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## Appendix E. Hydrologic Modeling

### Technical Memorandum 2

**TO:** Stockton East Water District, Calaveras County Water District

**CC:** California Department of Water Resources

**PREPARED BY:** Andres Diaz, Dominick Amador (Woodard & Curran)

**REVIEWED BY:** Leslie Dumas (Woodard & Curran)

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**RE:** Integrated Surface Water – Groundwater Model Documentation

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## TABLE OF CONTENTS

<b>1.</b>	<b>GENERAL INTRODUCTION</b> .....	<b>6</b>
1.1	Description and Purpose.....	6
1.2	Watershed Setting.....	6
<b>2.</b>	<b>CWRP MODEL SETUP</b> .....	<b>8</b>
2.1	Existing Condition Scenario .....	9
2.1.1	Hydrology.....	9
2.1.2	Evapotranspiration.....	10
2.1.3	Surface Water Operations.....	11
2.1.4	Stream System.....	13
2.1.5	Initial Conditions.....	14
2.2	Climate Change Scenarios.....	15
2.2.1	Precipitation.....	18
2.2.2	Evapotranspiration.....	20
2.3	Adaptation Strategies.....	21
2.3.1	Project Descriptions.....	22
2.3.2	Project Modeling Assumptions.....	23
2.3.3	Water Available for Recharge.....	25
2.3.4	Summary.....	27
<b>3.</b>	<b>CWRP MODEL RESULTS</b> .....	<b>29</b>
3.1	Analytical Framework .....	29
3.2	Land and Water Use.....	31
3.2.1	Existing Conditions .....	31
3.2.2	Climate Vulnerability.....	33

---

3.2.3	Climate Adaptation .....	35
3.3	Stream and Reservoir Systems.....	41
3.3.1	Existing Conditions .....	41
3.3.2	Climate Vulnerability .....	44
3.3.3	Climate Adaptation.....	47
3.4	Groundwater System .....	50
3.4.1	Existing Conditions .....	50
3.4.2	Climate Vulnerability.....	51
3.4.3	Climate Adaptation (Tier 1).....	54
3.4.4	Climate Adaptation (Tier 2).....	58
3.4.5	Climate Adaptation (Scenario Comparison) .....	61
3.4.5.1	Groundwater Storage.....	61
3.4.5.2	Groundwater Levels .....	63
3.4.5.3	Impact on Monitoring Network .....	68
<b>4.</b>	<b>CALAVERAS RIVER WATERSHED WATER BUDGET .....</b>	<b>71</b>
<b>5.</b>	<b>CONCLUSIONS AND NEXT STEPS .....</b>	<b>75</b>
5.1	Highlights.....	75
5.1.1	Climate Vulnerability .....	75
5.1.2	Adaptation Strategies .....	76
5.2	Model Considerations .....	77
<b>6.</b>	<b>REFERENCES .....</b>	<b>79</b>

**FIGURES**

Figure 1. Calaveras River Watershed .....7

Figure 2. Map of the ESJWRM model domain and the Calaveras River Watershed.....9

Figure 3. Annual precipitation under existing conditions (TOP100) ..... 10

Figure 4. Annual Crop Evapotranspiration Rates under Existing conditions (TOP100)..... 11

Figure 5. Agricultural Surface Water Deliveries from Calaveras River to SEWD under Existing conditions (TOP100)..... 12

Figure 6. Agricultural Surface Water Deliveries from Calaveras River to CCWD under Existing conditions (TOP100)..... 13

Figure 7. Map of ESJWRM model with the added stream reaches..... 14

Figure 8. The initial Groundwater level Heads in the CWRP model simulations..... 15

Figure 9. Diagram displaying the stochastic approach towards simulating future climate conditions ..... 16

Figure 10. Projected range of climate changes in the Delta Catchment..... 17

Figure 11. Diagram of the 16 climate condition runs ..... 18

Figure 12. Map displaying the Weather Generator Thiessen Polygons..... 19

Figure 13. Boxplot of annual precipitation for all climate conditions ..... 20

Figure 14. annual Actual evapotranspiration for all climate conditions..... 21

Figure 15. Map of the benefit areas of Tier 1 and Tier 2 scenarios ..... 23

Figure 16. Annual Average Water Available for Recharge with Tier 1 Adaptation Strategies for all climate conditions..... 26

Figure 17. Annual average water available for recharge with Tier 2 Adaptation Strategies for all climate conditions..... 27

Figure 18. Annual time series of water used with Tier 1 Adaptation Strategies under Existing conditions (TOP100)..... 28

Figure 19. Annual Time series of water used with Tier 2 Adaptation Strategies under Existing conditions (TOP100)..... 28

Figure 20. Calaveras River Watershed – Existing Conditions (TOP100)      Agricultural Land and Water Use Budget ..... 32

Figure 21. Calaveras River Watershed – Existing Conditions (TOP100)      Urban Land and Water Use Budget ..... 32

Figure 22. Water Supply Requirement for all climate conditions ..... 33

Figure 23. Surface Water Deliveries For all climate conditions ..... 34

Figure 24. Groundwater pumping for all climate conditions ..... 35

Figure 25. Impact on Surface Water Supply with Tier 1 Adaptation Strategies ..... 36

Figure 26. Impact on Surface Water Supply with Tier 2 Adaptation Strategies ..... 37

Figure 27. annual surface water supply Under Climate Change Conditions (T2P100) ..... 38

Figure 28. Annual Average Direct Recharge from Tier 1 Adaptation Strategies..... 39

Figure 29. annual average direct recharge from Tier 2 Adaptation Strategies..... 39

Figure 30. annual average in-lieu and direct recharge from Tier 1 Adaptation Strategies..... 40

Figure 31. annual average in-lieu and direct recharge from Tier 2 Adaptation Strategies..... 41

Figure 32. Runoff estimates in HUC-12 watersheds for Existing conditions ..... 42

Figure 33. Annual Inflow to New Hogan Reservoir under Existing Conditions (TOP100) ..... 44

Figure 34. Annual new Hogan Inflow for all climate Conditions ..... 45

Figure 35. Monthly Average Inflow to New Hogan Reservoir ..... 46

---

Figure 36. Monthly Maximum Inflow to New Hogan Reservoir .....	46
Figure 37. Daily Inflow to the Calaveras River below New Hogan Under Climate Change Conditions (T2P100) .....	47
Figure 38. Monthly Maximum Flow in the Calaveras River at Bellota Weir Under Climate Change Conditions (T2P100) .....	48
Figure 39. Monthly average Outflow of the Calaveras River to the San Joaquin River Under Climate Change Conditions (T2P100) .....	49
Figure 40. Monthly average Outflow of the Calaveras River to the San Joaquin River in Critical Years Under Climate Change Conditions (T2P100) .....	49
Figure 41. Groundwater Budget Under Existing Conditions (TOP100) .....	51
Figure 42. Annual Change of groundwater in Storage for all climate Conditions .....	52
Figure 43. Cumulative change of Groundwater in storage for all climate Conditions .....	53
Figure 44. Average Annual Change of Groundwater in Storage with No-Action .....	54
Figure 45. Average Annual applied recharge of Tier 1 Adpatation Strategies .....	55
Figure 46. Annual Fate of recharge for Tier 1 Adpatation Strategies Under Climate Change Conditions (T2P100) .....	56
Figure 47. Average Annual Fate of Recharge for Tier 1 Adpatation Strategies for all climate Conditions .....	57
Figure 48. Average Annual Change of Groundwater in Storage with Tier 1 Adaptation Strategies .....	57
Figure 49. Annual averaged applied recharge of Tier 2 Adpatation Strategies .....	58
Figure 50. Annual Fate of recharge for Tier 2 Adpatation Strategies Under Climate Change Conditions (T2P100) .....	59
Figure 51. Average Annual Fate of Recharge for Tier 2 Adpatation Strategies for all climate Conditions .....	60
Figure 52. Average Annual Change of Groundwater in Storage with Tier 2 Adaptation Strategies .....	60
Figure 53. Cumulative change of groundwater in storage Under Climate Change Conditions (T2P100) .....	63
Figure 54. average groundwater level in the Calaveras Watershed Under Climate Change Conditions (T2P100) .....	64
Figure 55. Contours of groundwater level differences at the end of simulation between Tier 1 Adaptation Strategies and No-Actions Under Climate Change Conditions (T2P100) .....	65
Figure 56. Contours of groundwater level differences at the end of simulation between Tier 2 Adaptation Strategies and No-Actions Under Climate Change Conditions (T2P100) .....	66
Figure 57. average groundwater level in the SWED Under Climate Change Conditions (T2P100) .....	67
Figure 58. average groundwater level in the CCWD Under Climate Change Conditions (T2P100) .....	67
Figure 59. Minimum Threshold exceedances Under Climate Change Conditions (T2P100) .....	69
Figure 60. Minimum threshold exceedances Under Climate Change Conditions with Tier 1 Adaptation Strategies (Tier 1-T2P100) .....	70
Figure 61. Minimum Threshold exceedances Under Climate Change Conditions with Tier 2 Adaptation Strategies (Tier 2-T2P100) .....	70

**TABLES**

Table 1. Project Characteristics for Tier 1 and Tier 2 scenarios .....	22
Table 2. Water available for surface water projects (AFY) .....	24
Table 3. Average Yield for Projects .....	25
Table 4. Analytical framework for key metrics used in the resiliency plan .....	30
Table 5. Average Annual Hydrologic conditions in the upper Sub-watersheds .....	43

---

Table 6. Average Annual Change of Groundwater in Storage for no-action, Tier 1, and Tier 2 Scenarios ... 62  
Table 7. Average Groundwater Levels compared against existing conditions after the 50-year simulation  
(Units: Feet)..... 68  
Table 8. Water Budget for Existing Conditions (TOP100) Scenarios..... 71  
Table 9. Water Budget for most likely conditions (T2P100) scenarios..... 73

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# 1. GENERAL INTRODUCTION

## 1.1 Description and Purpose

The Calaveras Watershed Resiliency Plan (CWRP) Model serves as a comprehensive analytical tool for evaluating water resource dynamics and climate adaptation strategies within the Calaveras River Watershed. This model uses the Integrated Water Flow Model (IWF) platform, a robust hydrologic simulation framework capable of representing the interconnected surface water and groundwater systems that characterize California's complex water resources.

The model represents an adaptation of the Eastern San Joaquin Water Resources Model (ESJWRM), which was developed to support the preparation of the Groundwater Sustainability Plan (GSP) for the Eastern San Joaquin (ESJ) Groundwater Subbasin. By leveraging this existing foundation, the Calaveras Watershed model benefits from established calibration data, validated hydrologic parameters, and proven modeling approaches while incorporating watershed-specific refinements.

The model has been configured to address two critical objectives:

- **Climate Vulnerability Assessment:** The model evaluates how changes in temperature, precipitation, and extreme weather events impact both natural and operational conditions within the watershed. This assessment identifies hydrologic risk in surface water supplies, groundwater resources, and ecological conditions under various climate scenarios.
- **Adaptation Strategy Evaluation:** The model serves as a platform to assess the effectiveness of potential adaptation measures. By simulating various projects and management strategies, the study evaluates future hydrologic conditions, validates adaptation concepts, and quantifies the impact and efficacy of proposed actions.

These modeling objectives aim to provide watershed managers and stakeholders with practical information to support planning decisions and prioritize investments that improve water resource resilience under a changing climate.

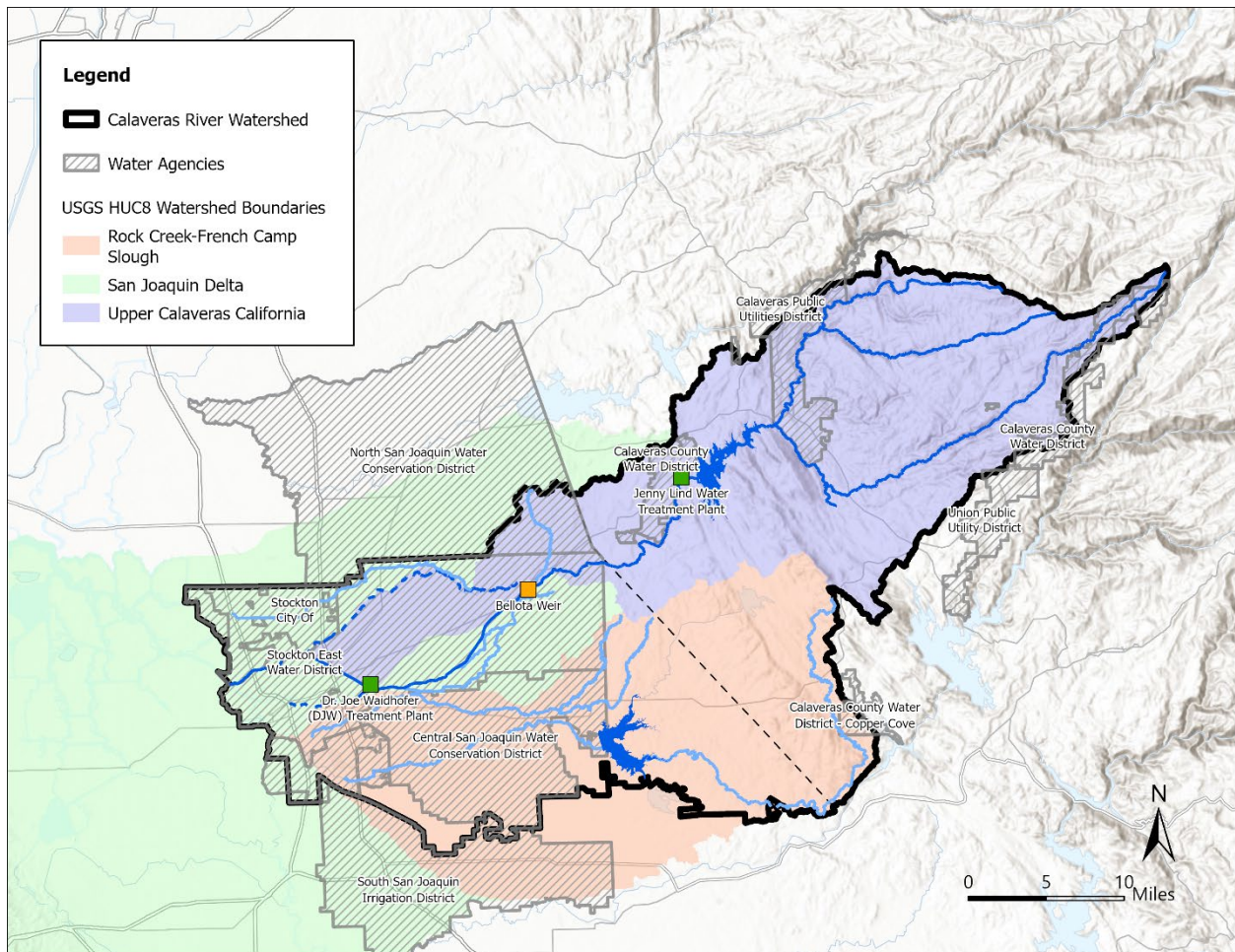
## 1.2 Watershed Setting

The Calaveras River Watershed study area encompasses portions of Calaveras, San Joaquin, and Stanislaus Counties in central California. The watershed extends approximately 84 kilometers from the Sierra Nevada headwaters to its confluence with the San Joaquin River at the City of Stockton. The study boundary was delineated based on hydrologic criteria in the upper river watershed (upstream of New Hogan Dam) and modified to include operational boundaries in the lower watershed to account for irrigation districts whose primary surface water source is the Calaveras River system, specifically Stockton East Water District (SEWD) and Central San Joaquin Water Conservation District (CSJWCD).

The modeling framework divides the watershed into two geographic zones based on hydrologic characteristics and model structure. The upper watershed encompasses the area east of the Eastern San Joaquin Groundwater Subbasin boundary, extending from the Calaveras River's headwaters down to New Hogan Reservoir. The lower watershed consists of all areas where the watershed intersects the ESJ Subbasin

boundary, utilizing the existing ESJWRM model structure to simulate land surface processes, stream dynamics, and groundwater flow. The upper watershed is simulated using a downscaled version of the Sacramento Soil Moisture Accounting Model (SAC-SMA) to represent rainfall-runoff processes and reservoir inflows. The following section describes the detailed configuration and calibration approach for both modeling components.

**FIGURE 1. CALAVERAS RIVER WATERSHED**



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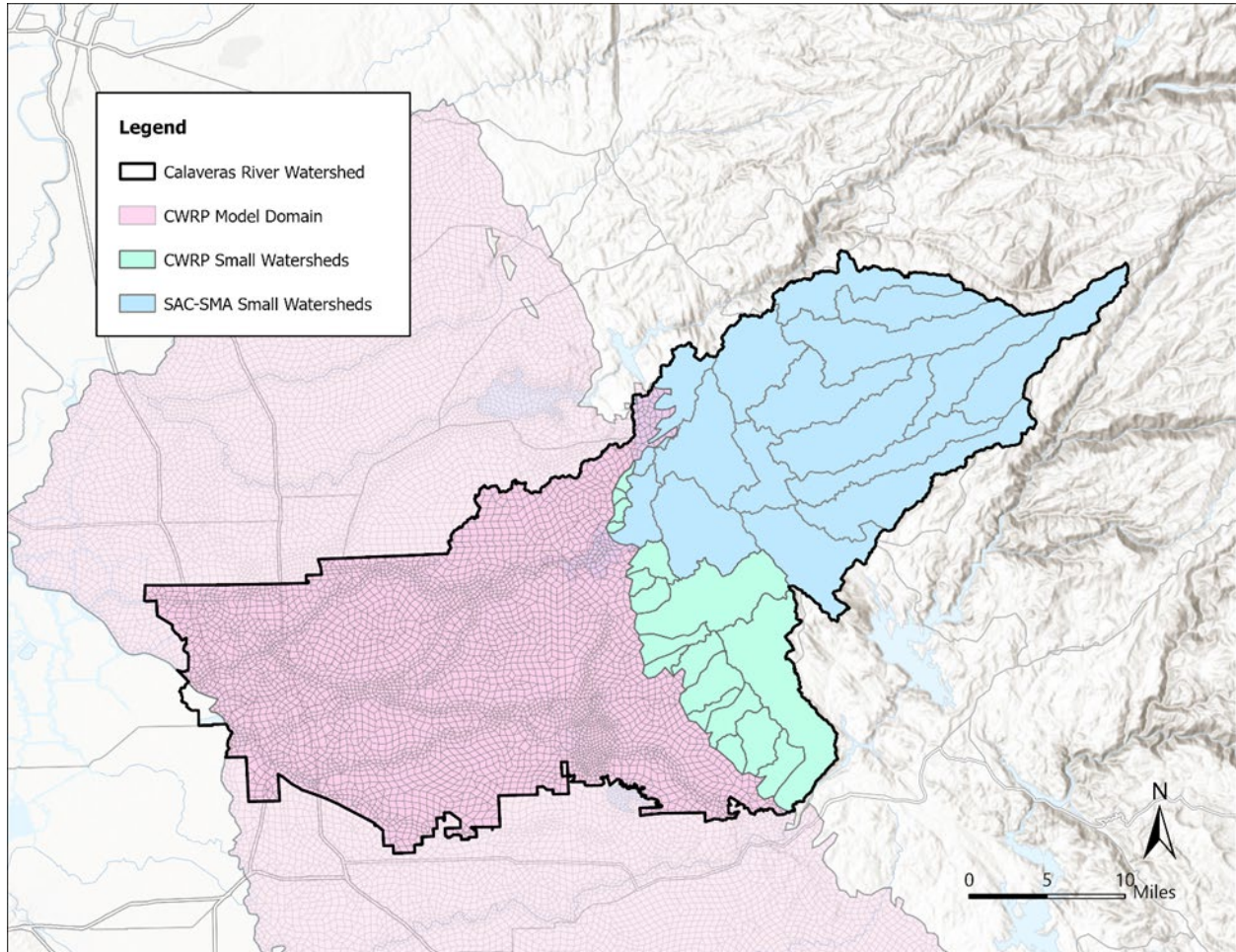
## 2. CWRP MODEL SETUP

The CWRP Model was developed by adapting the ESJWRM Projected Conditions Baseline model scenario. This adaptation involved refinements to enhance the model's capability to simulate climate impacts and adaptation strategies specific to the Calaveras River watershed. Key modifications include integration of updated hydrologic and climatic datasets from the California Department of Water Resources (DWR) Watershed Studies program.

The general model setup encompasses several refinements to components that define the temporal extent, physical processes, and boundary conditions of the simulation. These components include precipitation, which drives runoff generation and recharge processes; evapotranspiration (ET) calculations that represent consumptive losses from native vegetation, crops, and open water; surface water operations and dynamic streams that simulate reservoir management, diversions, and instream flows; initial conditions that establish starting water levels and storage volumes; and boundary conditions that define fluxes entering and leaving the model domain. Each of these components is described in the following subsections, with particular attention to data sources, processing methods, and assumptions that influence model behavior and results.

The extent of the CWRP model and how it covers part of the Calaveras River watershed is shown in Figure 2. The area of the watershed that is covered by the CWRP elements is defined throughout this report as the Lower Watershed, as it encompasses the area of the watershed downstream of New Hogan Reservoir and mountain foothills. This area, as it is modeled by an integrated surface water-groundwater model, will present model results for water supply, flood and basin conditions. Additionally, the CWRP model uses a rainfall runoff modeling module, called Small Watersheds, to simulate the foothills area of the watershed that are not part of the New Hogan Reservoir catchment area, to obtain baseflow and runoff from that area. The catchment of New Hogan Reservoir is defined throughout this report as the Upper Watershed and while it is not part of the CWRP model, information for precipitation, temperature and inflow to New Hogan Reservoir is available from DWR's Watershed Studies.

**FIGURE 2. MAP OF THE ESJWRM MODEL DOMAIN AND THE CALAVERAS RIVER WATERSHED**



## 2.1 Existing Condition Scenario

The CWRP existing condition scenario (TOP100) represents conditions under existing operations with no changes in climate, and no climate-related adaptation strategies. The 50-year period simulates hydrologic conditions between Water Years (WY) 1969 and 2018. The model operates on a monthly timestep to capture seasonal variations in hydrology, land surface operations, stream dynamics, and groundwater conditions. This section describes features that are unique to the existing conditions scenario and how key model inputs were configured to represent watershed conditions. Additional information on the ESJWRM Projected Conditions Baseline can be found in Appendix 2-A of the Eastern San Joaquin Groundwater Subbasin GSP.

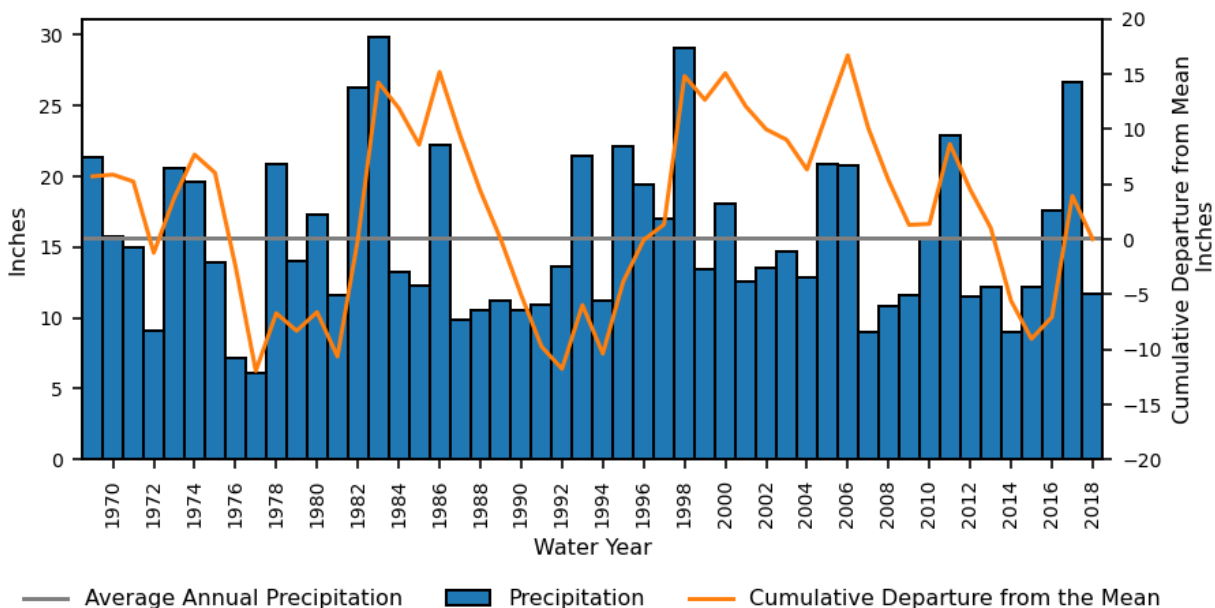
### 2.1.1 Hydrology

Precipitation and temperature data representing existing climate conditions were obtained from the DWR Watershed Studies, which utilize observed precipitation from the Livneh Unsplit dataset (1915-2018) and detrended temperature data combining Livneh (1915-2015) with the Precipitation-Elevation Regressions on

Independent Slopes Model (PRISM) for WY 2016-2018. The precipitation data are provided on a gridded spatial resolution of approximately 3.4 miles in the east-west direction and 4.25 miles in the north-south direction. Each model element within the Calaveras River Watershed was assigned precipitation inputs based on Thiessen polygon interpolation from the nearest grid point.

Figure 3 shows the annual variation in precipitation across the Calaveras River Watershed for the 50-year simulation period (WY 1969-2018), which ranges from approximately 6 inches per year during drought periods to over 29 inches per year during wet years. Average annual precipitation across the watershed is approximately 15 inches. Major dry periods and drought conditions include WYs 1976-1977, 1987-1992, 2000-2002, 2007-2009, and 2012-2015, while notable wet periods include WY 1982-1983 and 1995-1998. This historical sequence provides a representative range of hydrologic variability for evaluating existing water resource conditions and establishes the foundation for climate change scenario analysis.

**FIGURE 3. ANNUAL PRECIPITATION UNDER EXISTING CONDITIONS (TOP100)**



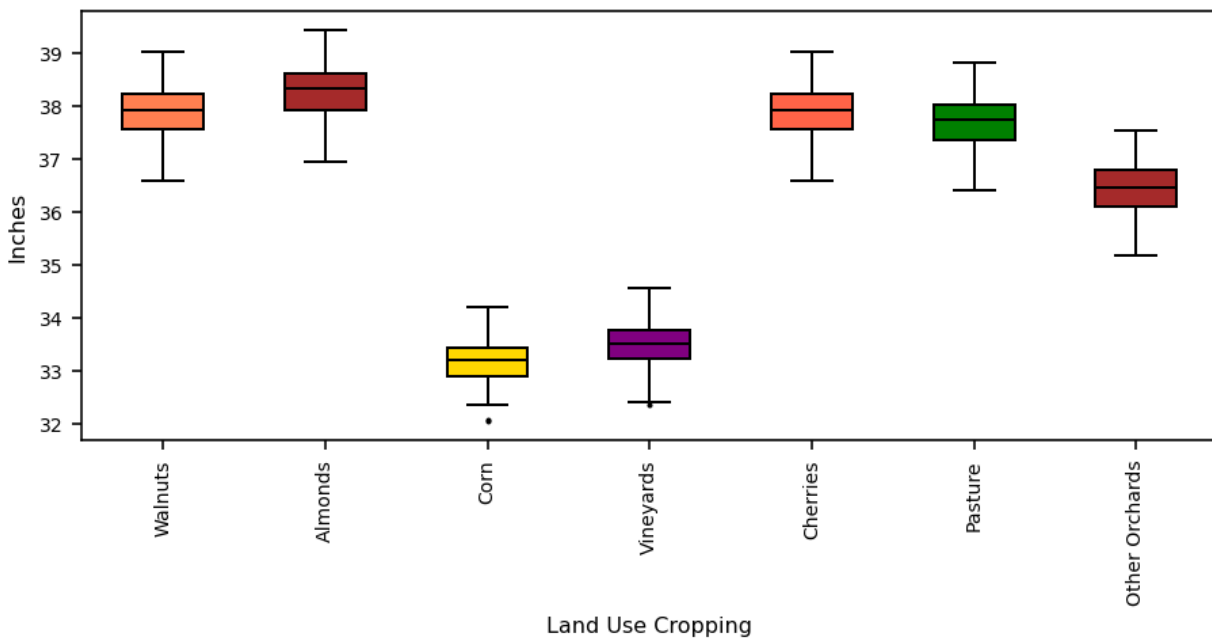
### 2.1.2 Evapotranspiration

Evapotranspiration quantifies water loss to the atmosphere through soil evaporation and plant transpiration, including water derived from precipitation and applied irrigation. The CWRP model framework builds upon calibrated values from the ESJWRM, expanding them to capture climatic and annual variability from the DWR Watershed Studies dataset. Temperature data from the Watershed Studies were converted to reference evapotranspiration ( $ET_0$ ) using Hargreaves Equation. Potential Evapotranspiration ( $ET_P$ ) was calculated using the crop-coefficient method, consistent with the ESJWRM, integrating crop-specific coefficients, water availability, and soil moisture dynamics. The calibrated crop coefficients ( $K_C$ ) resulted in crop evapotranspiration ( $ET_c$ ) that closely aligned with the ESJWRM the conditions documented in the GSP.

