	738,000	57,000	93,000	574,000	724,000
2017	Wet	74,000	303,000	3,000	0	4,000	125,000	12,000	259,000	781,000	64,000	88,000	649,000	801,000
2018	Average	60,000	320,000	2,000	0	4,000	114,000	10,000	200,000	710,000	51,000	75,000	586,000	712,000
2019	Wet	118,000	332,000	4,000	2,000	4,000	76,000	12,000	347,000	895,000	76,000	108,000	684,000	868,000
2020	Dry	141,000	272,000	3,000	9,000	5,000	111,000	11,000	200,000	752,000	48,000	67,000	583,000	698,000
2021	Wet	118,000	332,000	4,000	7,000	4,000	76,000	12,000	351,000	904,000	76,000	119,000	685,000	881,000
2022	Wet	118,000	332,000	4,000	7,000	5,000	70,000	12,000	437,000	984,000	83,000	128,000	701,000	912,000
2023	Average	126,000	310,000	3,000	6,000	5,000	98,000	10,000	342,000	901,000	67,000	100,000	618,000	785,000
2024	Dry	141,000	272,000	3,000	6,000	5,000	106,000	11,000	325,000	869,000	65,000	92,000	596,000	753,000
2025	Wet	118,000	332,000	4,000	7,000	5,000	72,000	12,000	460,000	1,010,000	86,000	130,000	696,000	912,000
2026	Dry	141,000	272,000	3,000	52,000	6,000	64,000	11,000	315,000	864,000	63,000	94,000	595,000	753,000
2027	Dry	141,000	272,000	3,000	49,000	6,000	67,000	11,000	343,000	893,000	68,000	103,000	587,000	758,000
2028	Dry	141,000	272,000	3,000	50,000	6,000	69,000	11,000	296,000	847,000	60,000	89,000	604,000	753,000
2029	Dry	141,000	272,000	3,000	55,000	6,000	66,000	11,000	223,000	778,000	50,000	75,000	577,000	701,000
2030	Shasta Critical	122,000	244,000	2,000	49,000	6,000	138,000	8,000	156,000	725,000	46,000	68,000	586,000	700,000
2031	Shasta Critical	122,000	244,000	2,000	51,000	6,000	136,000	8,000	173,000	741,000	49,000	74,000	584,000	706,000
2032	Wet	118,000	332,000	4,000	46,000	6,000	62,000	12,000	347,000	925,000	78,000	131,000	699,000	909,000
2033	Dry	141,000	272,000	3,000	60,000	6,000	68,000	11,000	196,000	757,000	50,000	75,000	565,000	690,000
2034	Wet	118,000	332,000	4,000	47,000	6,000	49,000	12,000	345,000	913,000	77,000	130,000	660,000	867,000
2035	Wet	118,000	332,000	4,000	48,000	6,000	55,000	12,000	342,000	917,000	76,000	126,000	695,000	898,000
2036	Wet	118,000	332,000	4,000	50,000	6,000	97,000	12,000	337,000	955,000	79,000	133,000	719,000	931,000
2037	Wet	118,000	332,000	4,000	49,000	6,000	58,000	12,000	382,000	961,000	85,000	146,000	654,000	885,000
2038	Average	126,000	310,000	3,000	53,000	6,000	105,000	10,000	199,000	812,000	59,000	99,000	593,000	751,000
2039	Average	126,000	310,000	3,000	52,000	6,000	123,000	10,000	171,000	801,000	54,000	86,000	615,000	756,000
2040	Dry	141,000	272,000	3,000	66,000	6,000	94,000	11,000	204,000	797,000	55,000	88,000	574,000	717,000
2041	Dry	141,000	272,000	3,000	62,000	7,000	99,000	11,000	158,000	753,000	49,000	73,000	573,000	695,000
2042	Average	126,000	310,000	3,000	51,000	6,000	104,000	10,000	207,000	819,000	59,000	97,000	608,000	763,000
2043	Dry	141,000	272,000	3,000	68,000	7,000	98,000	11,000	197,000	797,000	57,000	90,000	582,000	729,000