This approach allows monthly and annual  $ET_0$  rates to vary with climatic conditions while maintaining the overall water balance.

Figure 4 illustrates the distribution of annual potential evapotranspiration rates across different cropping categories in the Calaveras River Watershed. Walnuts, the predominant crop in the study area, exhibit an average annual  $ET_c$  of approximately 37.9 inches per year, with values ranging from 36.6 to 39.0 inches depending on climatic conditions and irrigation management. Corn, another predominant crop in the area, shows an average annual  $ET_c$  of approximately 33.2 inches per year, ranging from 32.1 to 34.2 inches across the simulation period. Additional details on evapotranspiration calibration and validation for the Eastern San Joaquin region can be found in Appendix 2-A of the GSP.

**FIGURE 4. ANNUAL CROP EVAPOTRANSPIRATION RATES UNDER EXISTING CONDITIONS (TOP100)**



### 2.1.3 Surface Water Operations

Surface water operations in the CWRP model represent the complex interaction between reservoir management, streamflow dynamics, and water deliveries throughout the Calaveras River Watershed. These operations are critical to simulating both water supply reliability and hydrologic response under varying climate conditions.

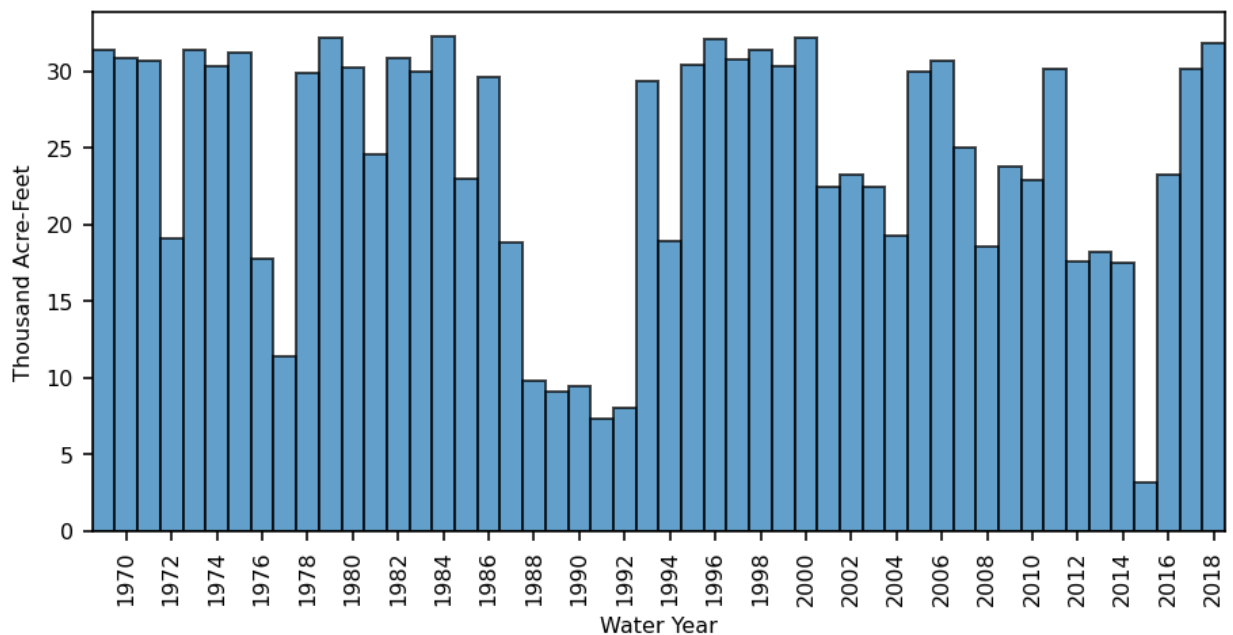
Reservoir operations for New Hogan Dam, Farmington Dam, and New Melones Dam were obtained from HEC-ResSim models developed as part of the DWR Watershed Studies. ResSim is a reservoir operations model that simulates rule-based water management decisions including flood control operations, water supply releases, environmental flow requirements, and hydropower generation. The ResSim models operate on a three-hour timestep to capture detailed operational dynamics, which are then aggregated to monthly

values for input into the CWRP model. This aggregation maintains water balance while providing computationally efficient integration with the groundwater and agricultural water use components of the model.

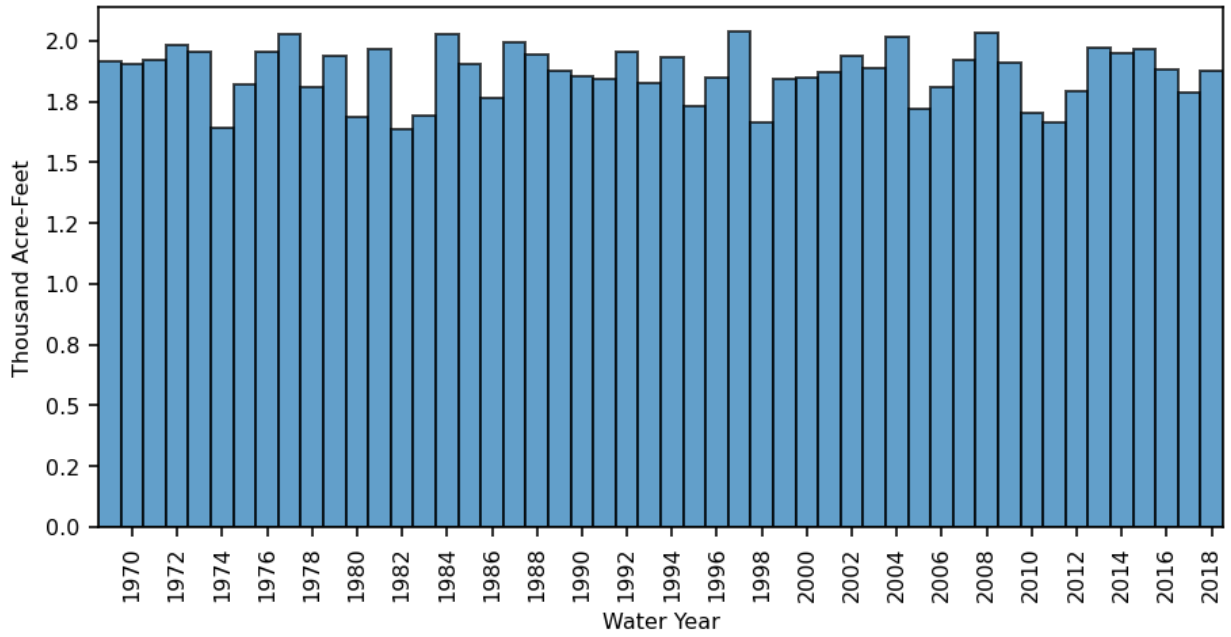
Unimpaired streamflow entering the model domain are derived from multiple sources depending on watershed characteristics. For smaller tributaries, the IWFM Small Watershed Package simulates rainfall-runoff processes based on local precipitation and land surface characteristics. For the larger upper watershed, the Sacramento Soil Moisture Accounting Model (SAC-SMA) provides naturalized flow estimates that account for snowmelt dynamics and basin-scale hydrologic routing. Additional tributary inflows outside of the Calaveras River Watershed are incorporated through hydrologic resampling of historical flow records, ensuring that all significant water sources entering the system are represented. Figure XX shows the spatial distribution of stream inflow locations throughout the watershed.

Surface water diversions include both agricultural and urban diversions from stream reaches and reservoirs. For diversions sourced from ResSim-managed reservoirs and major stream reaches, headgate diversion rates are calculated by ResSim based on water rights, contract allocations, and physical conveyance capacity. The CWRP model then applies diversion specifications to determine the fate of diverted water, including the percentage applied to fields, losses through canal seepage that contribute to groundwater recharge, and evaporative losses from open conveyance facilities. Figure 5 and Figure 6, respectively, display the major surface water diversion agricultural volumes serving Stockton East Water District (SEWD) and Central Calaveras Water District (CCWD) used for this study.

**FIGURE 5. AGRICULTURAL SURFACE WATER DELIVERIES FROM CALAVERAS RIVER TO SEWD UNDER EXISTING CONDITIONS (TOP100)**



**FIGURE 6. AGRICULTURAL SURFACE WATER DELIVERIES FROM CALAVERAS RIVER TO CCWD UNDER EXISTING CONDITIONS (TOP100)**

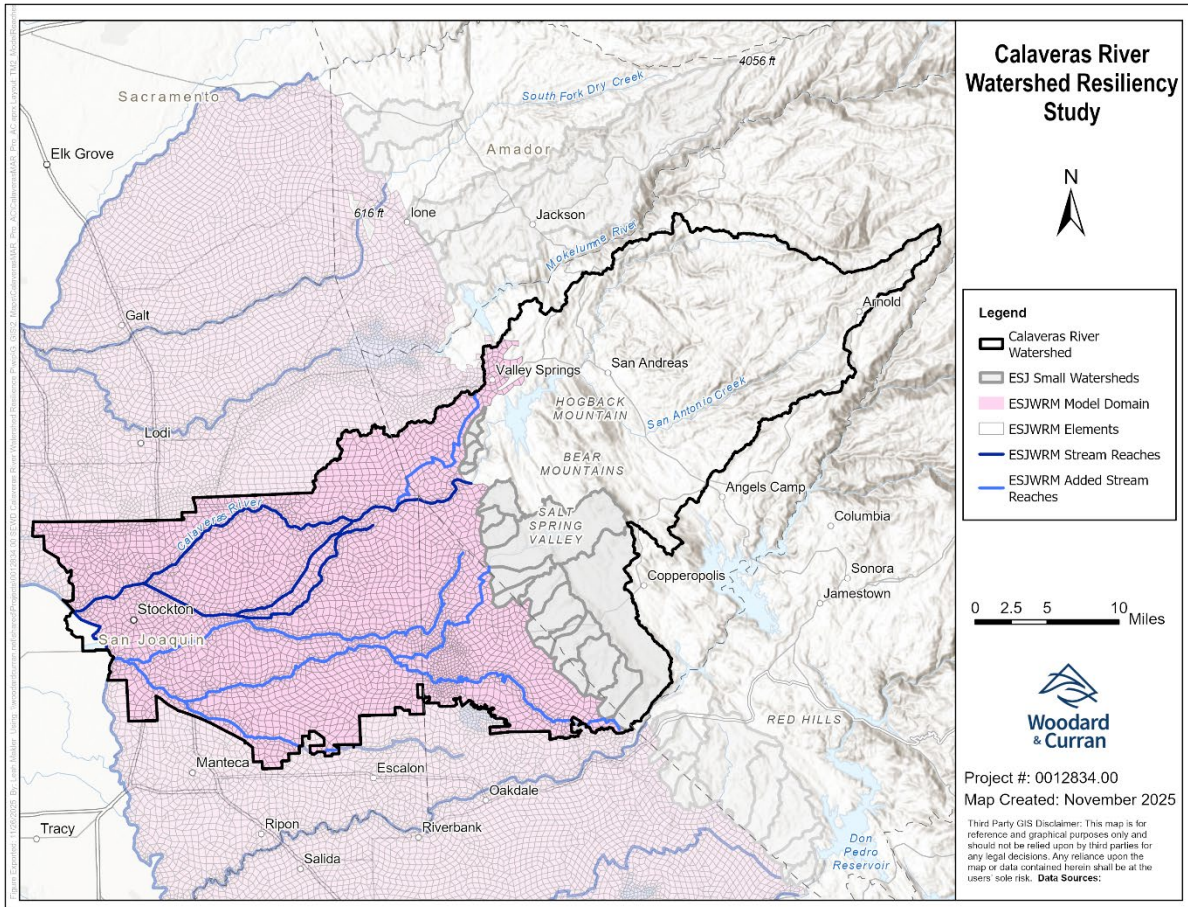


### 2.1.4 Stream System

The CWRP model stream network was expanded from the ESJWRM Projected Conditions Baseline to include additional stream reaches representing local tributaries within the Calaveras River watershed. Five new stream reaches were added to the model simulation: Dry Creek, Duck Creek, Indian Creek, Littlejohns Creek, Lone Tree Creek and Rock Creek. In the ESJWRM, these tributaries were simplified as streamlines using the IWFm Small Watershed Package but were converted to fully dynamic stream reaches in CWRP to better simulate stream-aquifer interactions and the hydrologic response of local tributaries to climatic variability.

Conversion to dynamic stream reaches using the IWFm stream-routing package allows for direct simulation of channel flow, stream-aquifer exchange, and groundwater interaction. Stream reach parameters, including channel geometry, bed conductance, and roughness coefficients, were calibrated using SAC-SMA naturalized streamflow estimates, inflow volumes from the IWFm small watershed package and ESJWRM water budget estimates. The added streams are shown in Figure 7, represented by the light blue lines in the southern region of the watershed.

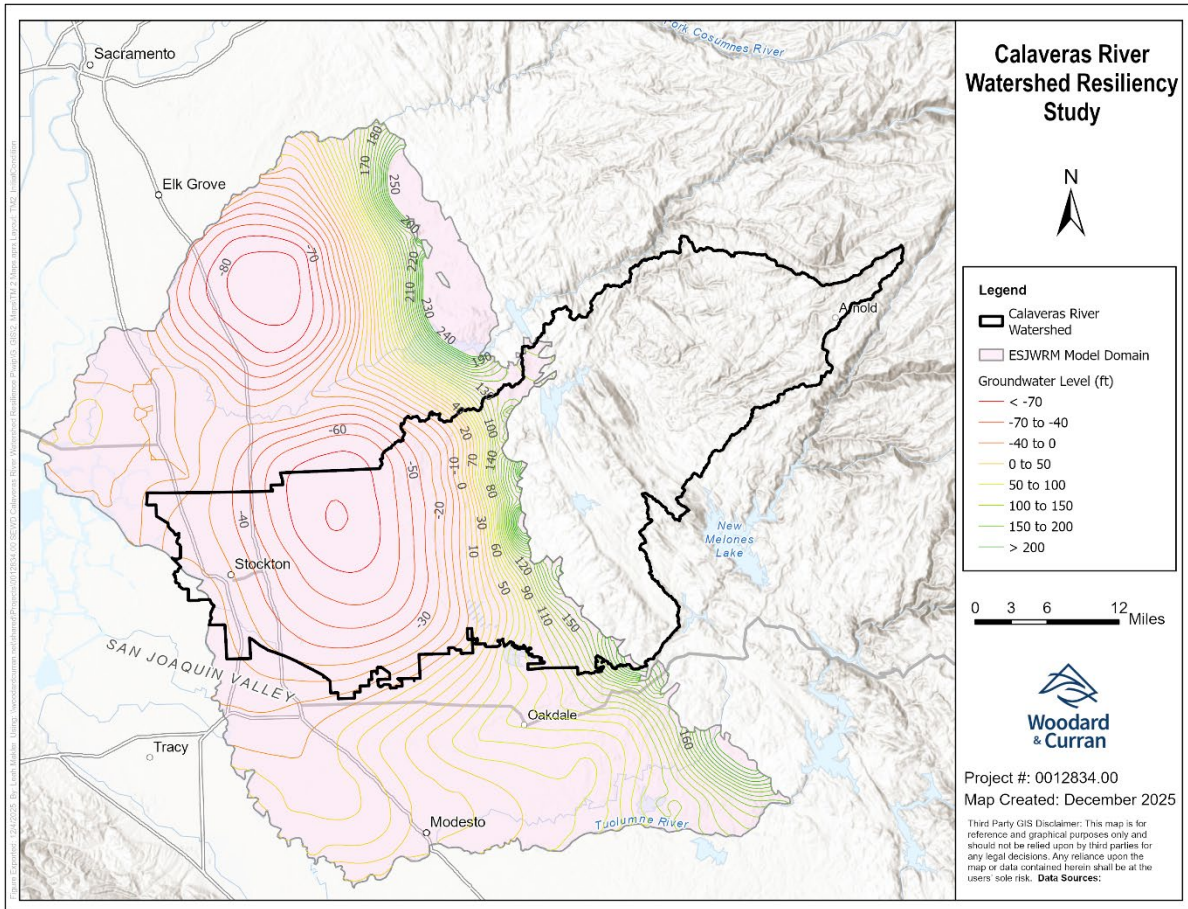
**FIGURE 7. MAP OF ESJWRM MODEL WITH THE ADDED STREAM REACHES**



### 2.1.5 Initial Conditions

Initial groundwater elevations for the CWRP model establish starting conditions for each of the four aquifer layers in the ESJWRM. Initial conditions for CWRP model were established using the final simulated conditions from the ESJWRM historical model, representing groundwater levels as of October 2023. Figure 8 illustrates the spatial distribution of initial groundwater elevations across the model domain, presented as transmissivity-weighted averages of the simulated conditions across all aquifer layers.

**FIGURE 8. THE INITIAL GROUNDWATER LEVEL HEADS IN THE CWRP MODEL SIMULATIONS**



## 2.2 Climate Change Scenarios

To evaluate how the Calaveras River Watershed will respond to future climate conditions, the CWRP model employs a bottom-up modeling framework using stochastic weather generation. Rather than applying specific Global Climate Model (GCM) projections directly to water system models, this approach uses GCM ensembles to define the probable range of future climate conditions, as illustrated in Figure 9. A stochastic weather generator then creates synthetic hydrology by systematically perturbing the region’s historical weather patterns. The resulting climate scenarios drive a fully integrated set of models that simulate hydrologic processes, reservoir operations, surface water systems, and groundwater conditions to determine climate vulnerability and the efficacy of adaptation strategies.

**FIGURE 9. DIAGRAM DISPLAYING THE STOCHASTIC APPROACH TOWARDS SIMULATING FUTURE CLIMATE CONDITIONS**

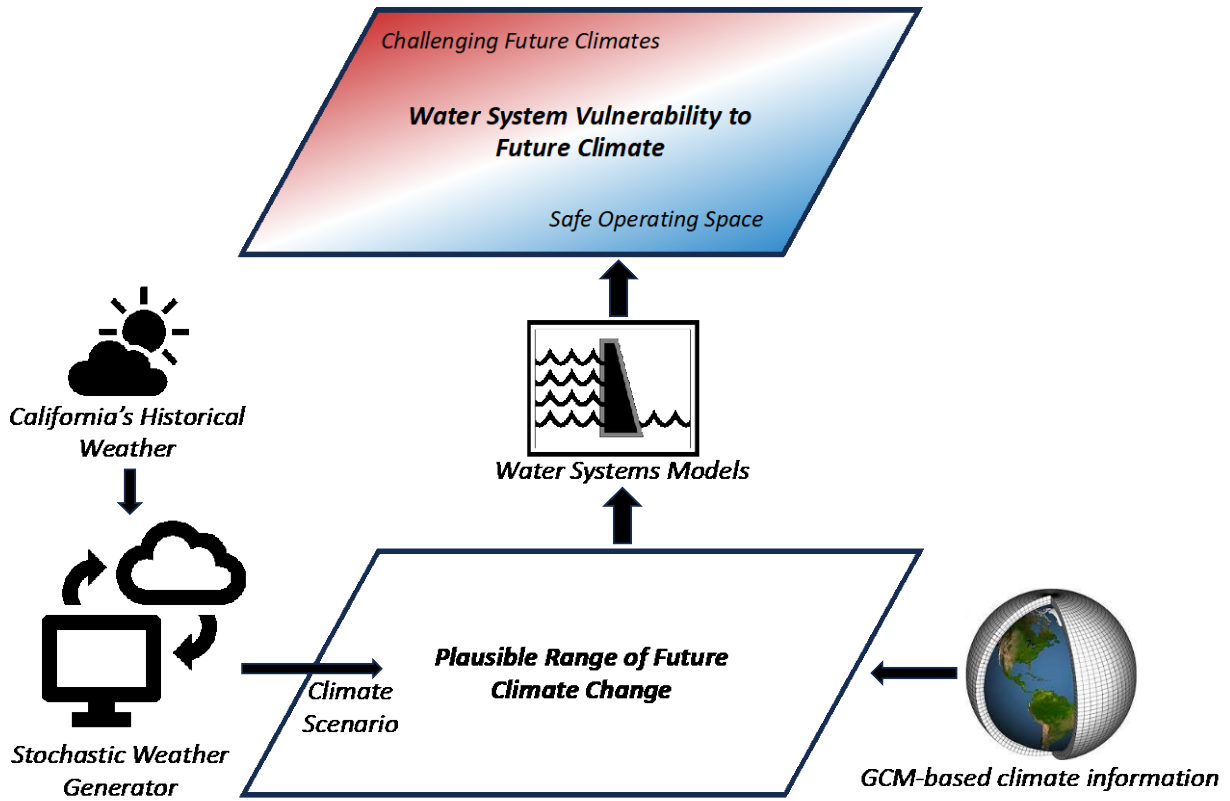
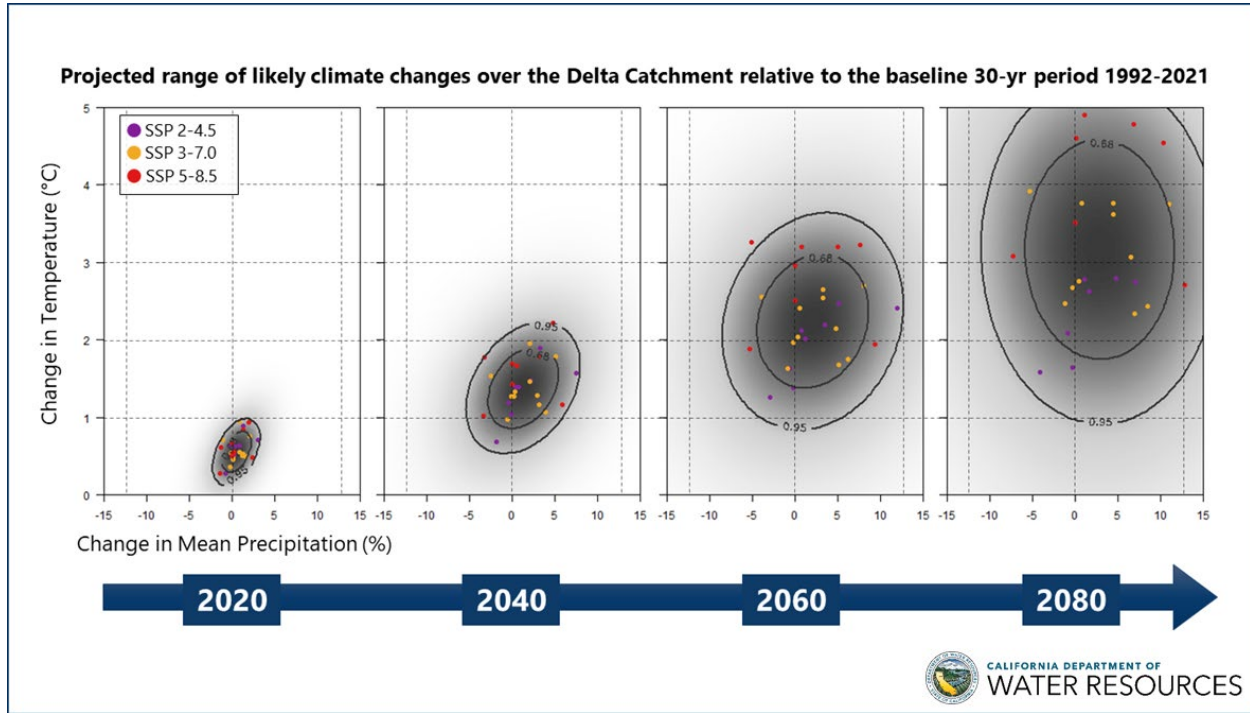


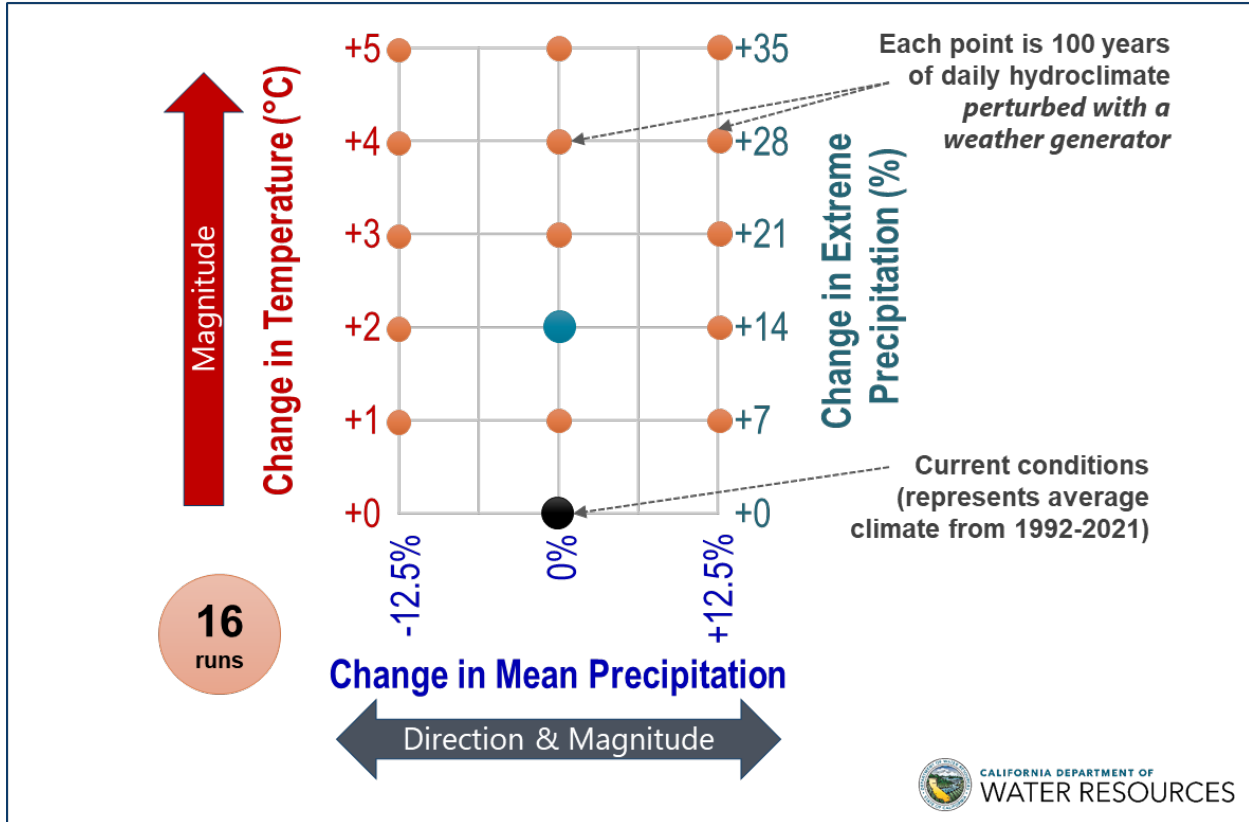
Figure 10 illustrates the projected range of climate change conditions for the region, showing how the distribution of temperature and precipitation shifts over time. The elliptical contours represent probability density functions of climate outcomes from multiple Global Climate Models under different emissions scenarios (SSP 2-4.5, SSP 3-7.0, and SSP 5-8.5). As shown in the progression from 2020 to 2080, the likelihood of higher temperature increases grows over time, while the range of precipitation changes remains broad, spanning from plus to minus 13 percent of normal.

**FIGURE 10. PROJECTED RANGE OF CLIMATE CHANGES IN THE DELTA CATCHMENT**



The CWRP climate vulnerability assessment evaluates existing conditions against 15 climate change scenarios (16 scenarios in total). These scenarios systematically vary three key climate parameters: mean annual temperature increases ranging from 1°C to 5°C above existing conditions, mean annual precipitation changes of -12.5%, 0%, and +12.5% relative to historical averages, and changes in extreme precipitation intensity up to 35% based on thermodynamic scaling relationships. This factorial design produces a climate scenario matrix that captures the combined effects of warming, precipitation shifts, and intensification of extreme events. Each scenario maintains a 50-year simulation period to evaluate both short-term variability and long-term trends in water resource conditions.

FIGURE 11. DIAGRAM OF THE 16 CLIMATE CONDITION RUNS



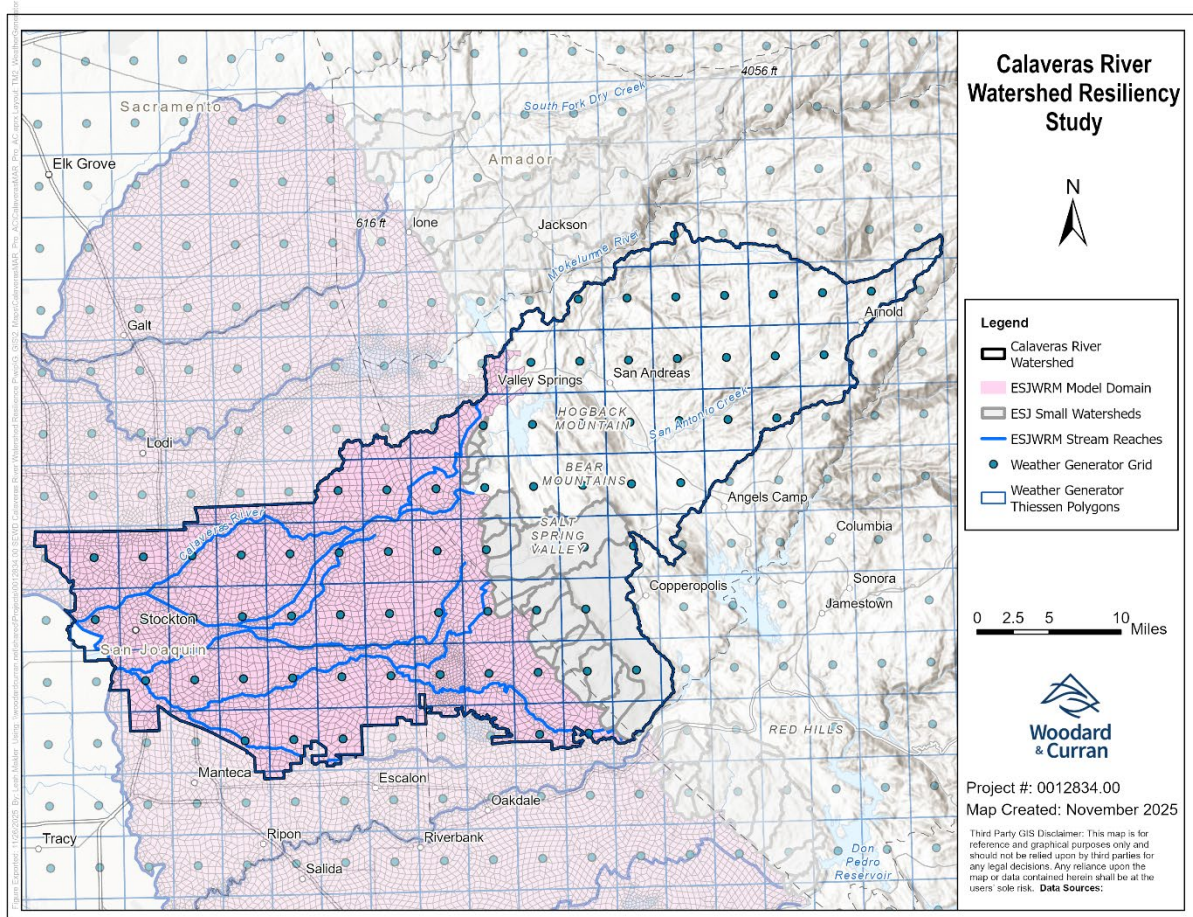
The most probable climate conditions for the 2050 planning horizon include a 2°C increase in mean annual temperature with no change in mean precipitation, designated as the T2P100 scenario. This condition aligns with the center of the mid-century probability distribution shown in Figure 10. Results presented throughout this report focus on the T2P100 reference condition while providing comparative analysis across all 15 climate scenarios.

The methodology for incorporating each of the climate scenarios and their effects on precipitation patterns, temperature regimes, and surface water operations is detailed in subsequent sections. Additional information on the stochastic weather generation framework, downscaling techniques, and climate perturbation methods can be found in the DWR San Joaquin Flood-MAR Watershed Studies technical documentation (California Department of Water Resources, 2025).

### 2.2.1 Precipitation

Precipitation was obtained from DWR's Watershed Studies, and similarly, used the Weather Generator grid to obtain precipitation over areas established by the Weather Generator Thiessen Polygons as shown in Figure 12. The analysis was established for both areas within the ESJWRM model domain and outside.

**FIGURE 12. MAP DISPLAYING THE WEATHER GENERATOR THIESSEN POLYGONS**

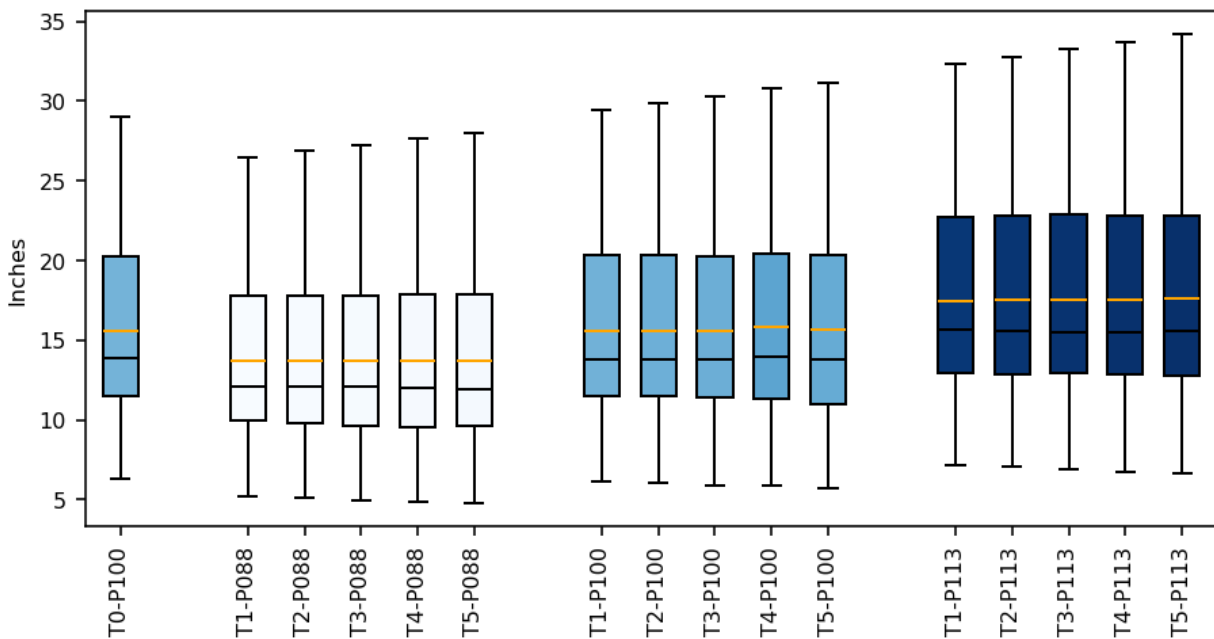


The existing conditions scenario (T0P100) and the climate change (T2P100) scenario maintain similar mean precipitation but exhibit distinctly different hydrologic characteristics due to the 2°C increase in temperature. However, the T2P100 scenario displays slightly greater variability in annual precipitation, with more pronounced values in both wet and dry years. This increased variability reflects the 14 percent intensification of extreme precipitation events associated with 2°C warming. This distinction indicates that warming alone, even without changes in mean precipitation, alters the timing, intensity, and variability of water availability. These changes have direct implications for reservoir operations, flood risk, groundwater recharge, and water supply reliability throughout the watershed.

Figure 13 presents box-and-whisker plots illustrating the annual modeled precipitation for the Calaveras River Watershed under various climate scenarios. The x-axis denotes scenario groupings, identified by changes in temperature (T0 through T5) and precipitation changes (P088, P100, P113). Each box plot displays the interquartile range of simulated annual water supply requirements, with the central black line indicating the median value and whiskers representing the 5<sup>th</sup> and 95<sup>th</sup> percentiles. The orange line represents the mean value, and outliers are shown as individual points.

Figure 13 shows the annual precipitation boxplot over the lower watershed, which besides showing the three different grouping for 88%, 100% and 113% change in precipitation, also highlights the impact of temperature, displaying higher variability in climate conditions that have higher temperatures.

**FIGURE 13. BOXPLOT OF ANNUAL PRECIPITATION FOR ALL CLIMATE CONDITIONS**



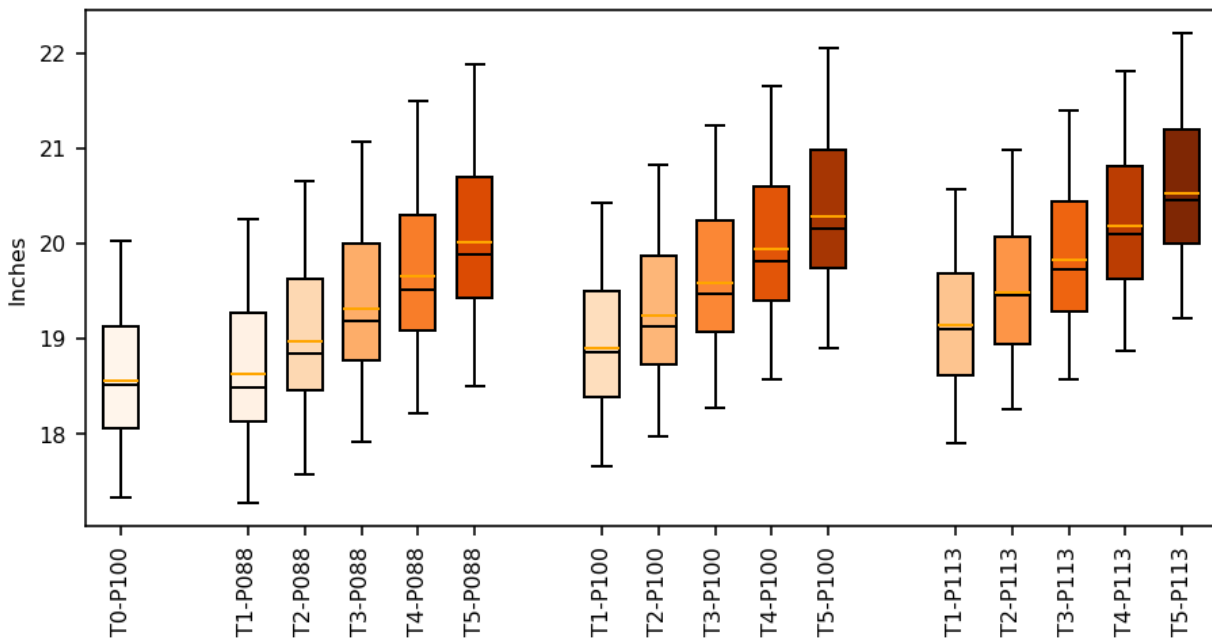
## 2.2.2 Evapotranspiration

Building upon the methodology established for the CWRP existing conditions scenario, potential evapotranspiration was obtained from the temperature information from the Weather Generator. Using Hargreaves methodology to estimate extraterrestrial radiation and the Thiessen polygons to estimate an average temperature through the watershed, different crop evapotranspiration rates were established for the different climate conditions. The CWRP model calculates actual evapotranspiration for all land uses within the watershed, including agricultural lands with varying crop types, urban landscapes, and native vegetation. Actual evapotranspiration represents the consumptive water use that occurs under field conditions, accounting for water availability constraints from both precipitation and applied irrigation.

Figure 14 illustrates the annual actual evapotranspiration rates under varying climate conditions within the watershed. These values represent the area-weighted average across all agricultural, urban, and native vegetation land uses within the model domain. Under the TOP100 condition, the average actual evapotranspiration rate is 18.6 inches, whereas under the T2P100 condition, it increases to 19.2 inches. The results demonstrate a systematic increase of 0.35 inches in annual actual evapotranspiration for each 1°C rise in temperature. Additionally, the data show that for every 1% increase in precipitation, the actual

evapotranspiration rate rises by 0.02 inches, reflecting enhanced water availability for consumptive use during wetter conditions.

**FIGURE 14. ANNUAL ACTUAL EVAPOTRANSPIRATION FOR ALL CLIMATE CONDITIONS**



### 2.3 Adaptation Strategies

The adaptation strategy evaluation is structured around two implementation tiers that reflect distinct levels of infrastructure investment and operational complexity. Tier 1 includes near-term actions that include projects that have already been initiated or strategies that can be implemented within the existing infrastructure and operational framework. Tier 2 represents long-term investments, including additional infrastructure, changes to reservoir operations, and water management strategies.

Water supplies for Tier 1 strategies are sourced under SEWD’s existing contract allocations from New Hogan and New Melones Reservoirs, supplemented by additional supplies from Linden Water Rights. Tier 2 strategies utilize these same sources plus additional water made available through the proposed Farmington Reservoir Project, which expands the overall water supply portfolio for adaptation activities.

Both tiers incorporate Water Available for Recharge (WAFR) identified through the DWR Watershed Studies as a key component of groundwater sustainability strategies. Tier 1 utilizes WAFR generated through the Streamlined Flood-MAR (MAR 90/20) strategy, which permits diversions for recharge between December and March when streamflow exceeds historical 90<sup>th</sup> percentile levels. This approach captures up to 20 percent of measured flow using existing infrastructure. Tier 2 incorporates WAFR from the Integrated Forecast-Informed Resources Management (I-FIRM) strategy, a more comprehensive approach that

combines managed aquifer recharge with refined reservoir operations and new infrastructure to maximize water supply benefits while maintaining flood protection requirements.

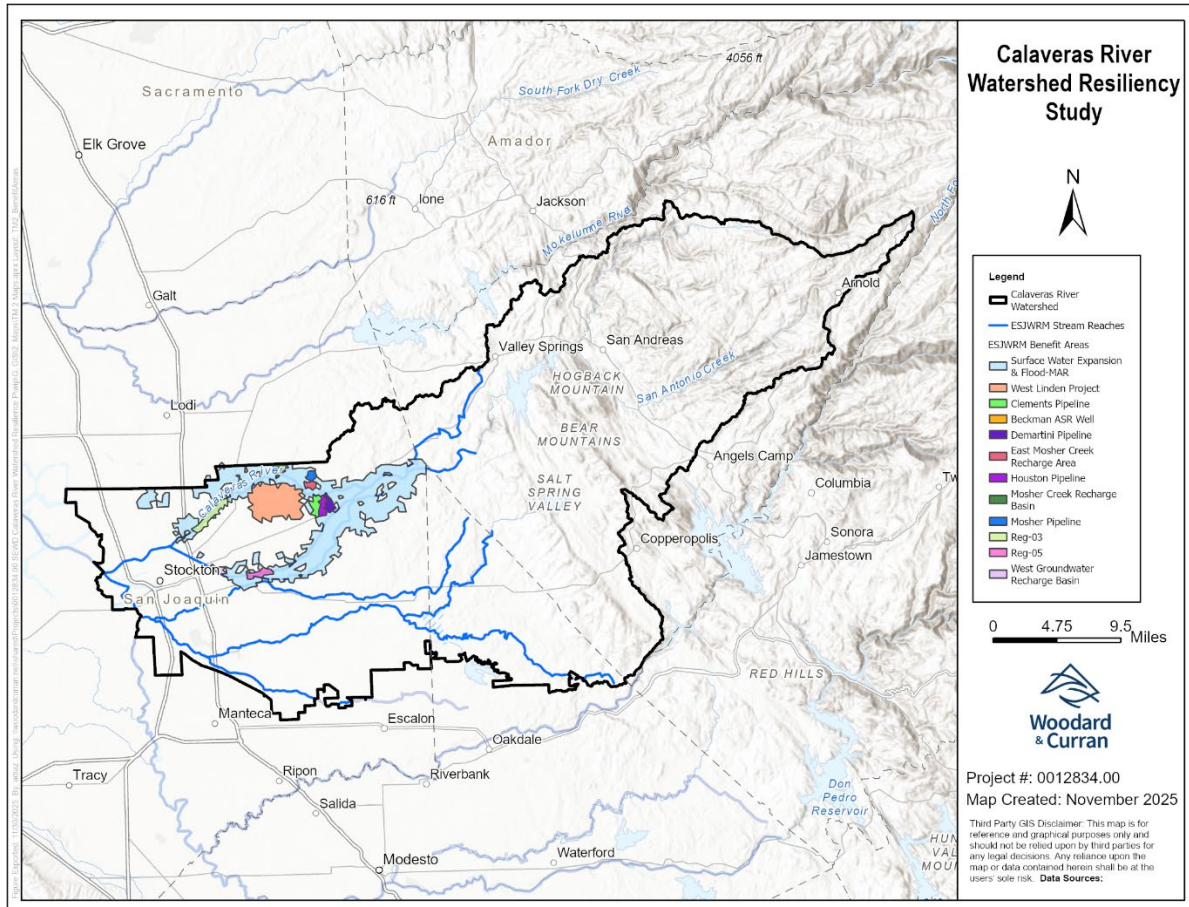
### 2.3.1 Project Descriptions

The adaptation scenarios evaluate thirteen surface water projects across the Tier 1 and Tier 2 scenarios. Project specifications are based on SEWD's *Water Supply Master Plan* and include water source, recharge method, and annual capacity for each project as summarized in Table 1. Figure 15 shows the spatial distribution of projects throughout the watershed.

**TABLE 1. PROJECT CHARACTERISTICS FOR TIER 1 AND TIER 2 SCENARIOS**

Tier	Project Name	Water Source	Recharge Type	Project Capacity (AFY)
1	Reg-02 & Clements Pipeline Phase 1	Linden Water Rights and Calaveras River Flood Flows	Direct	891
		Calaveras River Unused Allocation	In-Lieu	1,500
1	Reg-02 & Clements Pipeline Phase 2	Calaveras River Unused Allocation and Linden Water Rights	Direct	17,100
1	Surface Water Expansion	Calaveras River and Stanislaus River Unused Allocations	In-Lieu	13,537
1	West Groundwater Recharge Basin	Calaveras River and Stanislaus River Unused Allocations	Direct	16,000
1	Beckman ASR Well	Mokelumne River Flood Flows	Direct	328
1	West Linden Project	Calaveras River Unused Allocation, Linden Water Rights and Mokelumne River Flood Flows	Direct	11,603
1	Reg-03	Spill Reduction	Direct	964
1	Reg-05	Spill Reduction	Direct	321
2	Demartini Pipeline	Linden Water Rights	Direct	3,056
		Calaveras River Unused Allocation	In-Lieu	769
2	Houston Pipeline	Calaveras River Unused Allocation and Linden Water Rights	Direct	2,213
		Calaveras River Unused Allocation	In-Lieu	1,154
2	Mosher Pipeline	Calaveras River Unused Allocation and Linden Water Rights	Direct	1,400
		Calaveras River Unused Allocation	In-Lieu	481
2	Mosher Creek Recharge Basin	Calaveras River Unused Allocation and Linden Water Rights	Direct	19,338
2	East Mosher Creek Recharge Area	New Hogan Contract, WAFR, Mokelumne + Linden WR	Direct	16,606

**FIGURE 15. MAP OF THE BENEFIT AREAS OF TIER 1 AND TIER 2 SCENARIOS**



### 2.3.2 Project Modeling Assumptions

Water supply availability for adaptation projects varies by source and water year type to reflect operational constraints and hydrologic variability. Table 2 shows the volume of water available of each source depending on the CDEC Water Year Type Dataset. New Hogan and New Melones Reservoir sources are available in both Tier 1 and Tier 2 scenarios, while water from Farmington Dam becomes available only in Tier 2, following completion of that infrastructure investment. The water volumes shown represent supplies available specifically for adaptation projects and are in addition to deliveries for existing agricultural and urban demands served by SEWD and CCWD.

Water availability from New Hogan and New Melones Reservoirs was determined together with SEWD based on their existing contracts and historical diversions. Farmington Dam water availability was determined using the Conjunctive Use Study of Farmington Dam, from the U.S. Army Corps of Engineers (1998), together with results from the Watershed Studies ResSim of the flow of Littlejohns Creek after Farmington, assuming 4,000 AFY of environmental flow for Littlejohns Creek.

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**TABLE 2. WATER AVAILABLE FOR SURFACE WATER PROJECTS (AFY)**

<b>WY Type</b>	<b>New Hogan Reservoir</b>	<b>New Melones Reservoir</b>	<b>Linden Reservoir</b>	<b>Farmington Dam (only Tier 2)</b>
W	80,100	90,000	16,000	71,800
AN	80,100	90,000	16,000	36,700
BN	80,100	90,000	16,000	38,400
D	70,000	15,000	0	24,700
C	40,000	0	0	15,800

Water availability for projects is limited to Wet, Above Normal, and Below Normal water year types. These water year types are influenced by climate conditions, which can vary based on temperature and precipitation changes. In drier conditions, water year types tend to shift toward Dry and Critically Dry, while wetter conditions lead to more Wet water year types. Consequently, project water availability is directly tied to hydrologic conditions with different yields expected under varying climate scenarios. Table 3 shows the average yield by project for the T0P100 and T2P100 climate conditions.

**TABLE 3. AVERAGE YIELD FOR PROJECTS**

Tier	Project Name	Recharge Type	Project Capacity (AFY)	Tier 2 - Average Yield	
				TOP100 (AFY)	T2P100 (AFY)
1	Reg-02 & Clements Pipeline Phase 1	Direct	891	500	400
		In-Lieu	1,500	800	700
1	Reg-02 & Clements Pipeline Phase 2	Direct	17,100	8,900	7,500
1	Surface Water Expansion	In-Lieu	13,537	7,000	6,000
1	West Groundwater Recharge Basin	Direct	16,000	8,300	7,100
1	Beckman ASR Well	Direct	328	200	100
1	West Linden Project	Direct	11,603	6,000	5,100
1	Reg-03	Direct	964	500	400
2	Reg-05	Direct	321	200	100
2	Demartini Pipeline	Direct	3,056	1,600	1,400
		In-Lieu	769	400	300
2	Houston Pipeline	Direct	2,213	1,200	1,000
		In-Lieu	1,154	600	500
2	Mosher Pipeline	Direct	1,400	700	600
		In-Lieu	481	200	200
2	Mosher Creek Recharge Basin	Direct	19,338	8,300	6,900
	East Mosher Creek Recharge Area	Direct	16,606	7,100	5,900

### 2.3.3 Water Available for Recharge

Water Available for Recharge represents an additional water supply component in both Tier 1 and Tier 2 adaptation strategies beyond the direct infrastructure projects. WAFR volumes and timing were determined using methodologies from the DWR San Joaquin Flood-MAR Watershed Studies, with Tier 1 utilizing the MAR 90/20 approach and Tier 2 employing the I-FIRM strategy. Winter flood diversions provide a significant amount of recharge that can complement surface water delivery improvements and help offset climate-driven increases in groundwater demand.

Tier 1 - Relies on the MAR-90/20 strategy which stems from diversion criteria established under the State Water Resources Control Board's (SWRCB) streamlined permitting process for temporary and standard water rights used to divert high flows for underground storage. Under this strategy, water may be diverted for recharge when flows at the diversion point exceed the 90<sup>th</sup>-percentile historical gaged daily flow, with diversions capped at 20 percent of the total flow.

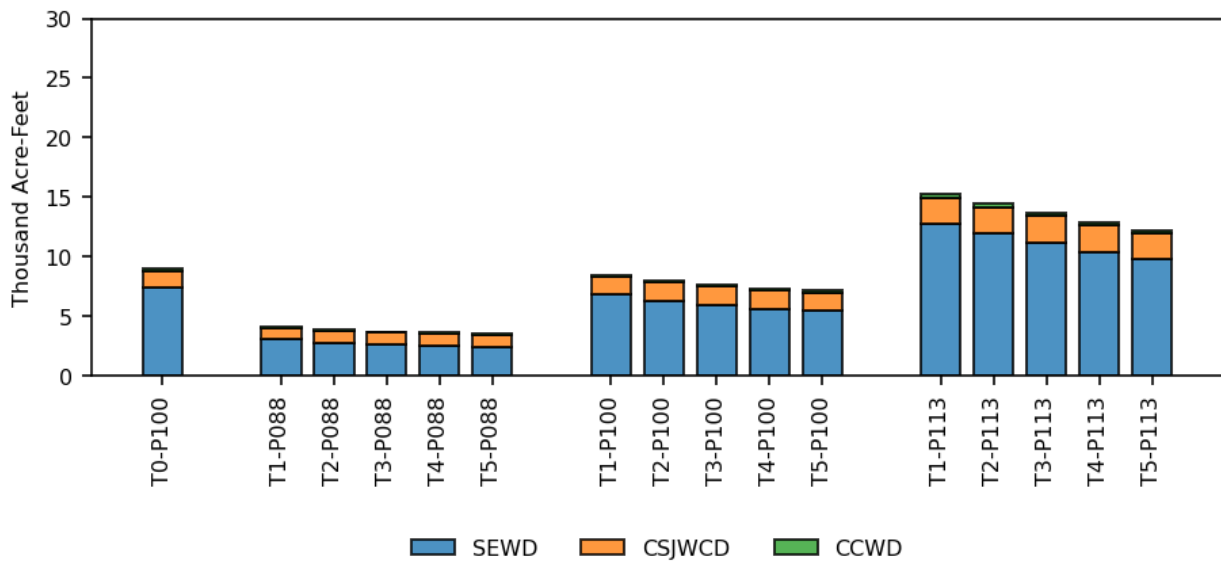
Tier 2 - Applies the integrated forecast-informed resources management (I-FIRM) Flood-MAR strategy. This approach integrates managed aquifer recharge (MAR) with forecast-informed

reservoir operations (FIRO) to support long-term sustainability and climate resilience. It uses flows higher than the 90<sup>th</sup>-percentile monthly flow between November 1<sup>st</sup> and June 14<sup>th</sup> (start of the fully appropriated streams season) and only when the Sacramento-San Joaquin River Delta (Delta) is in true excess or excess with restrictions conditions (except during FIRO operations). FIRO operations are set on five- to seven-day probabilistic setup to maximize recharge opportunities and reduce flood risk during the period between November through March and to diversify ecosystem benefits from March through June.