Land Surface Water Budget														
		Inflows									Outflows			
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Surface Water Deliveries [1]				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [2]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2044	Wet	118,000	332,000	4,000	53,000	6,000	70,000	12,000	320,000	916,000	77,000	129,000	663,000	870,000
2045	Wet	118,000	332,000	4,000	53,000	7,000	78,000	12,000	241,000	844,000	67,000	108,000	665,000	840,000
2046	Dry	141,000	272,000	3,000	68,000	7,000	100,000	11,000	112,000	714,000	44,000	61,000	560,000	666,000
2047	Dry	141,000	272,000	3,000	64,000	7,000	111,000	11,000	158,000	768,000	48,000	70,000	601,000	719,000
2048	Average	126,000	310,000	3,000	49,000	6,000	161,000	10,000	119,000	786,000	52,000	75,000	648,000	775,000
2049	Average	126,000	310,000	3,000	62,000	6,000	98,000	10,000	238,000	854,000	63,000	108,000	591,000	762,000
2050	Wet	118,000	332,000	4,000	54,000	7,000	83,000	12,000	259,000	869,000	66,000	105,000	685,000	856,000
2051	Dry	141,000	272,000	3,000	69,000	7,000	102,000	11,000	112,000	718,000	45,000	61,000	560,000	666,000
2052	Dry	141,000	272,000	3,000	67,000	7,000	97,000	11,000	149,000	747,000	47,000	66,000	570,000	682,000
2053	Shasta Critical	122,000	244,000	2,000	47,000	7,000	178,000	8,000	121,000	728,000	48,000	68,000	600,000	716,000
2054	Shasta Critical	122,000	244,000	2,000	34,000	7,000	187,000	8,000	138,000	740,000	40,000	55,000	563,000	658,000
2055	Dry	141,000	272,000	3,000	49,000	7,000	115,000	11,000	252,000	851,000	54,000	91,000	590,000	735,000
2056	Wet	118,000	332,000	4,000	46,000	7,000	109,000	12,000	279,000	906,000	67,000	112,000	699,000	878,000
2057	Wet	118,000	332,000	4,000	55,000	7,000	63,000	12,000	339,000	930,000	77,000	127,000	687,000	891,000
2058	Average	126,000	310,000	3,000	54,000	6,000	100,000	10,000	193,000	803,000	55,000	90,000	609,000	754,000
2059	Wet	118,000	332,000	4,000	55,000	7,000	62,000	12,000	345,000	935,000	78,000	130,000	685,000	893,000
2060	Dry	141,000	272,000	3,000	69,000	7,000	78,000	11,000	198,000	779,000	50,000	73,000	584,000	706,000
2061	Wet	118,000	332,000	4,000	55,000	7,000	61,000	12,000	347,000	936,000	77,000	128,000	688,000	894,000
2062	Average	126,000	310,000	3,000	58,000	6,000	100,000	10,000	192,000	806,000	56,000	90,000	609,000	755,000
2063	Average	126,000	310,000	3,000	54,000	6,000	99,000	10,000	197,000	806,000	56,000	91,000	609,000	756,000
2064	Dry	141,000	272,000	3,000	70,000	7,000	77,000	11,000	211,000	792,000	51,000	76,000	585,000	712,000
2065	Average	126,000	310,000	3,000	58,000	6,000	98,000	10,000	206,000	818,000	57,000	94,000	609,000	760,000
2066	Wet	118,000	332,000	4,000	55,000	7,000	63,000	12,000	340,000	931,000	77,000	127,000	687,000	891,000
2067	Wet	118,000	332,000	4,000	55,000	7,000	61,000	12,000	349,000	938,000	78,000	130,000	687,000	895,000
2068	Dry	141,000	272,000	3,000	69,000	7,000	75,000	11,000	205,000	782,000	50,000	73,000	586,000	709,000
2069	Dry	141,000	272,000	3,000	66,000	7,000	75,000	11,000	210,000	785,000	50,000	75,000	586,000	712,000
2070	Wet	118,000	332,000	4,000	55,000	7,000	62,000	12,000	344,000	933,000	77,000	128,000	687,000	892,000
Projected Average		124,000	295,000	3,000	45,000	6,000	96,000	11,000	250,000	830,000	61,000	95,000	622,000	778,000

[1] Projects & Management Actions aim to increase the amount of Surface Water transfers between GSA Member Agencies by approximately 45,000 AFY. The source of these Surface Water volumes is yet to be determined. The total volume of these transfers will not exceed the cumulative volumes remaining after demands are met within each GSA Member Agency. For a more detailed explanation of these Projects & Management Actions, see Section 7.1 of the *Sustainability Implementation* chapter.