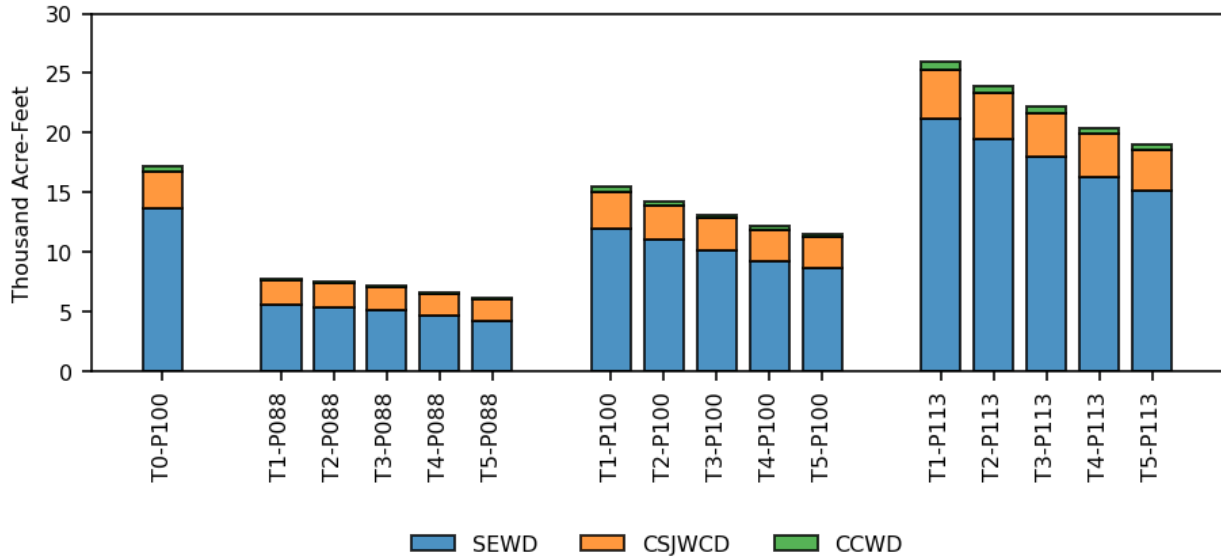
Figure 16 and Figure 17 show the annual average WAFR for Tier 1 and Tier 2 scenarios respectively. In case for the Tier 1 scenarios, under the TOP100 climate condition, the average WAFR is nine-thousand acre-feet (TAF) per year, with 82% coming from SEWD, 16% from CSJWCD, and 2% from CCWD. In the T2P100 climate condition, the average WAFR is 8 TAF per year. Overall WAFR decreases 0.4 TAF per year per 1-degree Celsius increase, and it increases 0.5 TAF per one percent increase in precipitation.

In case of Tier 2 scenarios, under the TOP100 climate condition, the average WAFR is 17 TAF per year, with 79% coming from SEWD, 18% from CSJWCD, and 3% from CCWD. In the T2P100 climate condition, the average WAFR is 14 TAF per year. Overall WAFR decreases 1.0 TAF per year per 1-degree Celsius increase, and it increases 0.8 TAF per one percent increase in precipitation.

**FIGURE 16. ANNUAL AVERAGE WATER AVAILABLE FOR RECHARGE WITH TIER 1 ADAPTATION STRATEGIES FOR ALL CLIMATE CONDITIONS**



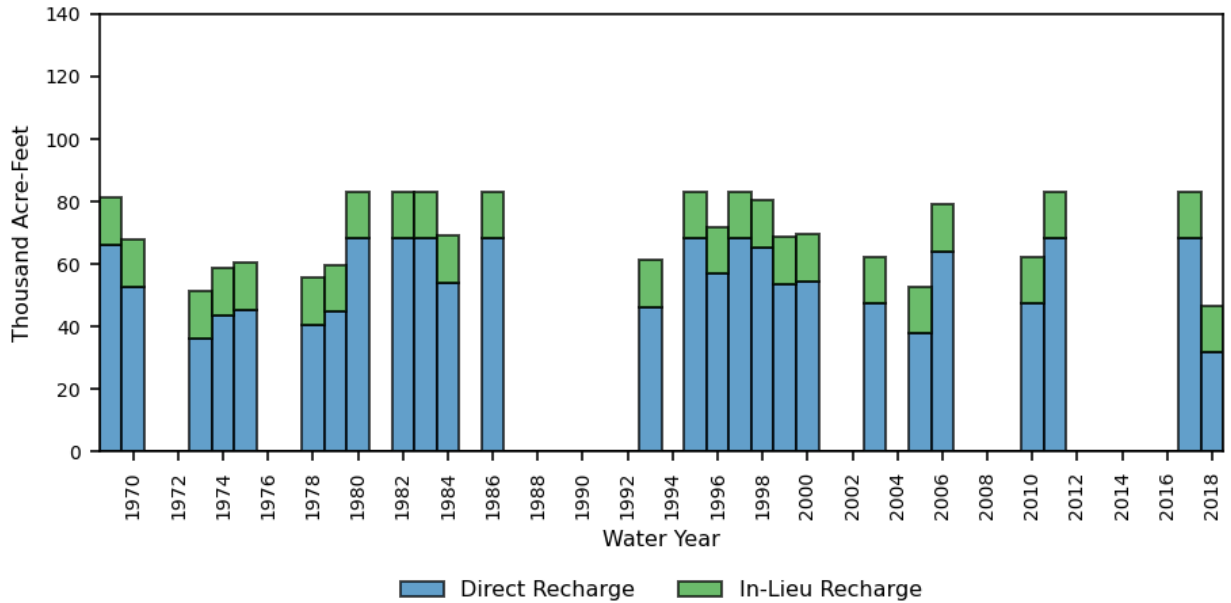
**FIGURE 17. ANNUAL AVERAGE WATER AVAILABLE FOR RECHARGE WITH TIER 2 ADAPTATION STRATEGIES FOR ALL CLIMATE CONDITIONS**



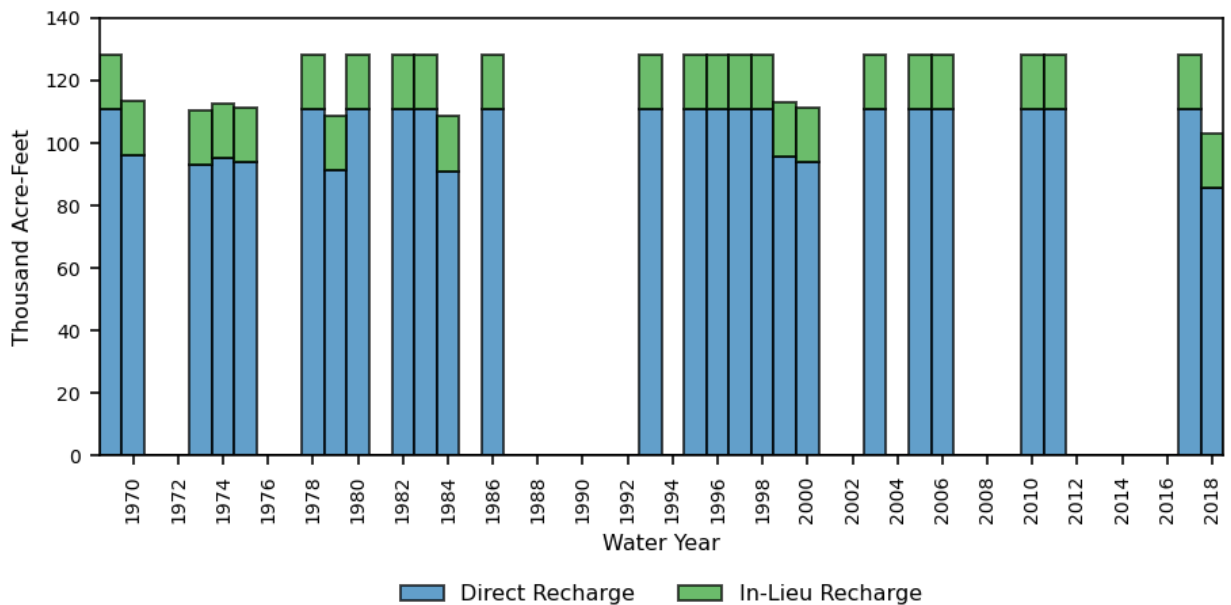
### 2.3.4 Summary

Combining the water delivered for projects and WAFR gives the total yield of recharge to watershed. The annual time series of total recharge from the Tier 1 and Tier 2 adaptation strategies are shown in Figure 18 and Figure 19 respectively. Total annual average of the volume of water between projects and WAFR is 31,200 AF for Tier 1 under the T2P100 climate condition, split between 24,600 AF of direct recharge to the aquifer, and 6,600 AF of in-lieu recharge for surface water supply. In the case of Tier 2 projects, total volume of recharge is 54,300 AF, split between 46,600 of direct recharge and 7,700 of in-lieu recharge.

**FIGURE 18. ANNUAL TIME SERIES OF WATER USED WITH TIER 1 ADAPTATION STRATEGIES UNDER EXISTING CONDITIONS (TOP100)**



**FIGURE 19. ANNUAL TIME SERIES OF WATER USED WITH TIER 2 ADAPTATION STRATEGIES UNDER EXISTING CONDITIONS (TOP100)**



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### 3. CWRP MODEL RESULTS

This section presents the CWRP model results organized into three primary components: existing conditions, a climate vulnerability assessment, and adaptation strategy performance. The results of the existing conditions scenario establish reference conditions for comparison across all scenarios. The climate vulnerability assessment evaluates impacts across 15 climate scenarios using key performance metrics including hydrology, agricultural and urban water demands, surface water systems, aquifer conditions, and environmental indicators. Finally, the adaptation strategy results quantify the effectiveness of proposed projects in mitigating climate impact and achieving management objectives. Climate conditions are presented primarily for the T2P100 reference scenario with comparisons provided for the full suite of scenarios to characterize the range of potential outcomes and identify conditions under which the watershed is most vulnerable.

#### 3.1 Analytical Framework

The climate vulnerability assessment and adaptation strategy evaluation are structured around a comprehensive analytical framework that organizes impacts into distinct risk categories, each evaluated through specific performance metrics. This framework, illustrated in Table 4, provides a systematic approach to characterizing how climate change affects multiple dimensions of watershed function and identifies where adaptation interventions can be most effective.

The analysis encompasses four primary risk categories that are directly simulated by the CWRP model: Direct Impacts, Flood, Water Supply, and Basin Sustainability. Direct impacts include changes to fundamental hydrologic drivers (temperature, precipitation, evapotranspiration) and resulting changes in applied water demand. Flood risks are assessed through reservoir flood space management and in-stream flood conditions. Water supply evaluation addresses surface water availability, groundwater production, and supplemental water supplies, including managed aquifer recharge. Basin sustainability examines long-term groundwater storage, groundwater level trends at GSP monitoring locations, and interconnected surface water depletions.

Additional risk categories, including Wildfire, Surface Water Quality, and Economy, are presented in the framework to acknowledge the broader context of climate vulnerabilities affecting the watershed. However, these categories are not directly simulated by the hydrologic model and are addressed in their independent reports, qualitatively, or through proxy indicators where appropriate.

Results are presented using two levels of detail. Key metrics represent the primary indicators used to evaluate climate vulnerability and adaptation effectiveness, focusing on variables most directly relevant to water management decisions and Sustainable Groundwater Management Act (SGMA) compliance. Detailed metrics provide supporting information on specific model components and spatial or temporal patterns that illuminate the mechanisms driving changes in key metrics. This tiered approach allows stakeholders to quickly assess overall system performance through key metrics while retaining access to detailed results for in-depth technical evaluation and local planning efforts.

A list of key metrics is presented below in Table 4.

**TABLE 4. ANALYTICAL FRAMEWORK FOR KEY METRICS USED IN THE RESILIENCY PLAN**

Risk Category	Impact	Metric (modeled CC impact)
Direct Impacts	Hydrology	Δ Temperature
		Δ Precipitation
		Δ Extreme Precipitation
	Water Demand	Δ Evapotranspiration
		Δ Water Demand
Flood	Flood Space Management	Δ New Hogan Inflow (Maximum)
	In-Stream Flood Conditions	Δ New Hogan Outflow (Maximum)
Water Supply	Surface Water	Δ New Hogan Inflow (Average)
		Δ Surface Water Deliveries
	Groundwater Use	Δ Groundwater Production
	Supplemental Supplies	Δ Supplemental Supplies
Basin Conditions	Groundwater Storage	Δ Groundwater Storage
	Groundwater Levels	Δ Groundwater Level
	Interconnected Surface Water	Δ Stream-Aquifer Interaction
	Inter-Watershed Dynamics	Δ Subsurface Inflow
Wildfire	Footprint	Annual Burn Probability
	Intensity	Characteristic Flame Length
	Ecosystem	Wildfire Risk to Wildlands Health
	Water Resources	Wildfire Risk to Water Resources
	Community Safety	Wildfire Risk to Community Safety
Surface Water Quality	Environmental Water Quality	Temperature (Proxy: Δ Stream Stage and Storage)
		Constituent Transport (Proxy: Δ Stream Stage)
		Sediment Yield (Proxy: Erosion Rates)
Economy	Agriculture	Indirect
	Urban	Indirect
	Forestry & Recreation	Indirect

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## 3.2 Land and Water Use

The land and water use budget functions as the central accounting mechanism for the **direct impacts and water supply risk categories**, characterizing the dynamic interaction between climate-driven water requirements and available hydrologic resources. Within the direct impacts category, the model simulates applied water demand to capture total agricultural and urban needs. The CWRP model calculates agricultural demand dynamically based on land use type, evapotranspiration rates, soil moisture conditions, and local irrigation management. Urban water demand is similarly computed dynamically based on population, per-capita consumption rates, and indoor vs outdoor water use requirements.

Water demand in Calaveras River Watershed is met through a combination of sources within the water supply risk category. Surface water deliveries represent water supplied from reservoirs, streams, and the delta to meet agricultural and urban demands. Groundwater pumping provides supplemental supply by extracting water from the aquifer system to satisfy demand not met by available surface water. Additionally, the model evaluates supplemental water supplies via managed recharge operations, including reinforcing the watersheds storage and conjunctive use system through direct and in-lieu recharge projects.

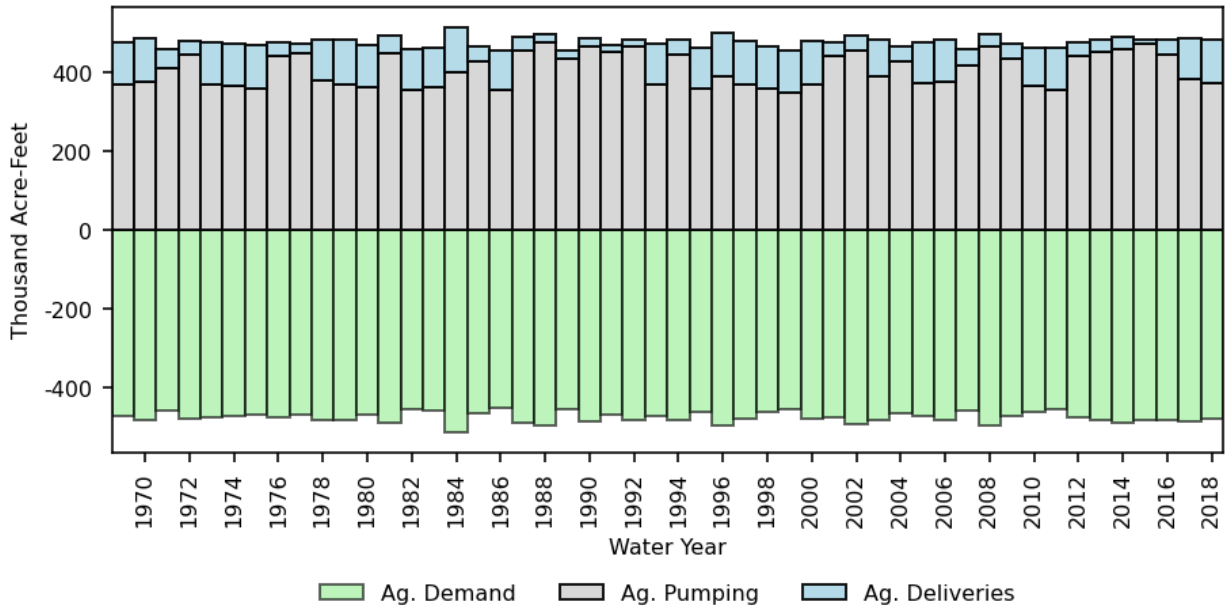
### 3.2.1 Existing Conditions

The existing conditions scenario (no-action, TOP100) land and water use budget illustrates the balance between water demand and supplies under existing land use and operational conditions. Agricultural and urban sectors rely on different combinations of surface water and groundwater that reflect local water rights, contract allocations, and hydrologic conditions. Surface water deliveries from New Hogan and New Melones Reservoirs vary with water year type and reservoir storage conditions, while groundwater serves as the primary water source when surface water is limited. This conjunctive use approach provides operational flexibility to maintain water supply reliability across the range of climatic and hydrologic conditions.

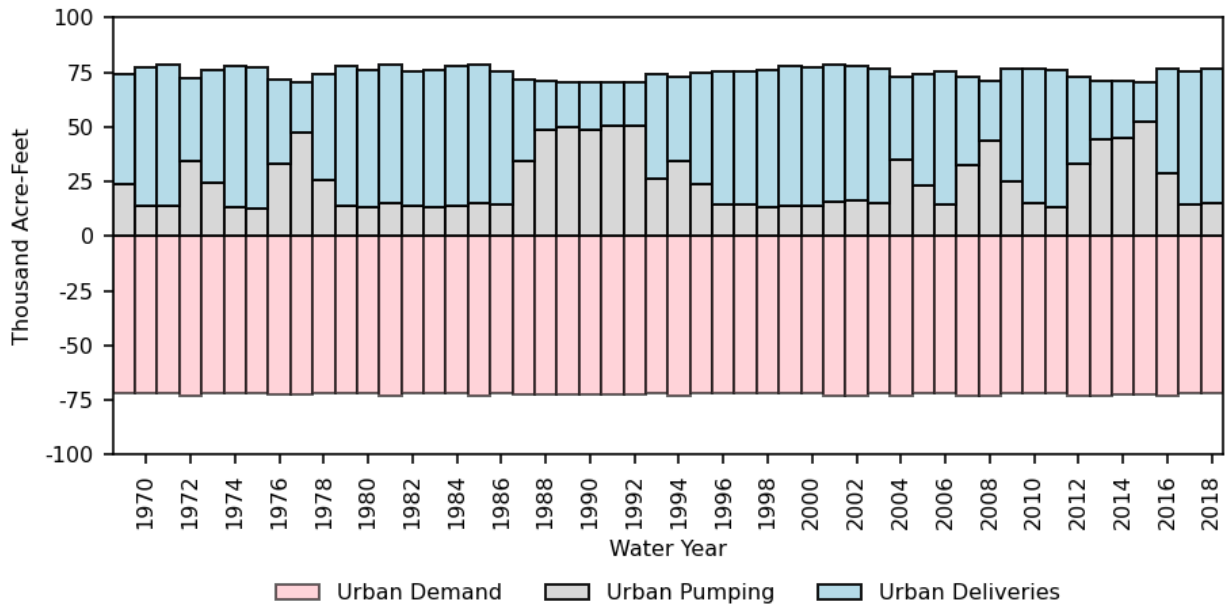
Agricultural water demand in the Calaveras River Watershed is 475 thousand acre-feet per year (TAFY) over the 50-year simulation period, with annual values ranging from 450 TAFY in cooler, wetter conditions to 513 TAFY during hot, dry periods (Figure 20). On average, 15 percent of agricultural demand is met through surface water deliveries, while the remaining 85 percent is supplied by groundwater pumping. The proportion of conjunctive use varies significantly with hydrologic conditions; in dry years, surface water can provide as low as two percent of the total water supply. In wet years, surface water availability increases to approximately 24 percent of demand, reducing stress on the groundwater system.

Throughout the existing conditions, urban water demand remains constant at 72 TAFY, reflecting a fixed population and per-capita consumption rates (Figure 21). Unlike agricultural water use, urban supplies rely more heavily on surface water deliveries, which provide an average of 68 percent of total demand. This proportion varies with water year type. During wet years, surface water can meet up to 90 percent of urban demand, allowing municipal groundwater wells to operate at minimal capacity. In contrast, dry years reduce surface water availability to as low as 25 percent of demand, requiring significant increases in groundwater pumping to maintain urban water services.

**FIGURE 20. CALAVERAS RIVER WATERSHED – EXISTING CONDITIONS (TOP100) AGRICULTURAL LAND AND WATER USE BUDGET**



**FIGURE 21. CALAVERAS RIVER WATERSHED – EXISTING CONDITIONS (TOP100) URBAN LAND AND WATER USE BUDGET**

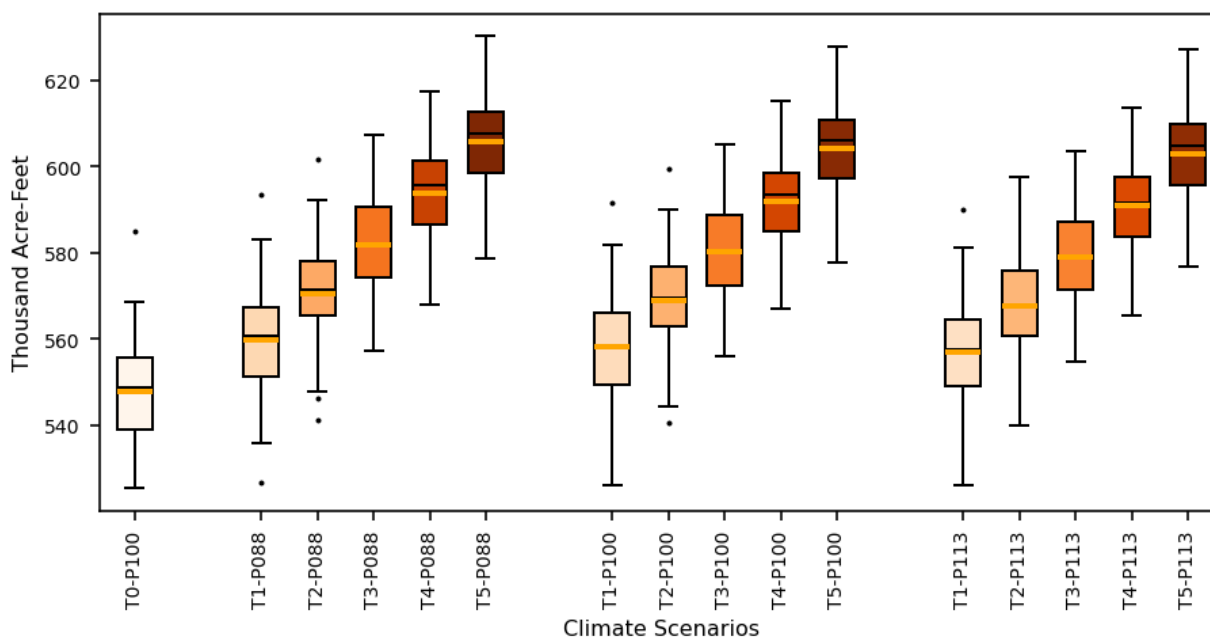


### 3.2.2 Climate Vulnerability

Climate change directly affects the water budget by increasing vegetative water demand and altering availability of surface water and groundwater conditions. Temperature increases drive higher consumptive use, while precipitation variability affects early season soil-moisture, surface water reliability, and the resulting need for groundwater extraction.

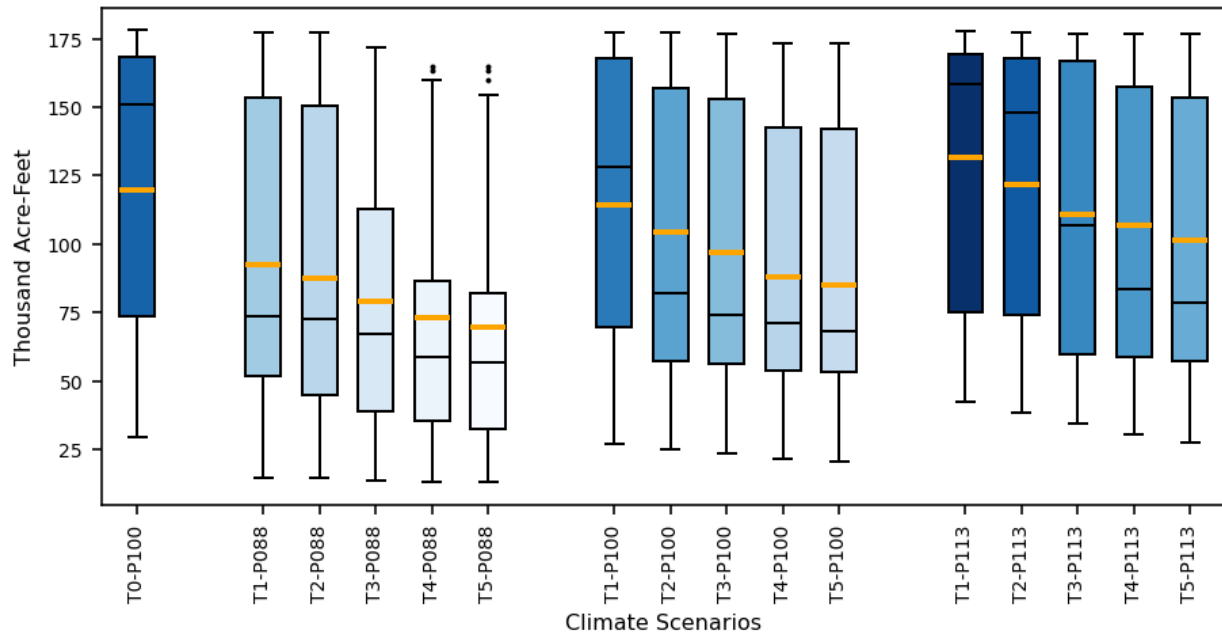
Total water demand responds primarily to temperature, with only minor effects related to precipitation (Figure 22). Under existing conditions (TOP100), average annual demand is 547 TAFY, increasing by 4% to 569 TAFY under the T2P100 scenario. Across all scenarios, demand rises approximately 11 TAFY for each 1°C temperature increase, while a 1 percent increase in precipitation reduces demand by approximately 0.1 TAFY. Water demand is driven by temperature as it directly drives evaporative losses and crop water requirements throughout the growing season, whereas precipitation has limited impact on annual water demand due to the region’s arid conditions.

**FIGURE 22. WATER SUPPLY REQUIREMENT FOR ALL CLIMATE CONDITIONS**



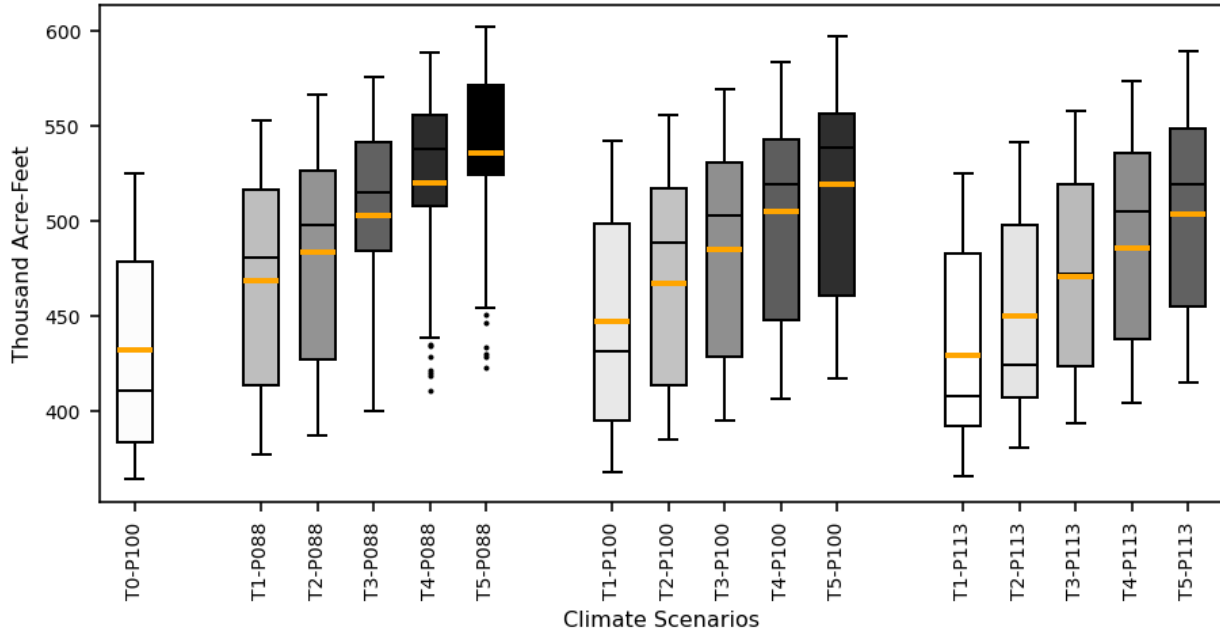
Surface water deliveries decline under warmer climate conditions as reservoir operations respond to shifting hydrologic patterns and increased demands (Figure 23). Existing conditions (TOP100) provide an average of 120 TAFY in surface water deliveries, while supplies in the T2P100 scenario are reduced to 104 TAFY. Surface water supplies decrease by approximately 4.4 TAFY for every 1°C temperature increase, reflecting increased extreme precipitation events, reduced snowpack, and increased upstream consumptive use. Precipitation changes have a smaller but positive effect, with deliveries increasing by 0.9 TAFY for every 1 percent rise in precipitation. In addition to the climactic trends shown in Figure 23, surface water deliveries exhibit substantial year-to-year variability within each climate scenario. Dry years within wetter scenarios can produce low deliveries comparable to drought conditions, while wet years in drier scenarios may temporarily restore delivery levels near existing conditions.

**FIGURE 23. SURFACE WATER DELIVERIES FOR ALL CLIMATE CONDITIONS**



To compensate for increased water demand and decreases in surface water supply, it is anticipated that growers will have a greater reliance on groundwater use under the climate change scenarios (Figure 24). Average annual pumping under the existing conditions scenario is 432 TAFY, rising to 467 TAFY under the T2P100 scenario. Pumping is sensitive to temperature, increasing by approximately 15.6 TAFY for every 1°C rise, which reflects the combined effect of higher demand and reduced surface water deliveries. Precipitation changes provide modest relief, with pumping decreasing by 1.0 TAFY for every 1 percent increase in precipitation. Like surface water deliveries, groundwater pumping shows significant interannual variability, with ranges exceeding 125 TAFY between wet and dry years within the same climate scenario. This variability underscores the importance of aquifer storage capacity and conjunctive use flexibility in maintaining water supply reliability under uncertain future conditions.

**FIGURE 24. GROUNDWATER PUMPING FOR ALL CLIMATE CONDITIONS**



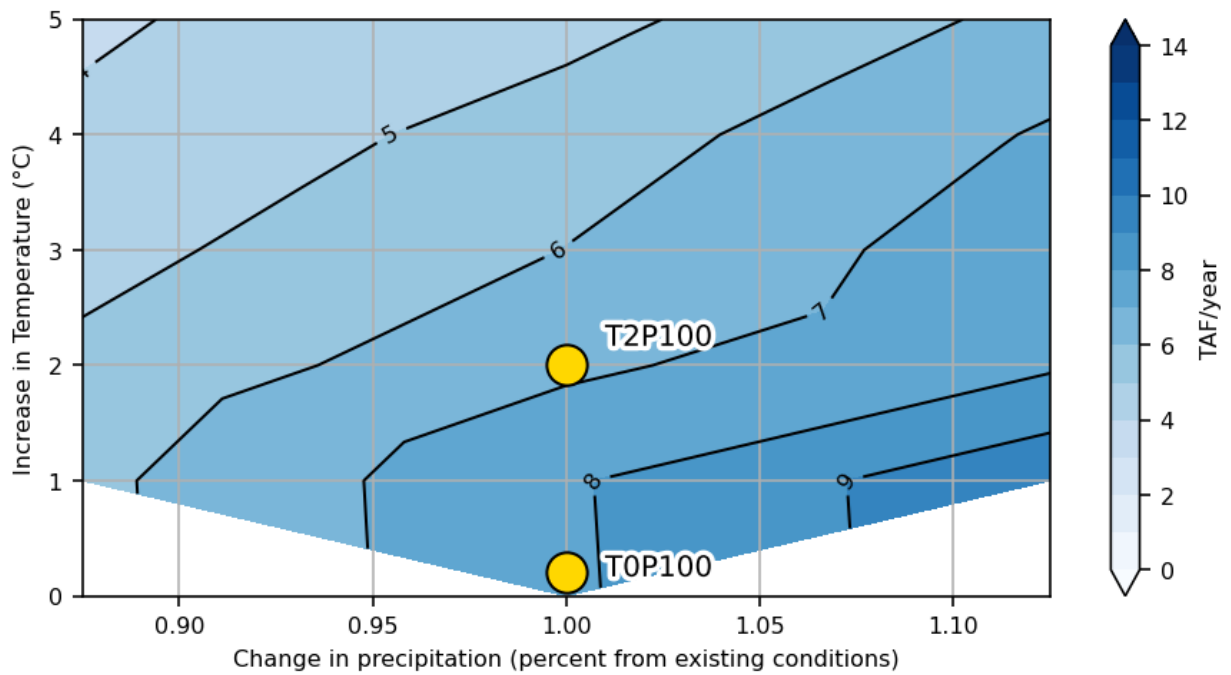
### 3.2.3 Climate Adaptation

The CWRP model climate adaptation analysis evaluates two tiers of adaptation that group projects and operational strategies based on infrastructure requirements and timeline. Tier 1 encompasses near-term actions including projects and strategies implementable within existing infrastructure, such as leveraging existing water supply projects and recharge through the MAR 90/20 regulatory framework. Tier 2 represents longer-term investments that require significant infrastructure development and enhanced operational capabilities, including the I-FIRM strategy and the Farmington Reservoir Project. Both tiers focus on augmenting surface water supplies and operational improvements rather than reducing demand. Agricultural and urban water demand remains unchanged across adaptation scenarios, as land use, evapotranspiration rates, population, and per capita consumption are held constant. The Tier 1 and Tier 2 projects and strategies increase surface water availability, reducing reliance on groundwater pumping and improving the watershed's resilience to climate variability.

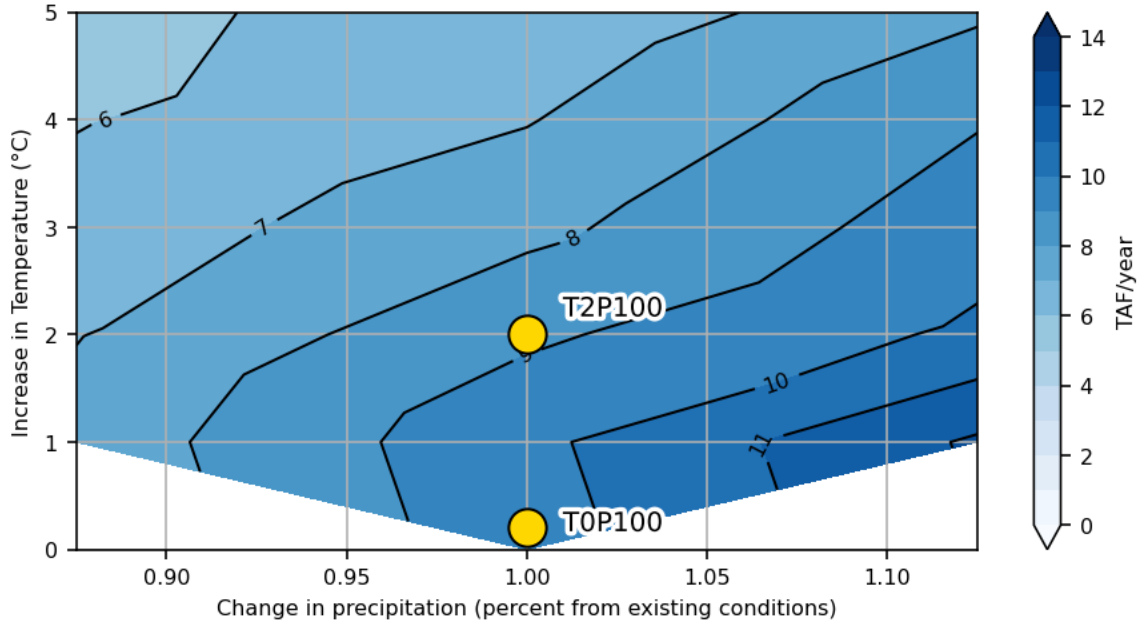
Tier 1 strategies provide meaningful increases in surface water deliveries across all climate scenarios, with the greatest benefits occurring under conditions with higher precipitation and moderate warming (Figure 25). These climate conditions typically produce more frequent wet years and fewer sustained droughts, allowing Tier 1 infrastructure and operations to capture and deliver additional high flows. Under existing conditions with tier 1 adaptation strategies (Tier 1-T0P100), projects increase average annual surface water deliveries by 7.9 TAFY, representing a 7% improvement over existing delivery volumes. Under climate change conditions with tier 2 adaptation strategies (Tier 1-T2P100), deliveries increase by 6.8 TAFY, also a 7% improvement. The consistent percentage gains across scenarios indicate that Tier 1 strategies maintain their proportional effectiveness even as absolute delivery volumes decline under warming conditions.

Tier 2 strategies provide larger increases in surface water deliveries due to additional infrastructure capacity and expanded operational flexibility (Figure 26). Like Tier 1 strategies, the highest absolute gains occur under wetter, moderately warm scenarios. Under existing conditions (TOP100), Tier 2 projects increase average deliveries by 9.6 TAFY, an 8% improvement over existing volumes. Under T2P100 climate conditions, deliveries increased by 8.8 TAFY, also representing an 8% increase. The incremental benefit of implementing Tier 2 projects and strategies in addition to Tier 1 strategies reflects the contributions of the Farmington Reservoir Project combined with leveraging additional supplies off the Calaveras and Mokelumne Rivers.

**FIGURE 25. IMPACT ON SURFACE WATER SUPPLY WITH TIER 1 ADAPTATION STRATEGIES**

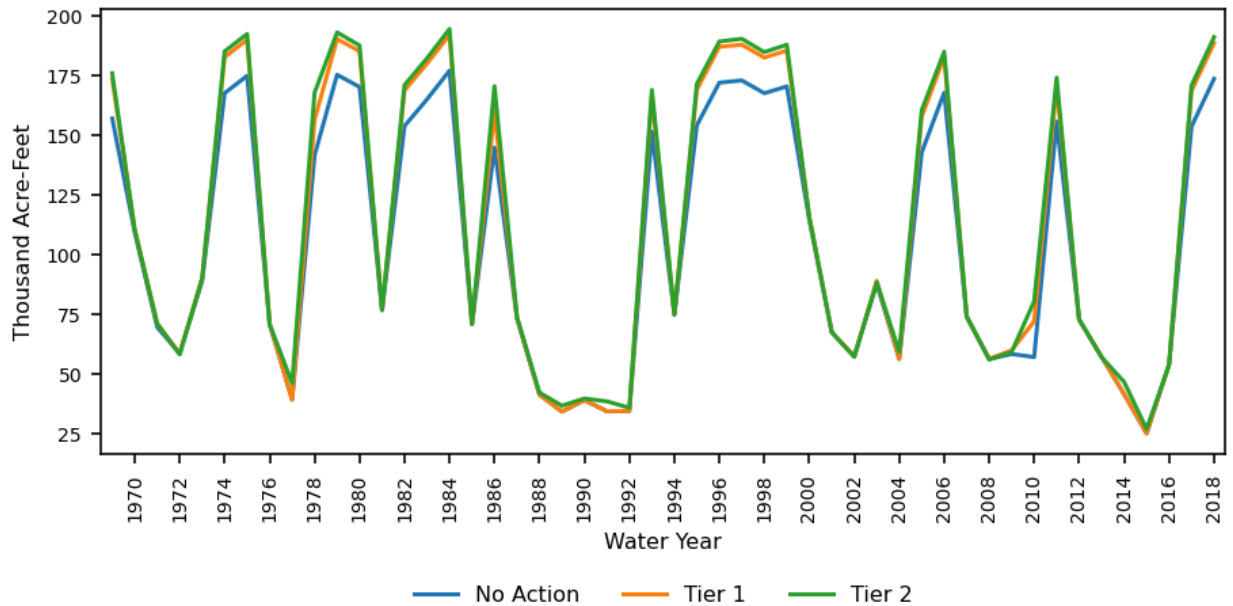


**FIGURE 26. IMPACT ON SURFACE WATER SUPPLY WITH TIER 2 ADAPTATION STRATEGIES**



The annual time series for the T2P100 scenario illustrates how adaptation strategies enhance water supply reliability during both wet and dry periods (Figure 27). Under existing conditions, surface water deliveries range from approximately 30 TAFY during severe drought years to 175 TAFY during exceptionally wet years. Tier 1 projects increase peak wet-year deliveries to 192 TAFY, while the addition of Tier 2 strategies achieves 195 TAFY. Importantly, adaptation projects also provide modest improvements during dry years by optimizing reservoir operations and leveraging the entirety of existing water rights and contracts. This dual benefit of enhancing both wet-year capture and dry-year reliability demonstrates that the adaptation portfolio addresses multiple dimensions of climate vulnerability rather than simply shifting water within the hydrologic cycle.

**FIGURE 27. ANNUAL SURFACE WATER SUPPLY UNDER CLIMATE CHANGE CONDITIONS (T2P100)**

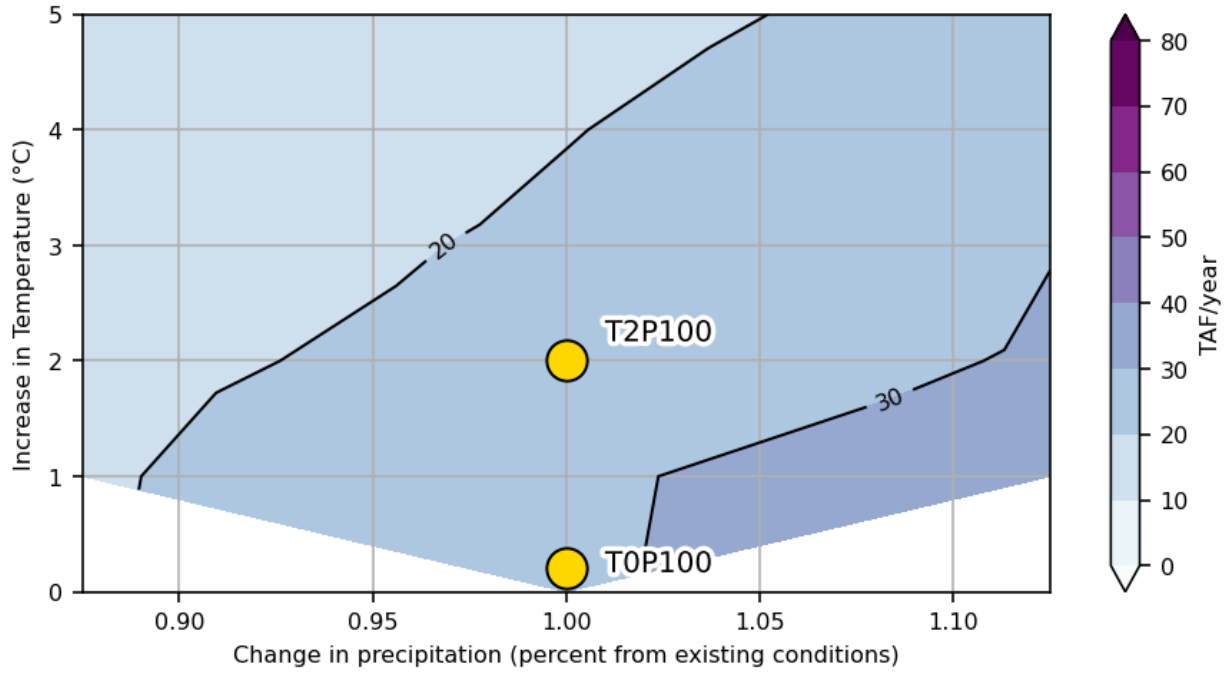


Beyond augmenting traditional surface water deliveries, both Tier 1 and Tier 2 strategies incorporate managed aquifer recharge to enhance watershed resilience and promote long-term storage. Direct recharge occurs when surface water is intentionally conveyed to recharge basins or agricultural lands during periods of high availability, with the purpose of percolating to underlying aquifers. This approach leverages WAFR identified through the DWR Watershed Studies, capturing flood flows that would otherwise pass through the system unused.

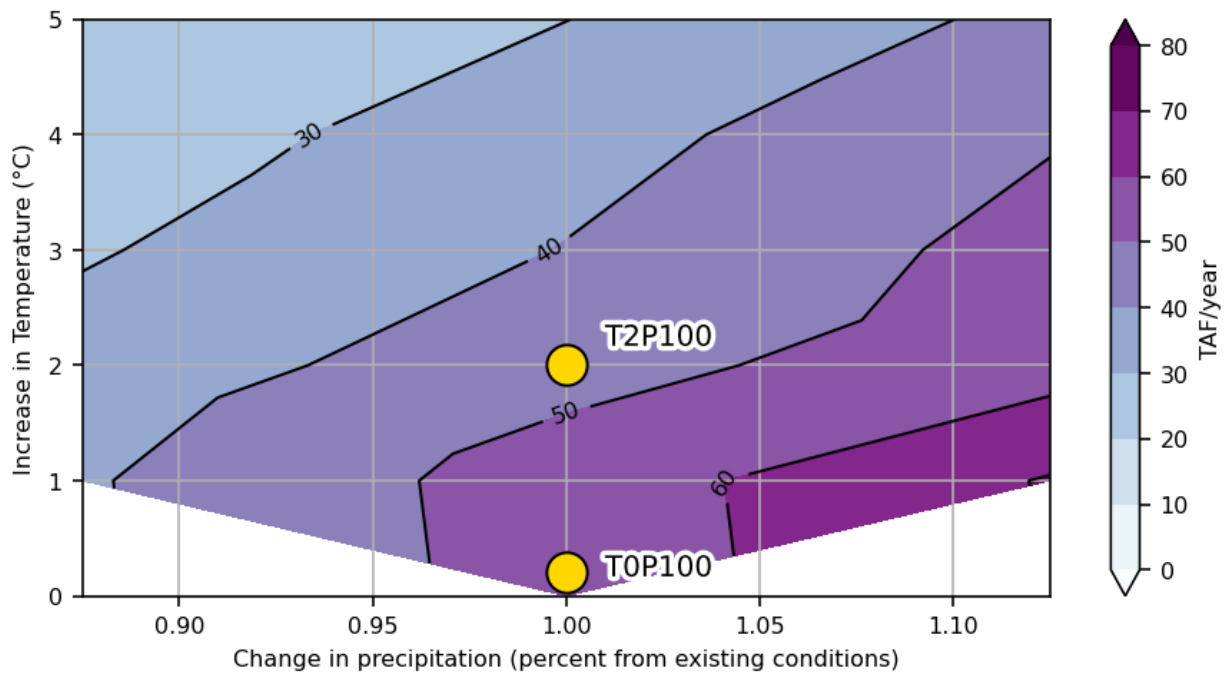
Tier 1 recharge operations utilize the MAR 90/20 strategy to capture high winter flows under existing infrastructure and streamlined permitting (Figure 28). Under existing conditions (TOP100), Tier 1 recharge averages 29 TAFY annually, whereas the T2P100 scenario, the average annual recharge is reduced to 25 TAFY, reflecting the temperature-driven reduction and overall streamflow availability. However, the intensification of extreme precipitation events under warming partially offsets this decline by creating more frequent high-flow windows suitable for diversion under the 90/20 criteria. Climate scenarios with increased precipitation (P113) demonstrate higher recharge potential, averaging 37 TAFY, while drier scenarios (P88) reduce average recharge to 11 TAFY.

Tier 2 recharge operations achieve higher volumes through the I-FIRM strategy, which employs forecast-informed reservoir management to increase WAFR availability beyond what MAR 90/20 can capture (Figure 29). Under existing conditions (TOP100), Tier 2 strategies averages 54 TAFY of recharge, increasing to 110 TAFY during wet years when coordinated reservoir releases and conveyance capacity can be optimized. Under the T2P100 scenario, average recharge remains robust at 47 TAFY, demonstrating that forecast-informed operations maintain effectiveness and the incremental recharge benefit of Tier 2 over Tier 1 averages between 22-71 TAFY across each of the climate scenarios.

**FIGURE 28. ANNUAL AVERAGE DIRECT RECHARGE FROM TIER 1 ADAPTATION STRATEGIES**



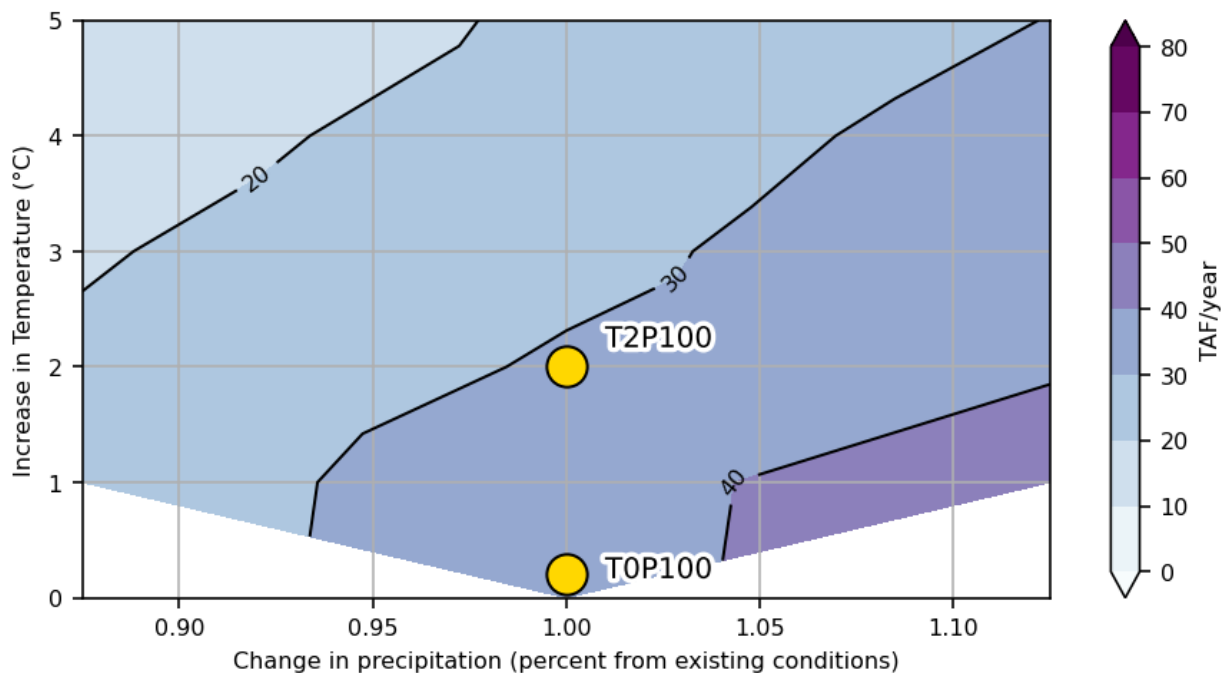
**FIGURE 29. ANNUAL AVERAGE DIRECT RECHARGE FROM TIER 2 ADAPTATION STRATEGIES**



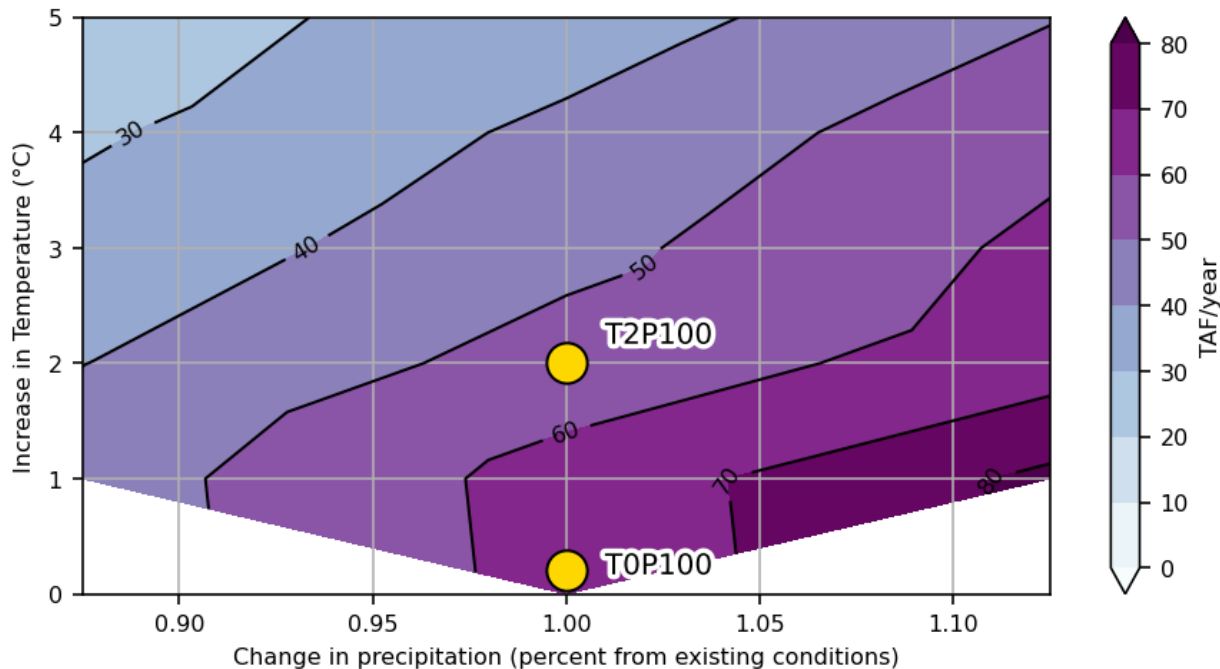
The combined benefits of increased surface water deliveries for in-lieu and direct recharge from WAFR create substantial cumulative impacts in the Calaveras River Watershed (Figure 30 and Figure 31). Utilizing Tier 1 strategies under the T2P100 scenario, the combined effect of these projects brings a total of approximately 32 TAFY of additional supply to the watershed. This impact is comprised of 7 TAFY from in-lieu programs related to increased deliveries and 25 TAFY from direct recharge projects. Tier 2 strategies enhance this total to 54 TAFY, with 7 TAFY from in-lieu recharge and 47 TAFY from direct recharge under I-FIRM operations.