[2] Runoff includes return flows to all surface water sources leaving the Plan Area. Return flows were not separated due to model limitations.

Table 6-8: Projected Groundwater Budget with Climate Change and Projects & Management Actions

Groundwater Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	63,000	45,000	24,000	132,000	212,000	8,000	65,000	34,000	319,000	(135,000)	(29,000)	(164,000)
2015	Shasta Critical	49,000	45,000	24,000	118,000	200,000	8,000	65,000	34,000	308,000	(123,000)	(26,000)	(148,000)
2016	Dry	93,000	45,000	24,000	162,000	134,000	11,000	65,000	34,000	244,000	(87,000)	(10,000)	(97,000)
2017	Wet	88,000	73,000	38,000	199,000	129,000	12,000	56,000	30,000	228,000	(17,000)	(6,000)	(23,000)
2018	Average	75,000	51,000	27,000	153,000	118,000	10,000	62,000	33,000	223,000	43,000	14,000	57,000
2019	Wet	108,000	73,000	38,000	220,000	81,000	12,000	56,000	30,000	179,000	9,000	9,000	18,000
2020	Dry	67,000	45,000	24,000	136,000	115,000	11,000	65,000	34,000	226,000	(112,000)	(17,000)	(129,000)
2021	Wet	119,000	73,000	38,000	231,000	80,000	12,000	56,000	30,000	179,000	22,000	10,000	31,000
2022	Wet	128,000	73,000	38,000	239,000	75,000	12,000	56,000	30,000	173,000	40,000	19,000	58,000
2023	Average	100,000	51,000	27,000	179,000	103,000	10,000	62,000	33,000	208,000	80,000	31,000	110,000
2024	Dry	92,000	45,000	24,000	161,000	111,000	11,000	65,000	34,000	222,000	(84,000)	(4,000)	(88,000)
2025	Wet	130,000	73,000	38,000	241,000	78,000	12,000	56,000	30,000	176,000	39,000	21,000	60,000
2026	Dry	94,000	45,000	24,000	164,000	70,000	11,000	65,000	34,000	180,000	(45,000)	2,000	(43,000)
2027	Dry	103,000	45,000	24,000	172,000	73,000	11,000	65,000	34,000	183,000	(39,000)	5,000	(35,000)
2028	Dry	89,000	45,000	24,000	158,000	74,000	11,000	65,000	34,000	185,000	(48,000)	0	(48,000)
2029	Dry	75,000	45,000	24,000	144,000	72,000	11,000	65,000	34,000	183,000	(60,000)	(7,000)	(67,000)
2030	Shasta Critical	68,000	45,000	24,000	137,000	144,000	8,000	65,000	34,000	251,000	(80,000)	(10,000)	(90,000)
2031	Shasta Critical	74,000	45,000	24,000	143,000	142,000	8,000	65,000	34,000	249,000	(73,000)	(8,000)	(81,000)
2032	Wet	131,000	73,000	38,000	243,000	67,000	12,000	56,000	30,000	166,000	57,000	12,000	69,000
2033	Dry	75,000	45,000	24,000	144,000	74,000	11,000	65,000	34,000	185,000	(63,000)	(13,000)	(75,000)
2034	Wet	130,000	73,000	38,000	242,000	55,000	12,000	56,000	30,000	153,000	52,000	10,000	62,000
2035	Wet	126,000	73,000	38,000	238,000	61,000	12,000	56,000	30,000	160,000	55,000	13,000	68,000
2036	Wet	133,000	73,000	38,000	244,000	102,000	12,000	56,000	30,000	201,000	65,000	18,000	83,000
2037	Wet	146,000	73,000	38,000	258,000	64,000	12,000	56,000	30,000	163,000	52,000	10,000	63,000
2038	Average	99,000	51,000	27,000	178,000	111,000	10,000	62,000	33,000	216,000	92,000	20,000	112,000
2039	Average	86,000	51,000	27,000	164,000	129,000	10,000	62,000	33,000	234,000	81,000	17,000	99,000
2040	Dry	88,000	45,000	24,000	157,000	100,000	11,000	65,000	34,000	211,000	(63,000)	(11,000)	(74,000)
2041	Dry	73,000	45,000	24,000	143,000	106,000	11,000	65,000	34,000	216,000	(68,000)	(13,000)	(81,000)
2042	Average	97,000	51,000	27,000	176,000	110,000	10,000	62,000	33,000	216,000	95,000	21,000	116,000
2043	Dry	90,000	45,000	24,000	160,000	104,000	11,000	65,000	34,000	215,000	(55,000)	(9,000)	(63,000)
2044	Wet	129,000	73,000	38,000	241,000	77,000	12,000	56,000	30,000	176,000	53,000	10,000	64,000