Over the 50-year simulation period, the cumulative water supply benefits of adaptation strategies represent a substantial investment in long-term watershed sustainability. Over the 50-year simulation period, Tier 1 projects contribute an estimated 1,550 TAF of total water supply augmentation under T2P100 conditions, while Tier 2 projects increase this to 2,700 TAF. These volumes translate to meaningful improvements in water balance, helping offset the systematic increases in demand and reductions in the surface water availability expected under climate change. The specific impacts on groundwater conditions, including storage gains, water level improvements, and SGMA sustainability metrics, are detailed in subsequent sections of this report.

**FIGURE 30. ANNUAL AVERAGE IN-LIEU AND DIRECT RECHARGE FROM TIER 1 ADAPTATION STRATEGIES**



**FIGURE 31. ANNUAL AVERAGE IN-LIEU AND DIRECT RECHARGE FROM TIER 2 ADAPTATION STRATEGIES**



### 3.3 Stream and Reservoir Systems

This section examines stream system dynamics and reservoir operations within the Calaveras River Watershed, addressing two risk categories from the analytical framework, Flood Control and Water Supply. The analysis evaluates how existing operations, climate change conditions, and the Tier 1 and Tier 2 adaptation strategies affect the interconnected components of the surface water system.

Flood-related impacts are assessed through two primary metrics, flood space management at New Hogan Reservoir and in-stream flow conditions. Together, these metrics describe the system’s ability to maintain adequate storage capacity for flood control and quantify the magnitude of potential downstream releases. Water supply metrics are characterized through interconnected components, including the overall inflow to reservoir, environmental releases, and volumetric diversions for agricultural and urban use. These metrics collectively reveal how climate change alters both the availability of water supplies and the system’s ability to manage extreme hydrologic events.

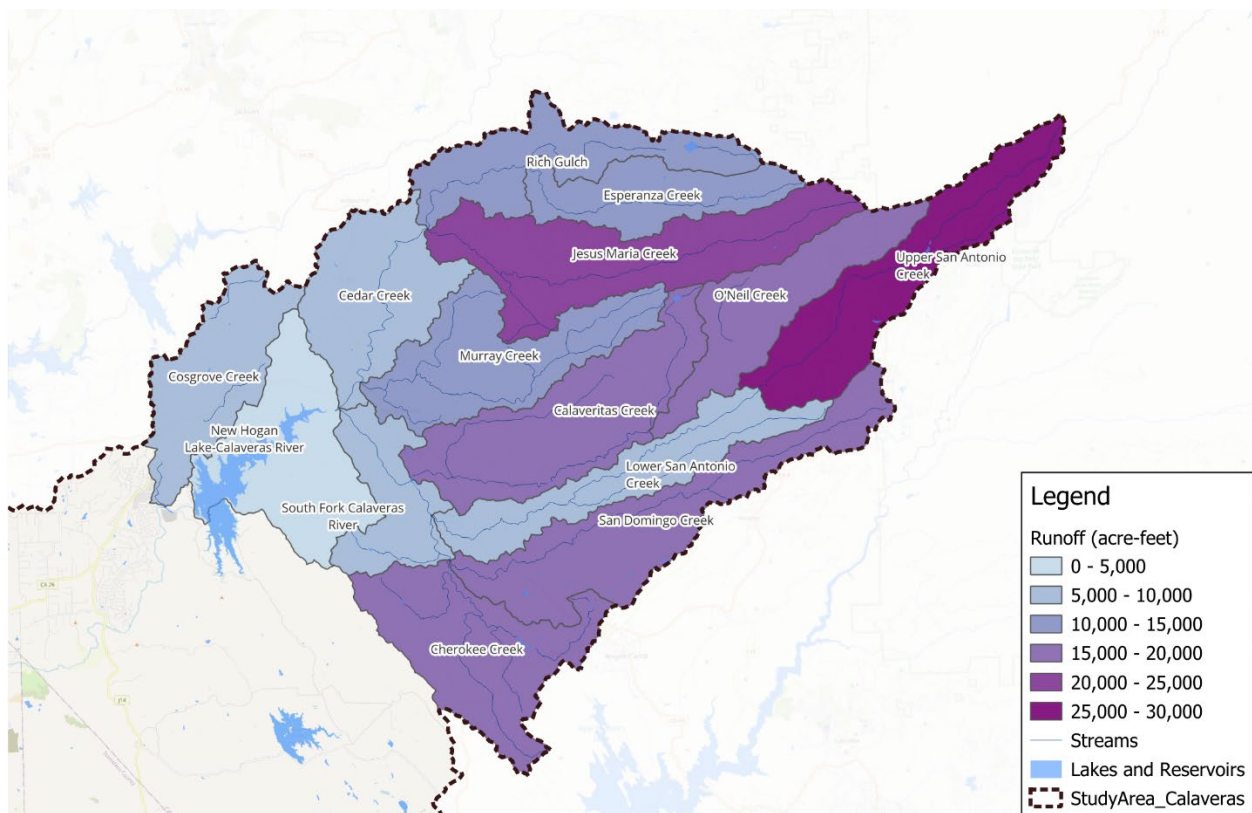
#### 3.3.1 Existing Conditions

The upper Calaveras River Watershed encompasses a diverse set of physical characteristics and vegetative conditions that affect reservoir inflow and water supplies. At the watershed scale, the Sacramento Soil Moisture Accounting model simulates how precipitation is transformed into streamflow using a combination of precipitation, evapotranspiration, and a variety of physical parameters. The model tracks water movement through multiple pathways including temporary storage in snowpack, root-zone soil moisture, and shallow groundwater systems that sustain baseflow between precipitation events. The SAC-

SMA configuration was verified against historical observations and downscaled to the sub-watershed level using precipitation data from PRISM (Parameter-elevation Regressions on Independent Slopes Model) and remotely sensed, high-resolution evapotranspiration data from OpenET.

Based on this downscaling, Figure 32 illustrates runoff at the sub-watershed scale, while Table 5 summarizes the key hydrological conditions. Annual average precipitation ranges from 28.9 to 46.3 inches while average annual evapotranspiration rates vary from 19.3 to 29.5 inches. The resulting annual runoff averages 10.3 inches across the watershed, representing the portion of precipitation that neither evaporates nor remains stored in soil or shallow aquifers.

**FIGURE 32. RUNOFF ESTIMATES IN HUC-12 WATERSHEDS FOR EXISTING CONDITIONS**

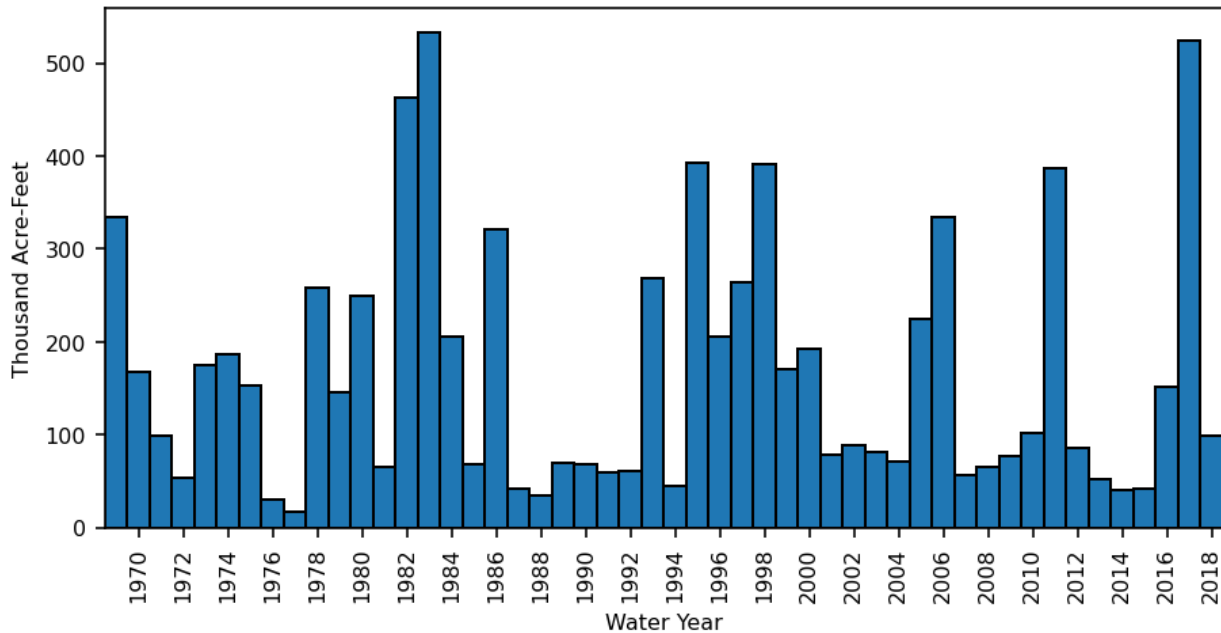


**TABLE 5. AVERAGE ANNUAL HYDROLOGIC CONDITIONS IN THE UPPER SUB-WATERSHEDS**

<b>HUC 12 Watershed</b>	<b>Area (ac.)</b>	<b>Precipitation (in.)</b>	<b>ET-Actual (in.)</b>	<b>Runoff (in.)</b>
Esperanza Creek	10,655	38.0	24.3	13.7
Rich Gulch	13,693	36.2	25.1	11.1
Jesus Maria Creek	22,468	37.1	24.5	12.6
Murray Creek	17,435	31.8	22.6	9.2
Cedar Creek	15,480	28.9	24.4	4.5
Upper San Antonio Creek	18,222	46.3	29.5	16.8
Lower San Antonio Creek	13,693	32.5	25.0	7.4
O'Neil Creek	13,476	40.7	27.4	13.3
Calaveritas Creek	21,267	31.8	23.2	8.5
San Domingo Creek	21,013	33.1	24.5	8.5
Cherokee Creek	18,777	29.1	19.3	9.8
South Fork Calaveras River	9,263	29.7	22.9	6.9
<b>Total</b>	<b>195,452</b>	<b>34.6</b>	<b>24.3</b>	<b>10.3</b>

New Hogan Reservoir captures runoff from the upper watershed, which exhibits substantial interannual variability driven by precipitation patterns (Figure 33). Under existing conditions, average annual inflow is 167 TAF, ranging from 16 TAF in critically dry years to 533 TAF in exceptionally wet years. The reservoir regulates this variability through seasonal and multi-year storage, providing flood protection during wet periods and water supply reliability during droughts. By dampening hydrologic extremes, New Hogan Reservoir reduces flood risk and supports agricultural, urban, and environmental water demands throughout the lower watershed.

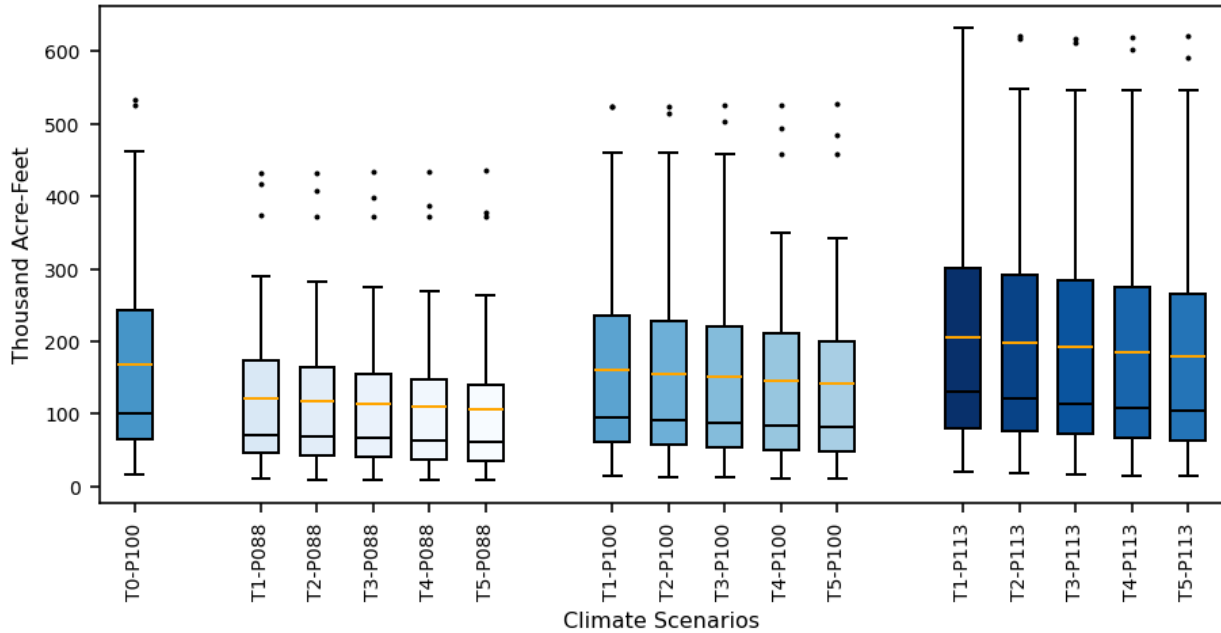
**FIGURE 33. ANNUAL INFLOW TO NEW HOGAN RESERVOIR UNDER EXISTING CONDITIONS (TOP100)**



### 3.3.2 Climate Vulnerability

Annual inflows to New Hogan Reservoir vary across climate scenarios, with precipitation changes driving the primary differences between each of the scenario groups shown in Figure 34. The three distinct groupings correspond to precipitation conditions, with P113 scenarios producing the highest median inflows, P100 scenarios generating intermediate flows, and P088 scenarios yielding the lowest inflows. Under the T2P100 scenario, average annual inflow is 156 TAF, with individual years ranging from 13 TAF to 524 TAF. This wide range reflects the sensitivity of watershed runoff to precipitation variability, mirroring the patterns observed in the existing conditions scenario.

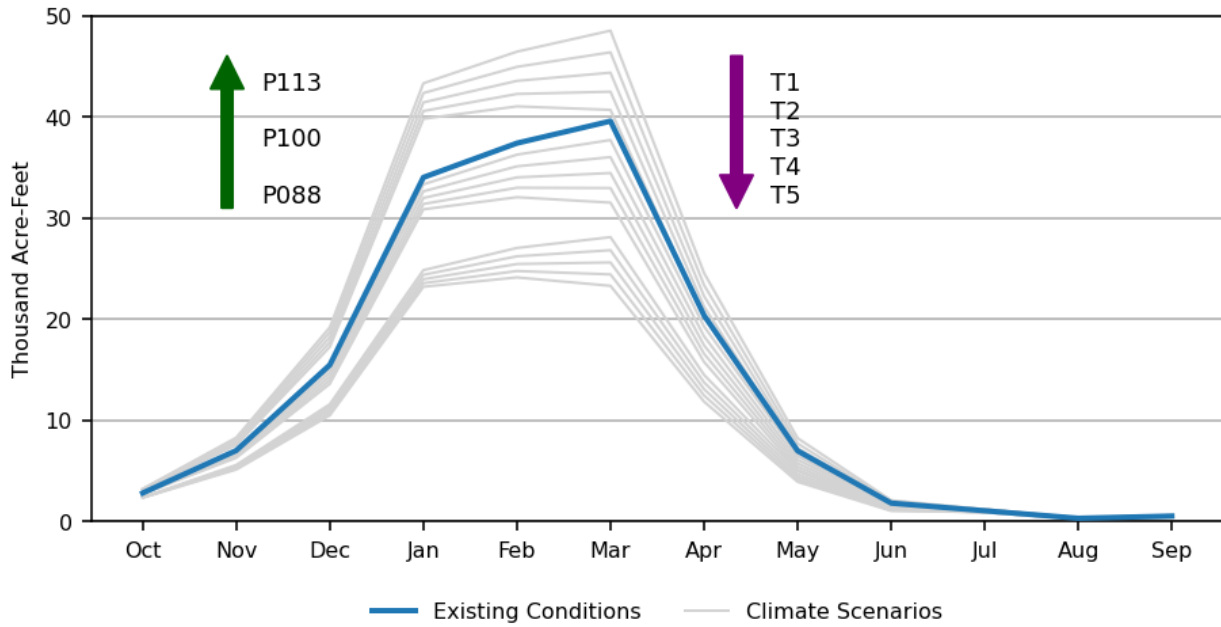
**FIGURE 34. ANNUAL NEW HOGAN INFLOW FOR ALL CLIMATE CONDITIONS**



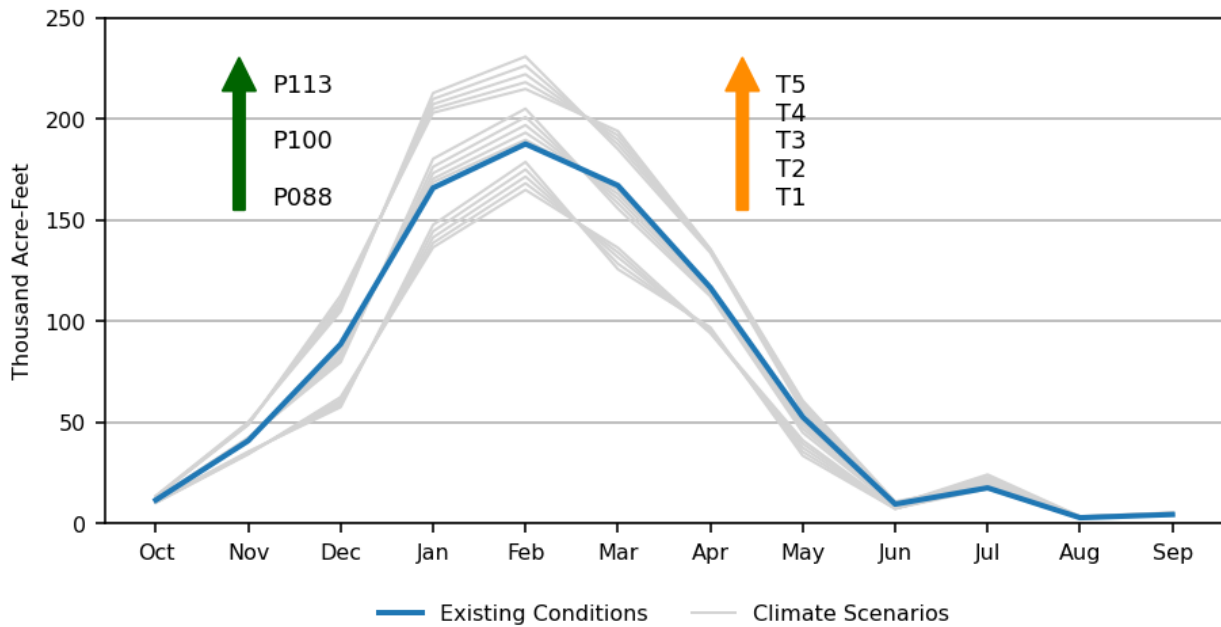
Monthly average inflows reveal distinct seasonal patterns and climate sensitivities (Figure 35). Within each precipitation group, inflows decrease progressively with increasing temperature. This pattern reflects higher evapotranspiration rates and reduced soil moisture storage in the upper watershed under warmer conditions, contributing to less streamflow and inflow to New Hogan Reservoir.

Figure 36, on the other hand, shows how monthly maximum inflows exhibit a contrasting response to warming as compared to the average inflow. While the same three precipitation-driven groupings are apparent, peak inflows increase with rising temperature within each group. This pattern reflects the intensification of extreme precipitation events under warmer conditions, where increased atmospheric moisture capacity produces more intense storms. Although annual and average monthly flows may decline with warming, the shift toward rain-dominated hydrology and more concentrated precipitation events increases flood magnitudes. These hydrologic dynamics impact reservoir flood management, as New Hogan Reservoir must balance competing objectives of capturing high flows for water supply while maintaining adequate flood space to protect downstream communities.

**FIGURE 35. MONTHLY AVERAGE INFLOW TO NEW HOGAN RESERVOIR**



**FIGURE 36. MONTHLY MAXIMUM INFLOW TO NEW HOGAN RESERVOIR**

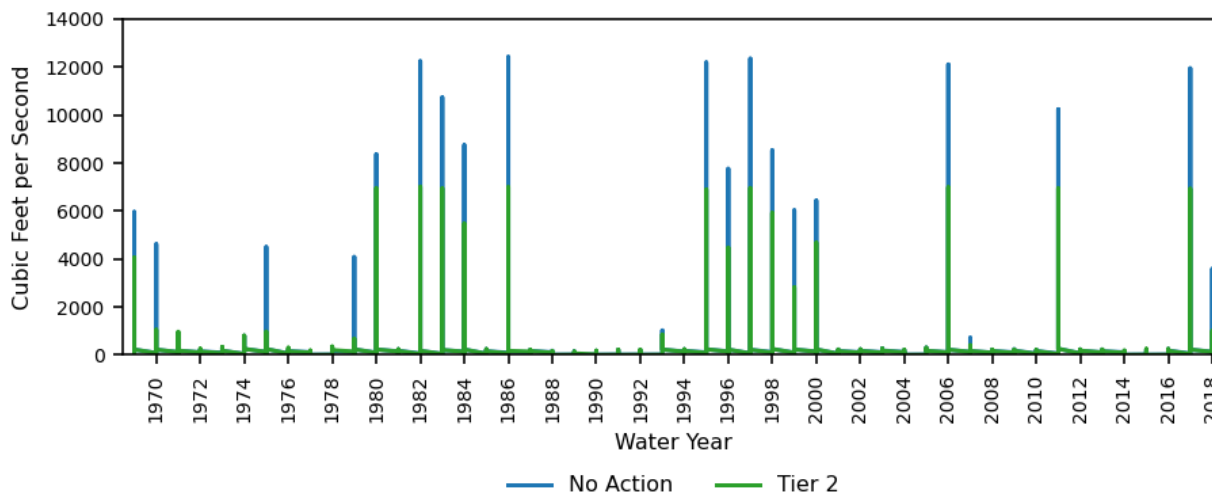


### 3.3.3 Climate Adaptation

Climate adaptation strategies for New Hogan Reservoir operations present significant opportunities to reduce flood risk while enhancing water supply capture through forecast-informed management. Tier 1 scenarios implement the Streamlined Flood-MAR (MAR 90/20) approach, which operates within existing reservoir rule curves and captures high flows when they exceed historical thresholds. Tier 2 scenarios employ the Integrated Forecast-Informed Resources Management (I-FIRM) strategy, which uses advanced weather forecasts and hydrologic modeling to dynamically adjust reservoir operations. By anticipating incoming storms with greater accuracy, I-FIRM allows operators to pre-release water ahead of flood events, creating additional flood storage capacity while making that water available for beneficial recharge rather than uncontrolled spill.

The flood risk reduction benefits of I-FIRM operations are evident in daily flow patterns below New Hogan Dam (Figure 37). Under the T2P100 climate scenario, annual average streamflow remains similar across all scenarios, with 197 TAF for no-action, 198 TAF for Tier 1, and 200 TAF for Tier 2 adaptation strategies. However, the distribution of these flows differs substantially. Tier 2 operations reduce peak daily flows to approximately 7,000 cubic feet per second (cfs), compared to maximum flows of 12,400 cfs under existing and Tier 1 conditions. This 44% reduction in peak discharge directly translates to reduced flood risk for downstream communities and infrastructure along the lower Calaveras River.

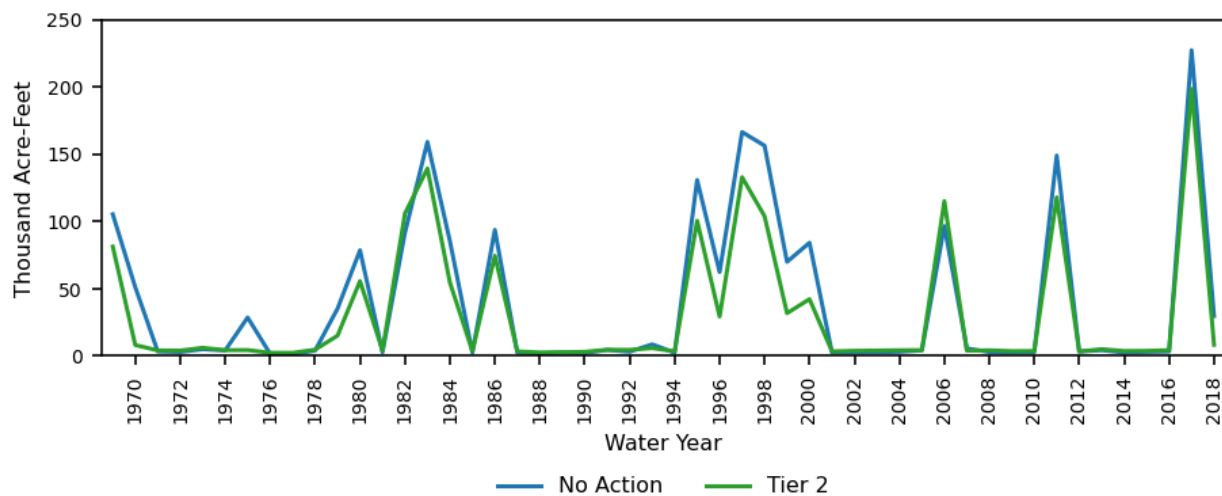
**FIGURE 37. DAILY INFLOW TO THE CALAVERAS RIVER BELOW NEW HOGAN UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



Assessing flood risk downstream of New Hogan Reservoir is constrained by the temporal resolution of the CWRP model. The CWRP model was adapted from the ESJWRM and maintains the monthly timestep suitable for long-term water budget analysis but inadequate for capturing short-duration flood peaks. While HEC-ResSim simulates reservoir operations at a three-hour timestep, these detailed flows are aggregated to monthly values when provided as inputs to CWRP. This temporal aggregation limits precise flood risk assessment and represents an area for future model refinement.

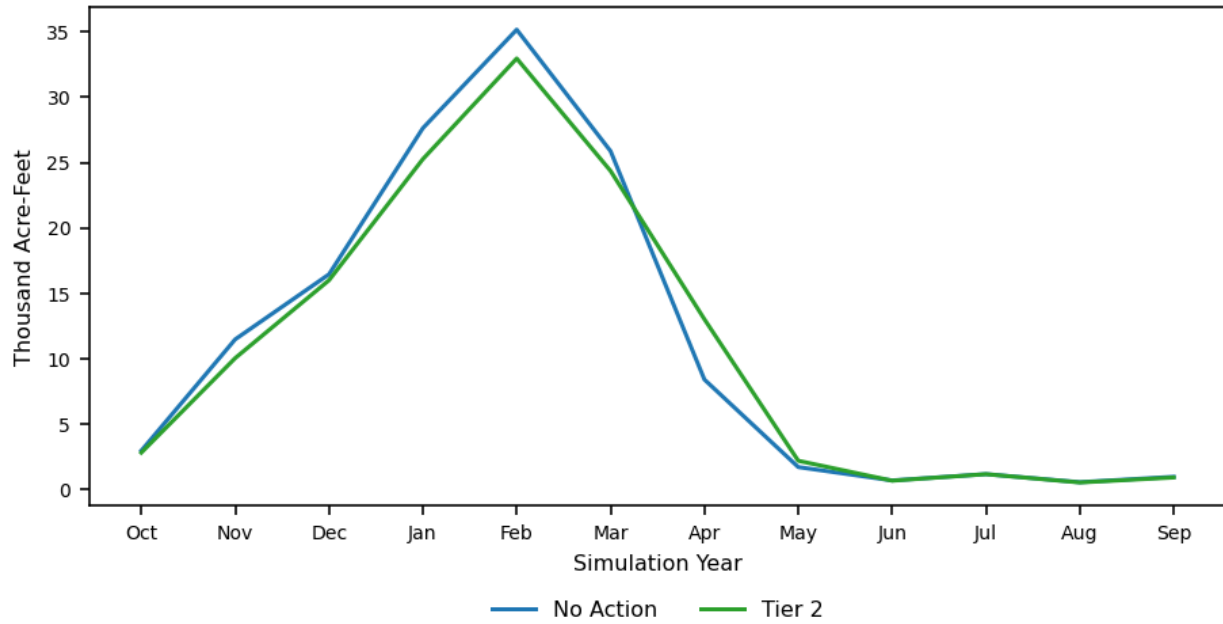
Despite these temporal limitations, flow patterns at Bellota Weir, upstream of the bypass to Mormon Slough, demonstrate meaningful flood protection benefits from Tier 2 strategies. Average annual flow at Bellota remains similar across T2P100 scenarios, ranging from 102 to 108 TAF for no-action, Tier 1, and Tier 2 conditions. However, maximum monthly flows show substantial reductions under I-FIRM operations (Figure 38). Tier 2 strategies reduce peak flows by capturing and diverting water during high-flow periods to managed recharge facilities. These flow reductions provide protection for agricultural lands and communities in the lower watershed, demonstrating that adaptation benefits are evident even at the monthly evaluation scale.

**FIGURE 38. MONTHLY MAXIMUM FLOW IN THE CALAVERAS RIVER AT BELLOTA WEIR UNDER CLIMATE CHANGE CONDITIONS (T2P100)**

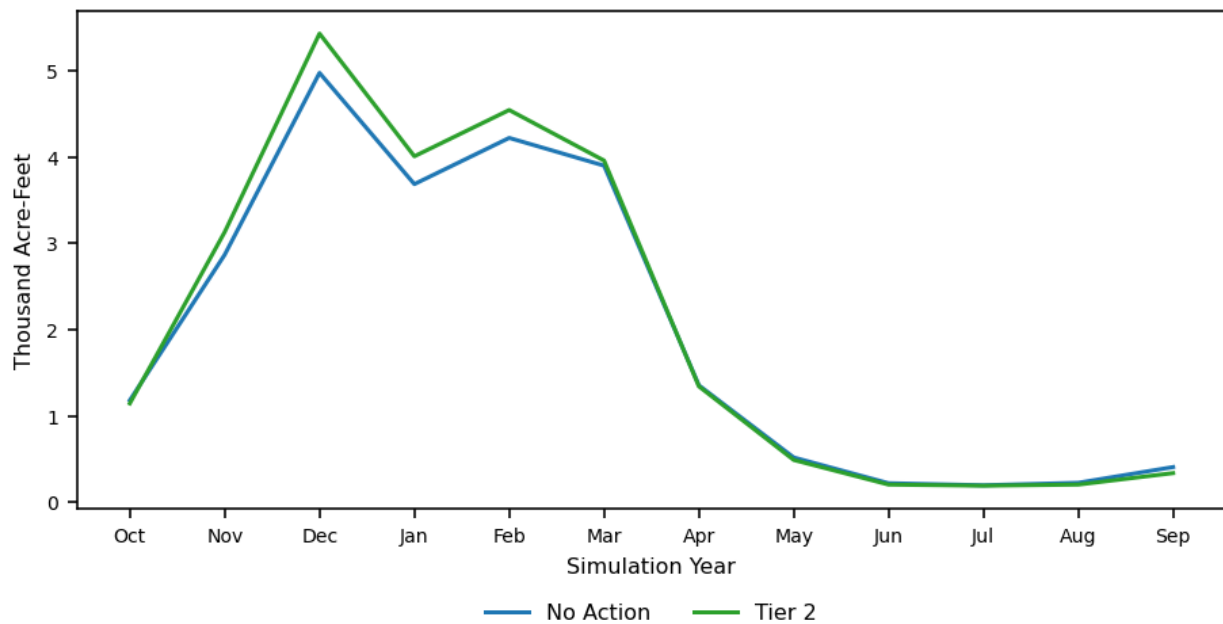


Beyond flood control, Tier 2 projects enhance stream ecological conditions through increased baseflows and reduced stream depletions. Figure 39 and Figure 40 show monthly average flows in the lower Calaveras River approaching its confluence with the San Joaquin River. Managed aquifer recharge operations improve stream conditions through two complementary mechanisms. During high-flow periods, diversions to recharge facilities reduce excess downstream flows that can cause erosion and habitat disturbance. During subsequent low-flow periods, the groundwater stored from those diversions returns to the stream through enhanced baseflow, sustaining higher flows when they are most needed. This dynamic is particularly evident during the multi-year drought sequences shown in Figure 40, where Tier 2 strategies maintain higher dry-season flows compared to no-action conditions. These sustained flows provide critical habitat benefits during periods when stream-dependent ecosystems are most vulnerable.

**FIGURE 39. MONTHLY AVERAGE OUTFLOW OF THE CALAVERAS RIVER TO THE SAN JOAQUIN RIVER UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



**FIGURE 40. MONTHLY AVERAGE OUTFLOW OF THE CALAVERAS RIVER TO THE SAN JOAQUIN RIVER IN CRITICAL YEARS UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



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### **3.4 Groundwater System**

The groundwater system represents a critical hydraulic and water supply component for the Calaveras River Watershed, supporting agricultural, municipal, and domestic uses. This section presents a comprehensive analysis of the groundwater system, which used integrated hydrologic modeling to simulate aquifer conditions, quantify system dynamics, and assess climate vulnerability.

The groundwater budget accounts for all water entering and leaving the aquifer system. Different budget components respond distinctly to precipitation patterns and operational decisions, with some remaining constant while others vary significantly between wet and dry periods. The analysis of existing conditions quantifies these sensitivities to identify which components will experience the greatest changes under altered climate conditions and where adaptation strategies can most effectively maintain aquifer sustainability.

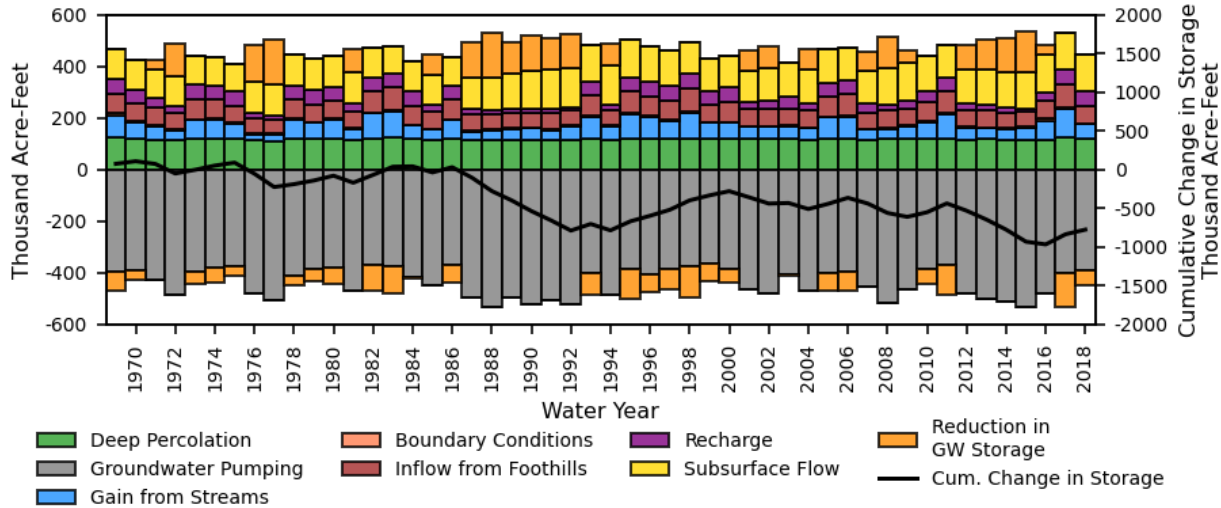
#### **3.4.1 Existing Conditions**

Groundwater change in storage is the difference between inflows and outflows in the groundwater system. Within the Calaveras River Watershed, inflows include deep percolation, stream seepage, conveyance recharge, and subsurface flow while the main outflow is groundwater pumping. Figure 41 presents the annual groundwater budget components for the existing conditions, (No-Action, TOP100) scenario. Inflows appear on the positive y-axis, outflows on the negative y-axis, and cumulative storage change is shown as a line referenced to the secondary y-axis.

The budget analysis demonstrates that groundwater pumping dominates storage dynamics. High pumping years produce substantial storage declines, while reduced pumping years allow aquifer recovery. Deep percolation remains stable throughout the 50-year simulation period. Stream seepage and conveyance recharge increase and during wet years where there is enhanced surface water availability and elevated stream conditions.

Subsurface flow is governed by the hydraulic gradient between the Calaveras River watershed and adjacent watersheds. At the beginning of the simulation, groundwater levels in the Mokelumne and Stanislaus River watersheds are higher than in the Calaveras River watershed, producing a net-inflow toward the Calaveras River watershed. As the simulation progresses and groundwater storage declines within the Calaveras River Watershed, this gradient steepens, resulting in increased subsurface inflow from the neighboring basins into the Calaveras River Watershed.

**FIGURE 41. GROUNDWATER BUDGET UNDER EXISTING CONDITIONS (TOP100)**



### 3.4.2 Climate Vulnerability

Climate change impacts the groundwater system in multiple ways. As discussed in previous sections, increases in temperature affect water supplies and demand, while precipitation patterns alter the timing and magnitude of recharge events, affect seasonal runoff and seepage to the aquifer system. This section quantifies how groundwater storage responds to systematic variations in temperature and precipitation across each of the climate scenarios spanning a range of plausible future conditions.

Figure 42 presents the distribution of annual groundwater storage changes across all climate scenarios. Under the T2P100 scenario (2°C warming, no precipitation change), the watershed experiences an average annual storage deficit of 34 TAF. Storage losses intensify with increasing temperature, ranging from 16 TAF annual deficit in TOP100 scenario to 61 TAF in the T5P100 scenario. Reductions in precipitation intensifies storage deficits, while scenarios with increased precipitation partially offsets temperature-driven losses.

Interannual variability in storage change also increases under warmer conditions. The T2P100 scenario exhibits annual storage changes ranging from +146 TAF to -195 TAF. Higher temperature scenarios amplify this variability due to more extreme weather events, evident in the expanded whisker ranges on the boxplots.

**FIGURE 42. ANNUAL CHANGE OF GROUNDWATER IN STORAGE FOR ALL CLIMATE CONDITIONS**

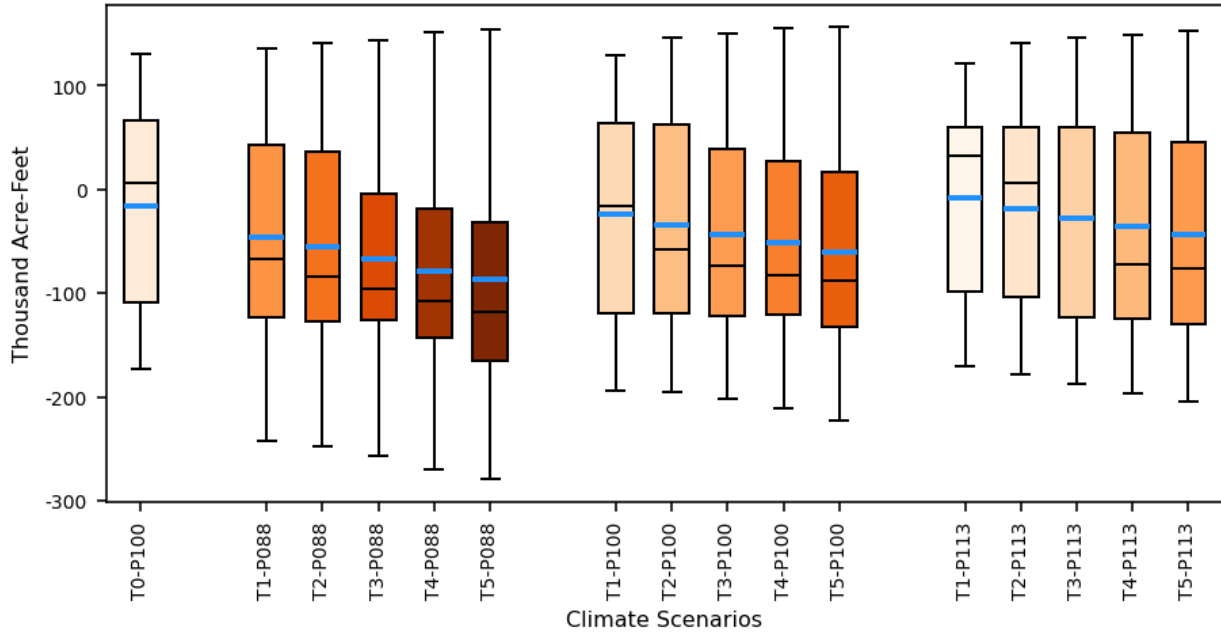


Figure 43 shows cumulative groundwater storage change over the 50-year simulation period for all 15 climate scenarios, with No-Action, T0P100 (existing conditions) and No-Action, T2P100 (climate change conditions) highlighted. All scenarios produce net cumulative storage decline, though the magnitude varies considerably. The most severe scenarios result in storage losses exceeding 4,000,000 AF over the simulation period.

**FIGURE 43. CUMULATIVE CHANGE OF GROUDNWEATER IN STORAGE FOR ALL CLIMATE CONDITIONS**

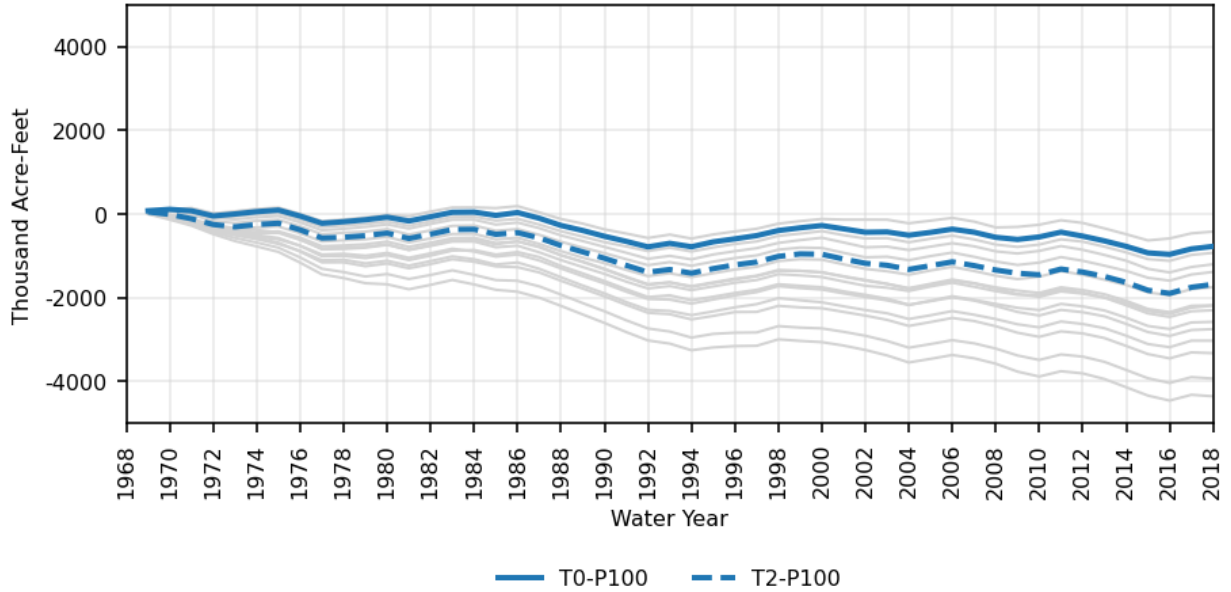
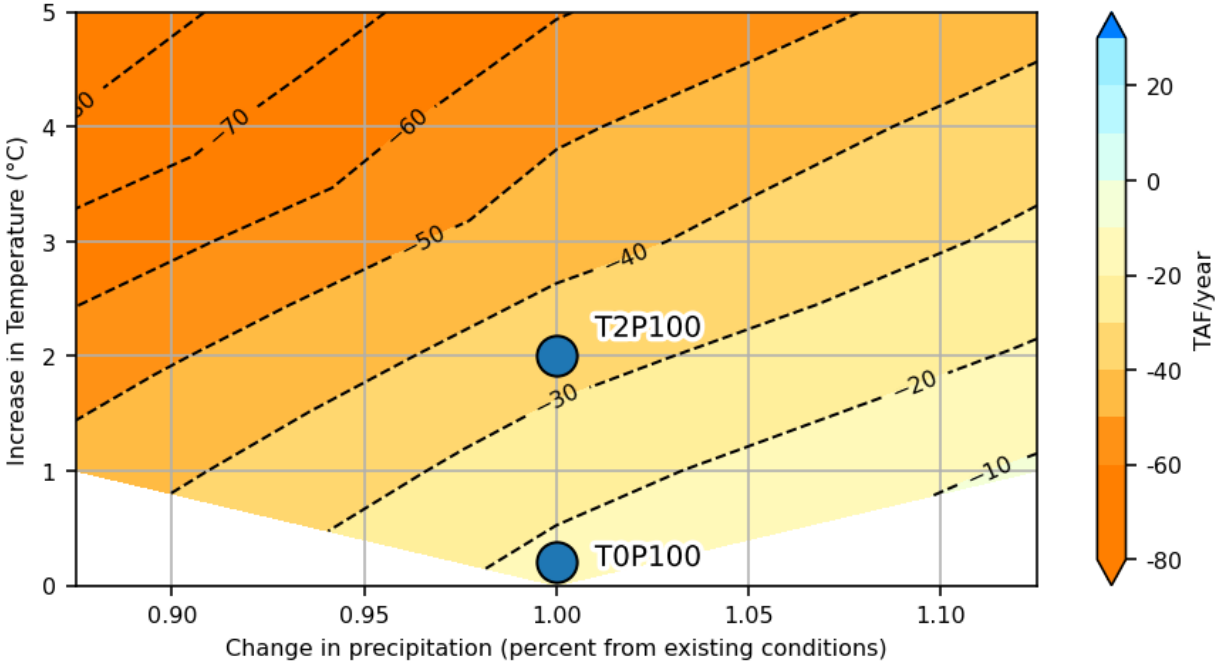


Figure 44 presents the relationship between temperature, precipitation, and average annual storage change as a response surface. The analysis reveals linear relationships. Groundwater storage decreases by approximately 9 TAF annually for each 1°C temperature increase and increases by 1.6 TAF annually for each 1% precipitation increase. No climate scenario achieves net positive average annual storage change without adaptation strategies, indicating that adaptation measures will be necessary to maintain groundwater sustainability across all plausible future climates.

**FIGURE 44. AVERAGE ANNUAL CHANGE OF GROUNDWATER IN STORAGE WITH NO-ACTION**

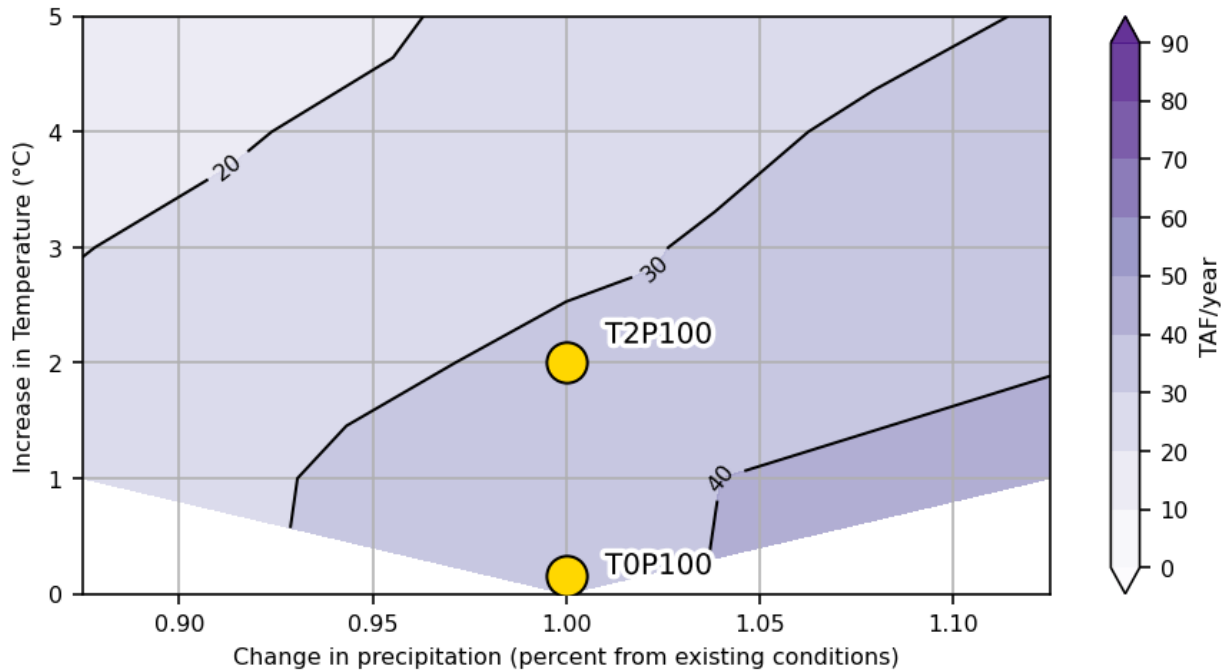


### 3.4.3 Climate Adaptation (Tier 1)

Tier 1 adaptation strategies enhance groundwater sustainability through increased surface water deliveries and managed aquifer recharge. These interventions modify the groundwater budget by augmenting recharge, reducing pumping demand through in-lieu surface water use, and improving deep percolation from irrigation practices. The combined effect of these changes is quantified as "applied recharge," representing the net improvement in aquifer conditions compared to the existing and no-action climate change conditions..

Applied recharge varies systematically across climate scenarios based on water availability and operational constraints (Figure 45). Under the TOP100 scenario, Tier 1 projects deliver 36 TAF of annual applied recharge, which is decreased to 32 TAF under the most probably climate scenario (T2P100). On average, recharge volumes decline approximately 4 TAF for each 1°C temperature increase due to reduced surface water availability and higher consumptive demands. Conversely, each 1% increase in precipitation enhances applied recharge by approximately 0.7 TAF by expanding the available water supply and diversions under the MAR 90/20 program. Scenarios with higher precipitation and moderate warming achieve the greatest recharge benefits, while hot, dry scenarios face the most constrained opportunities.

**FIGURE 45. AVERAGE ANNUAL APPLIED RECHARGE OF TIER 1 ADPATATION STRATEGIES**



Applied recharge does not translate directly to groundwater storage gains due to hydraulic interactions within the aquifer system. Instead, impacts are distributed among three “fates”, including increased groundwater storage, reduced stream seepage and decreased subsurface inflow. The distribution among these components evolves over time as aquifer conditions respond to cumulative recharge.

Applied recharge affects the groundwater system through three primary mechanisms: (1) increasing groundwater storage as additional water percolates into the aquifer and raises groundwater levels; (2) reducing stream seepage as higher groundwater levels decrease the hydraulic gradient between the aquifer and adjacent streams; and (3) decreasing net-subsurface inflow into the watershed, also due to reduced hydraulic gradients between the basin and neighboring groundwater systems. The distribution of applied recharge among these three mechanisms is referred to as the Fate of Recharge.

Figure 46 presents the annual Fate of Recharge for the T2P100 scenario under Tier 1 conditions, illustrating the changes in groundwater storage, stream seepage, and subsurface flow. Together, these components represent the total system-wide effect of applied recharge on the aquifer. Figure 46 also demonstrates that project benefits extend into years without active recharge. Elevated groundwater levels from prior recharge events continue to influence stream seepage and subsurface flow. Notably, during the initial years, the applied recharge contributes to increased groundwater storage. As additional recharge occurs, the impact to groundwater storage diminishes, and a larger proportion of the recharge manifests as subsurface flow and, to a lesser extent, reduced stream seepage. Average recharge volume for the T2P100 climate scenario under Tier 1 is 32 TAF per year. In this scenario 10 TAF (31 percent) mitigates groundwater overdraft, 17 TAF (53 percent) affects subsurface flow from outside the watershed, and 5 TAF (16 percent) stream seepage.