Groundwater Budget													
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					Change in Storage		
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows	Upper Aquifer	Lower Aquifer	Total Change in Storage
2045	Wet	108,000	73,000	38,000	220,000	84,000	12,000	56,000	30,000	183,000	31,000	6,000	37,000
2046	Dry	61,000	45,000	24,000	131,000	107,000	11,000	65,000	34,000	218,000	(79,000)	(16,000)	(96,000)
2047	Dry	70,000	45,000	24,000	139,000	118,000	11,000	65,000	34,000	229,000	(63,000)	(11,000)	(75,000)
2048	Average	75,000	51,000	27,000	154,000	168,000	10,000	62,000	33,000	273,000	68,000	17,000	85,000
2049	Average	108,000	51,000	27,000	187,000	104,000	10,000	62,000	33,000	209,000	90,000	22,000	112,000
2050	Wet	105,000	73,000	38,000	216,000	90,000	12,000	56,000	30,000	189,000	37,000	6,000	43,000
2051	Dry	61,000	45,000	24,000	131,000	109,000	11,000	65,000	34,000	220,000	(82,000)	(17,000)	(100,000)
2052	Dry	66,000	45,000	24,000	135,000	104,000	11,000	65,000	34,000	214,000	(80,000)	(14,000)	(94,000)
2053	Shasta Critical	68,000	45,000	24,000	138,000	185,000	8,000	65,000	34,000	292,000	(94,000)	(15,000)	(109,000)
2054	Shasta Critical	55,000	45,000	24,000	125,000	194,000	8,000	65,000	34,000	301,000	(97,000)	(19,000)	(116,000)
2055	Dry	91,000	45,000	24,000	161,000	122,000	11,000	65,000	34,000	233,000	(69,000)	(7,000)	(76,000)
2056	Wet	112,000	73,000	38,000	223,000	116,000	12,000	56,000	30,000	215,000	43,000	11,000	55,000
2057	Wet	127,000	73,000	38,000	239,000	70,000	12,000	56,000	30,000	169,000	46,000	13,000	59,000
2058	Average	90,000	51,000	27,000	168,000	106,000	10,000	62,000	33,000	212,000	86,000	21,000	107,000
2059	Wet	130,000	73,000	38,000	242,000	69,000	12,000	56,000	30,000	167,000	51,000	13,000	65,000
2060	Dry	73,000	45,000	24,000	143,000	85,000	11,000	65,000	34,000	196,000	(71,000)	(10,000)	(80,000)
2061	Wet	128,000	73,000	38,000	240,000	68,000	12,000	56,000	30,000	167,000	51,000	14,000	64,000
2062	Average	90,000	51,000	27,000	169,000	106,000	10,000	62,000	33,000	212,000	86,000	21,000	108,000
2063	Average	91,000	51,000	27,000	169,000	105,000	10,000	62,000	33,000	210,000	89,000	22,000	110,000
2064	Dry	76,000	45,000	24,000	145,000	84,000	11,000	65,000	34,000	195,000	(64,000)	(8,000)	(73,000)
2065	Average	94,000	51,000	27,000	172,000	104,000	10,000	62,000	33,000	210,000	94,000	23,000	117,000
2066	Wet	127,000	73,000	38,000	239,000	70,000	12,000	56,000	30,000	169,000	46,000	13,000	59,000
2067	Wet	130,000	73,000	38,000	241,000	68,000	12,000	56,000	30,000	166,000	53,000	14,000	67,000
2068	Dry	73,000	45,000	24,000	143,000	82,000	11,000	65,000	34,000	192,000	(66,000)	(9,000)	(75,000)
2069	Dry	75,000	45,000	24,000	145,000	82,000	11,000	65,000	34,000	193,000	(63,000)	(8,000)	(71,000)
2070	Wet	128,000	73,000	38,000	240,000	68,000	12,000	56,000	30,000	167,000	50,000	13,000	63,000
Projected Average		95,000	56,000	30,000	181,000	102,000	11,000	62,000	32,000	207,000	(4,000)	3,000	(1,000)

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