**FIGURE 46. ANNUAL FATE OF RECHARGE FOR TIER 1 ADPATATION STRATEGIES UNDER CLIMATE CHANGE CONDITIONS (T2P100)**

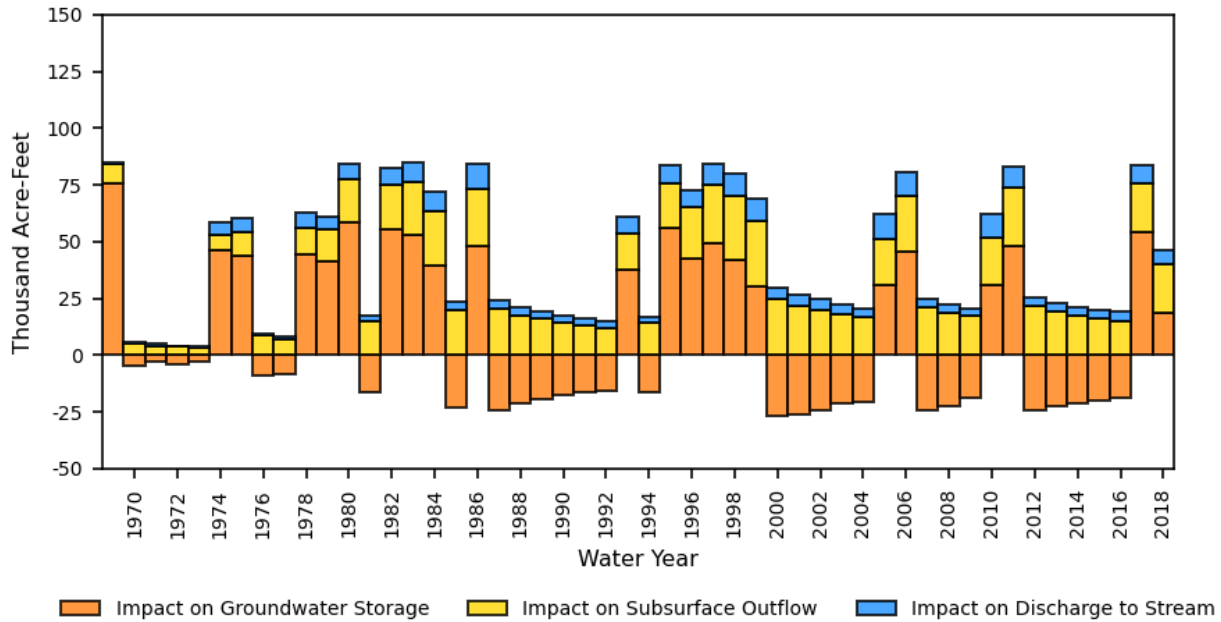
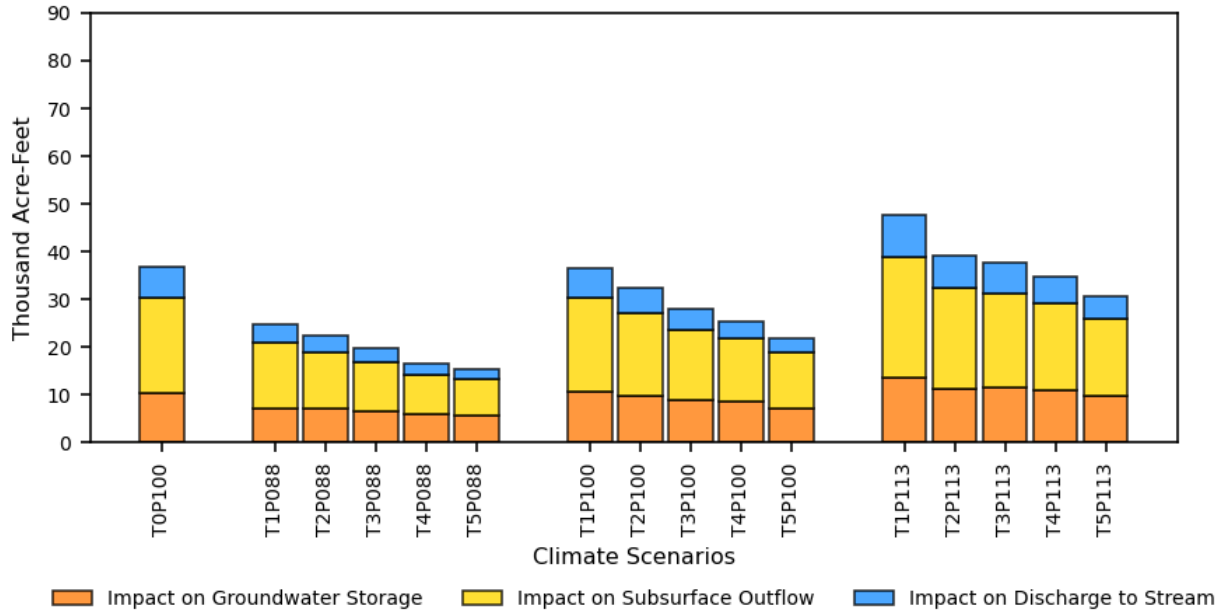


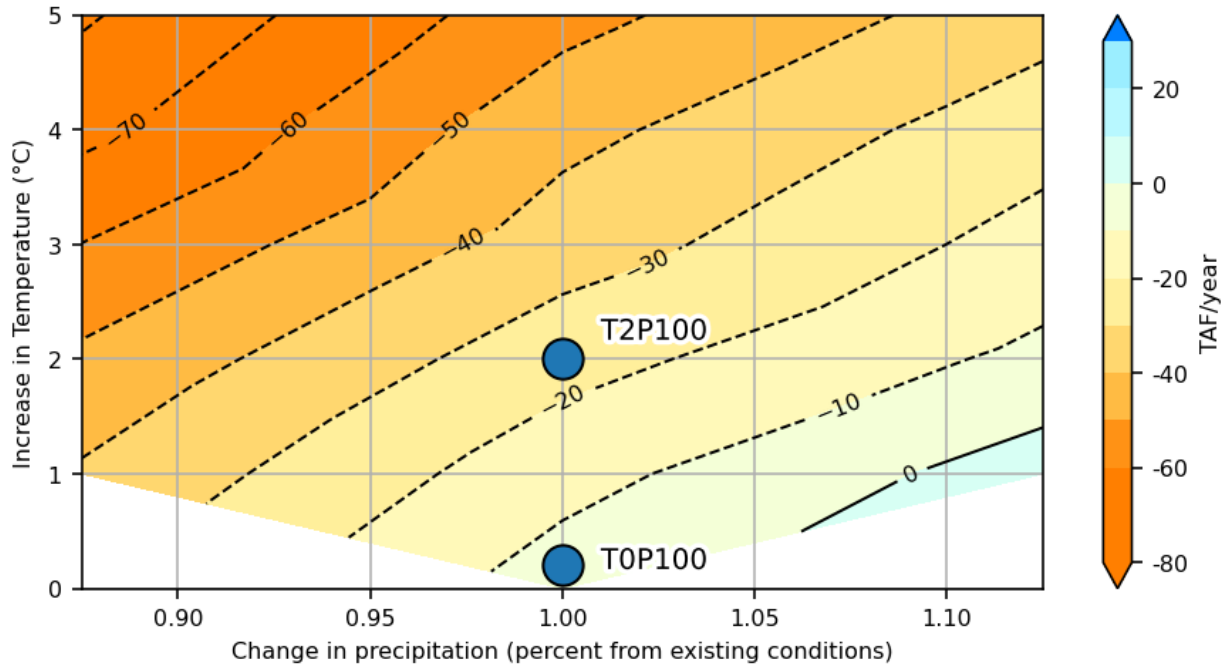
Figure 47 presents the annual average distribution of recharge across the 16 climate scenarios. Overall, the proportions allocated to the three fate components remain consistent: approximately 31 percent to changes in groundwater storage, 53 percent to impact in subsurface flow, and 16 percent to stream seepage.

Figure 48 shows the annual average change in groundwater storage for the Tier 1 climate scenarios. Under the T2P100 scenario, the annual average reduction in groundwater storage is 24 TAF, an improvement of 10 TAF relative to the no action climate change conditions. Across all Tier 1 scenarios, the projects yield an average improvement of 9 TAF per year. The benefit is greater under high-precipitation scenarios, averaging 11 TAF per year, compared to 7 TAF per year under low-precipitation scenarios. The T1P113 scenario is the only case that results in a net increase in groundwater storage, with an average gain of 5 TAF per year.

**FIGURE 47. AVERAGE ANNUAL FATE OF RECHARGE FOR TIER 1 ADPATATION STRATEGIES FOR ALL CLIMATE CONDITIONS**



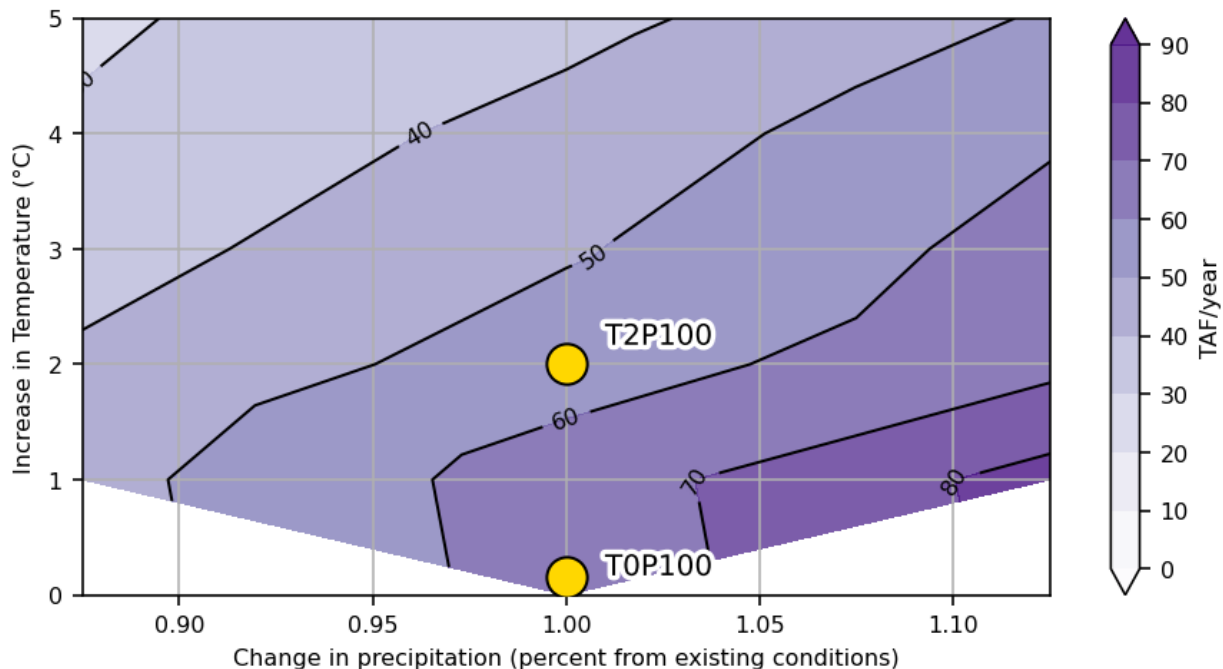
**FIGURE 48. AVERAGE ANNUAL CHANGE OF GROUNDWATER IN STORAGE WITH TIER 1 ADAPTATION STRATEGIES**



### 3.4.4 Climate Adaptation (Tier 2)

Annual applied recharge for the Tier 2 scenarios is presented in Figure 49. Like the Tier 1 scenarios, recharge rates are higher in scenarios with increased precipitation and lower temperatures, exhibiting a near-linear relationship with both temperature and precipitation. Under existing conditions, the applied recharge is 64 TAF, whereas under the T2P100 scenario, the available recharge is approximately 9 TAF lower or 55 TAF. In general, the applied recharge decreases by approximately 6 TAF per year for each 1°C increase in temperature, while it increases by 1.1 TAF for every 1% increase in precipitation.

**FIGURE 49. ANNUAL AVERAGED APPLIED RECHARGE OF TIER 2 ADPATATION STRATEGIES**



shows the annual fate of recharge components for the Tier 2 T2P100 scenario. Like for the Tier 1 scenario, elevated groundwater levels from prior recharge events continue to influence stream seepage and subsurface flow in subsequent years. Average applied recharge for the T2P100 climate scenario under Tier 2 is 55 TAF per year. Of this total, 18 TAF (31%) mitigates groundwater storage deficits, 30 TAF (53%) reduces subsurface inflow from adjacent basins, and 7 TAF (16%) decreases stream seepage. The proportional distribution among these three pathways remains like Tier 1, indicating that the fundamental hydraulic response is consistent even as the magnitude of recharge increases.

**FIGURE 50. ANNUAL FATE OF RECHARGE FOR TIER 2 ADPATATION STRATEGIES UNDER CLIMATE CHANGE CONDITIONS (T2P100)**

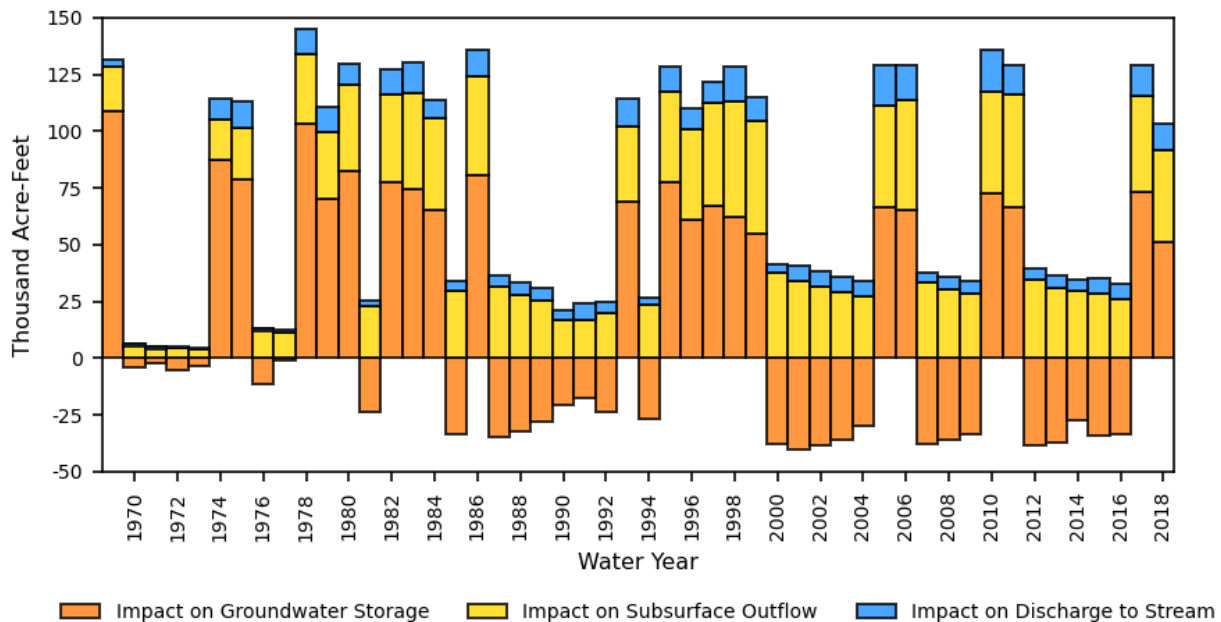
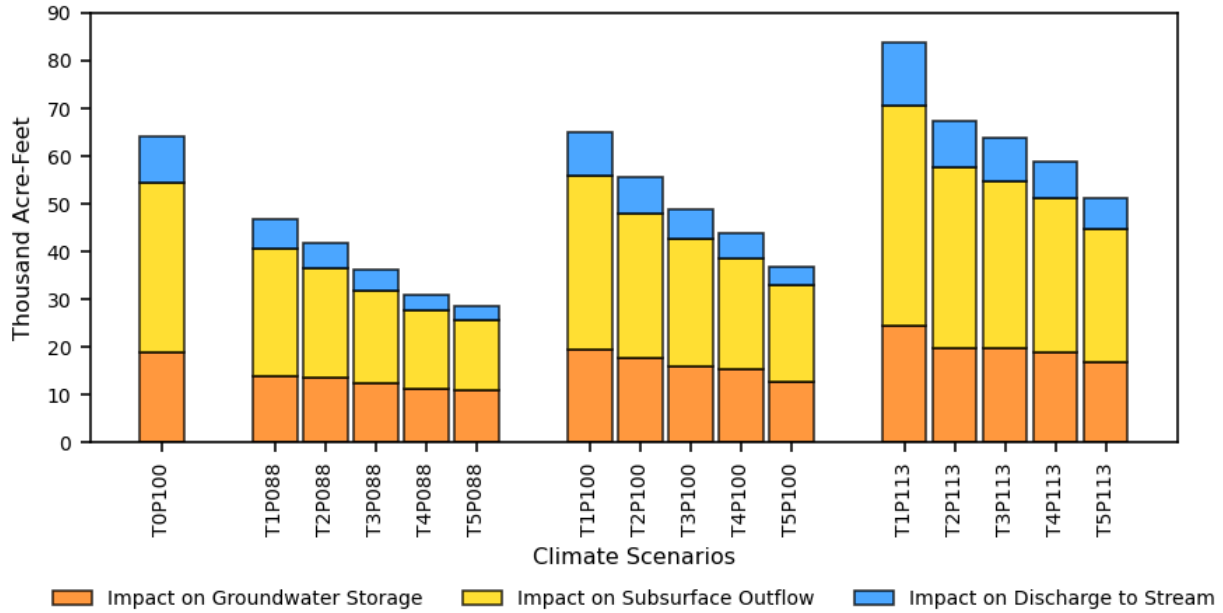


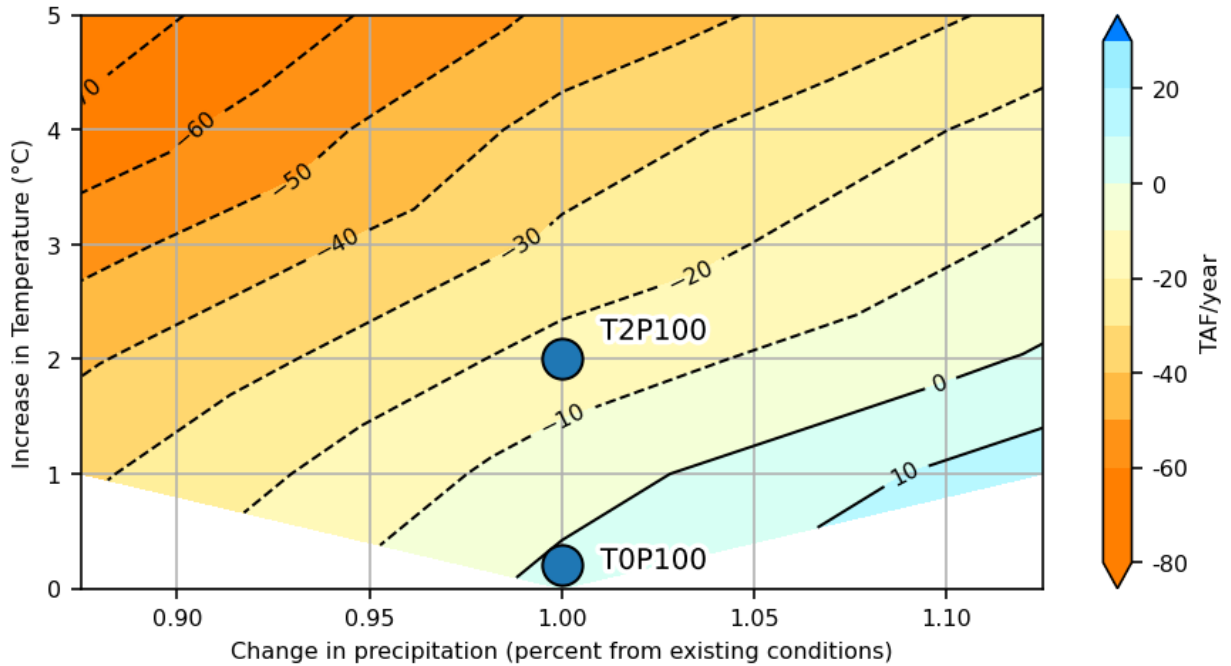
Figure 51 presents the annual average distribution of recharge across the 16 climate scenarios in Tier 2. Overall, the proportions allocated to the three fate components remain relatively consistent: approximately 32 percent to changes in groundwater storage, 55 percent to impact in subsurface flow, and 13 percent to stream seepage. Compared to Tier 1, the percentages of the fate of recharge remain very similar.

Figure 52 shows the annual average change in groundwater storage for the Tier 2 climate scenarios. Under the T2P100 scenario, the annual average reduction in groundwater storage is 16 TAF, an improvement of 18 TAF relative to the no-action climate change conditions. Across all Tier 2 scenarios, the projects yield an average improvement of 16 TAF per year. The benefit is greater under high-precipitation scenarios, averaging 20 TAF per year as compared to 12 TAF per year under low-precipitation scenarios. The T1P113 scenario is the only case that results in a net increase in groundwater storage, with an average gain of 5 TAF per year.

**FIGURE 51. AVERAGE ANNUAL FATE OF RECHARGE FOR TIER 2 ADPATATION STRATEGIES FOR ALL CLIMATE CONDITIONS**



**FIGURE 52. AVERAGE ANNUAL CHANGE OF GROUNDWATER IN STORAGE WITH TIER 2 ADAPTATION STRATEGIES**



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### **3.4.5 Climate Adaptation (Scenario Comparison)**

This section evaluates groundwater system responses across the no-action, Tier 1, and Tier 2 scenarios to evaluate adaptation effectiveness under varying climate conditions. The comparative analysis reveals how project implementation progressively improves groundwater sustainability metrics, with Tier 2 strategies providing sufficient benefit under moderate warming scenarios to maintain conditions comparable to existing climate without adaptation. Results are organized by key performance indicators, including groundwater storage changes, water level trends, and SGMA sustainability metrics.

#### **3.4.5.1 Groundwater Storage**

Table 6 summarizes the average annual change in groundwater storage across the no-action, Tier 1, and Tier 2 scenarios for all climate conditions in the Calaveras River watershed. The observed trends in groundwater storage changes are consistent across different climate conditions. Scenarios characterized by higher temperatures result in increased overdraft due to higher demand, reduced surface water availability, and greater reliance on groundwater pumping. In contrast, scenarios with greater precipitation offer reduced groundwater overdraft, as increased surface water availability mitigates groundwater depletion.

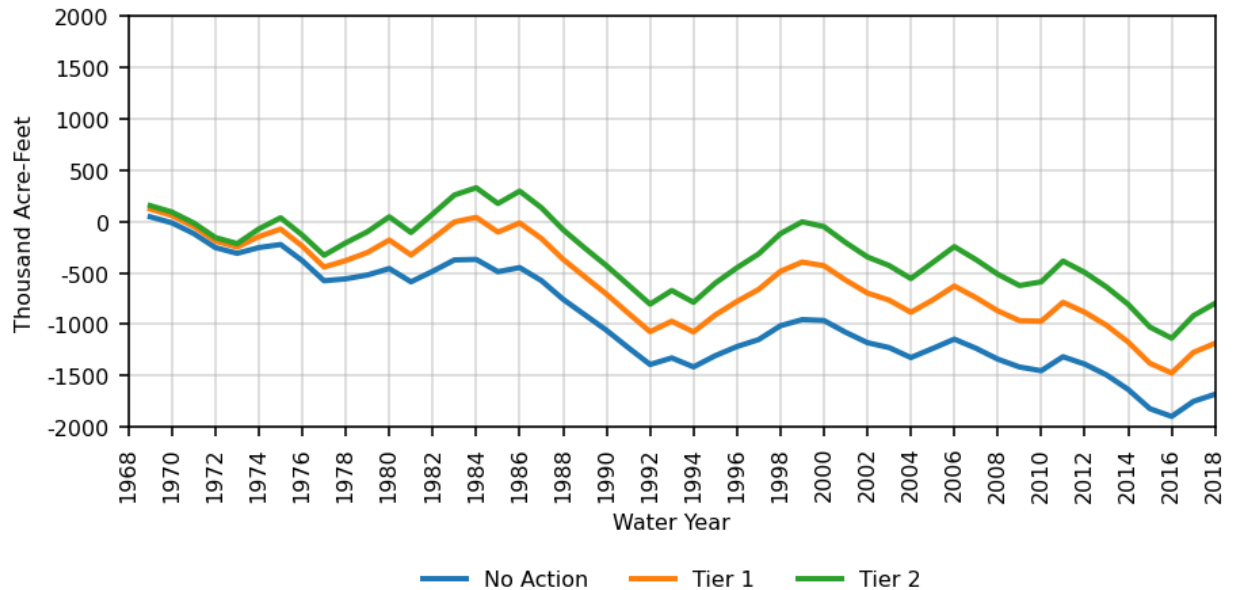
In the Tier 1 scenario, only one climate condition, T1P113, results in a positive change in groundwater storage. In Tier 2, three climate conditions yield a positive change: T0P100, T1P113, and T2P113. Notably, the implementation of Tier 2 projects under the T2P100 climate scenario is expected to result in a change in groundwater storage like that observed under the no-action existing conditions. This suggests that, in future scenarios, the implementation of Tier 2 projects will be necessary to maintain groundwater storage levels comparable to existing conditions without any project implementations.

**TABLE 6. AVERAGE ANNUAL CHANGE OF GROUNDWATER IN STORAGE FOR NO-ACTION, TIER 1, AND TIER 2 SCENARIOS**

<b>Climate Scenario</b>	<b>No-Action (AFY)</b>	<b>Tier 1 (AFY)</b>	<b>Tier 2 (AFY)</b>
<b>T0P100</b>	-15,500	-5,000	<b>3,300</b>
<b>T1P088</b>	-46,000	-38,800	-32,000
<b>T2P088</b>	-55,100	-48,000	-41,500
<b>T3P088</b>	-66,500	-59,800	-54,000
<b>T4P088</b>	-78,700	-72,700	-67,500
<b>T5P088</b>	-87,100	-81,300	-76,100
<b>T1P100</b>	-24,100	-13,400	-4,600
<b>T2P100</b>	-33,700	-23,700	-15,900
<b>T3P100</b>	-43,600	-34,800	-27,800
<b>T4P100</b>	-51,600	-43,000	-36,200
<b>T5P100</b>	-60,600	-53,300	-47,800
<b>T1P113</b>	-8,500	<b>5,100</b>	<b>15,900</b>
<b>T2P113</b>	-18,600	-7,400	<b>1,200</b>
<b>T3P113</b>	-27,700	-16,200	-7,800
<b>T4P113</b>	-35,000	-24,100	-16,000
<b>T5P113</b>	-43,800	-34,000	-26,900

Figure 53 illustrates the cumulative change in groundwater storage under the T2P100 climate condition for the no-action, Tier 1, and Tier 2 scenarios. The primary differences between the scenarios are observed during wet years, when the cumulative change in groundwater storage increases. During these years, the availability of water for recharge contributes to a positive change in groundwater storage. However, this positive impact is attenuated during dry years, when recharge is minimal, and the change in storage in the Tier 1 and Tier 2 scenarios tends to align with the no-action scenarios.

**FIGURE 53. CUMULATIVE CHANGE OF GROUNDWATER IN STORAGE UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



### 3.4.5.2 Groundwater Levels

Figure 54 presents the average groundwater levels for the Calaveras River Watershed across all project scenarios under the T2P100 climate condition. For comparison, the figure also includes the historical average groundwater level derived from the ESJWRM model used in the Eastern San Joaquin Subbasin GSP. The data indicates a continuing trend of declining groundwater levels. Under no-action climate change conditions, groundwater levels declined by 40 feet over the 50-year simulation period. The Tier 1 scenario shows a decline of 30 feet, while the Tier 2 scenario exhibits a more modest decline of 20 feet.

Overall, the trend in groundwater levels mirrors the cumulative change in storage observed in Figure 53. Specifically, wet years have a more pronounced positive impact on groundwater levels in the Tier 1 and Tier 2 scenarios, whereas dry years tend to stabilize groundwater levels, maintaining conditions similar to the no-action climate change scenario.

**FIGURE 54. AVERAGE GROUNDWATER LEVEL IN THE CALAVERAS WATERSHED UNDER CLIMATE CHANGE CONDITIONS (T2P100)**

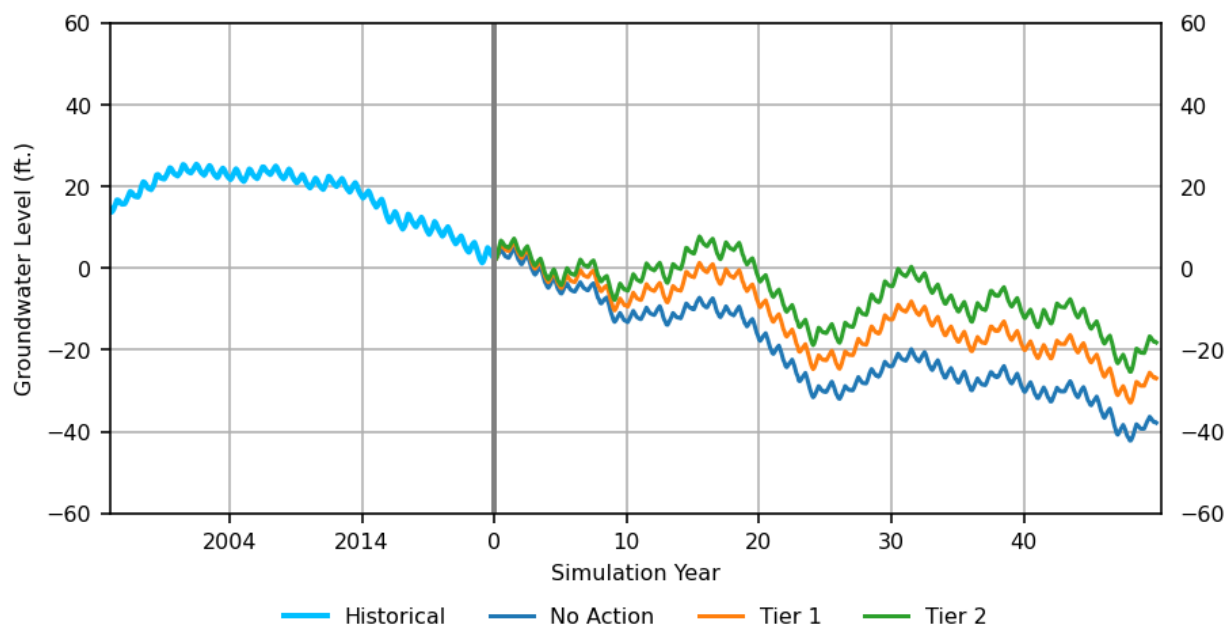


Figure 55 illustrates the impact of Tier 1 on groundwater levels across the watershed. The figure shows contour lines representing the difference in groundwater levels between the no-action climate change conditions and Tier 1 scenarios at the end of the 50-year simulation period. On average, groundwater levels in the watershed differ by 11 feet. However, the most significant difference, up to 30 feet, occurs in the area between the Calaveras River and Mormon Slough, downstream of Bellota. These results align with the benefit areas map presented in Figure 15.

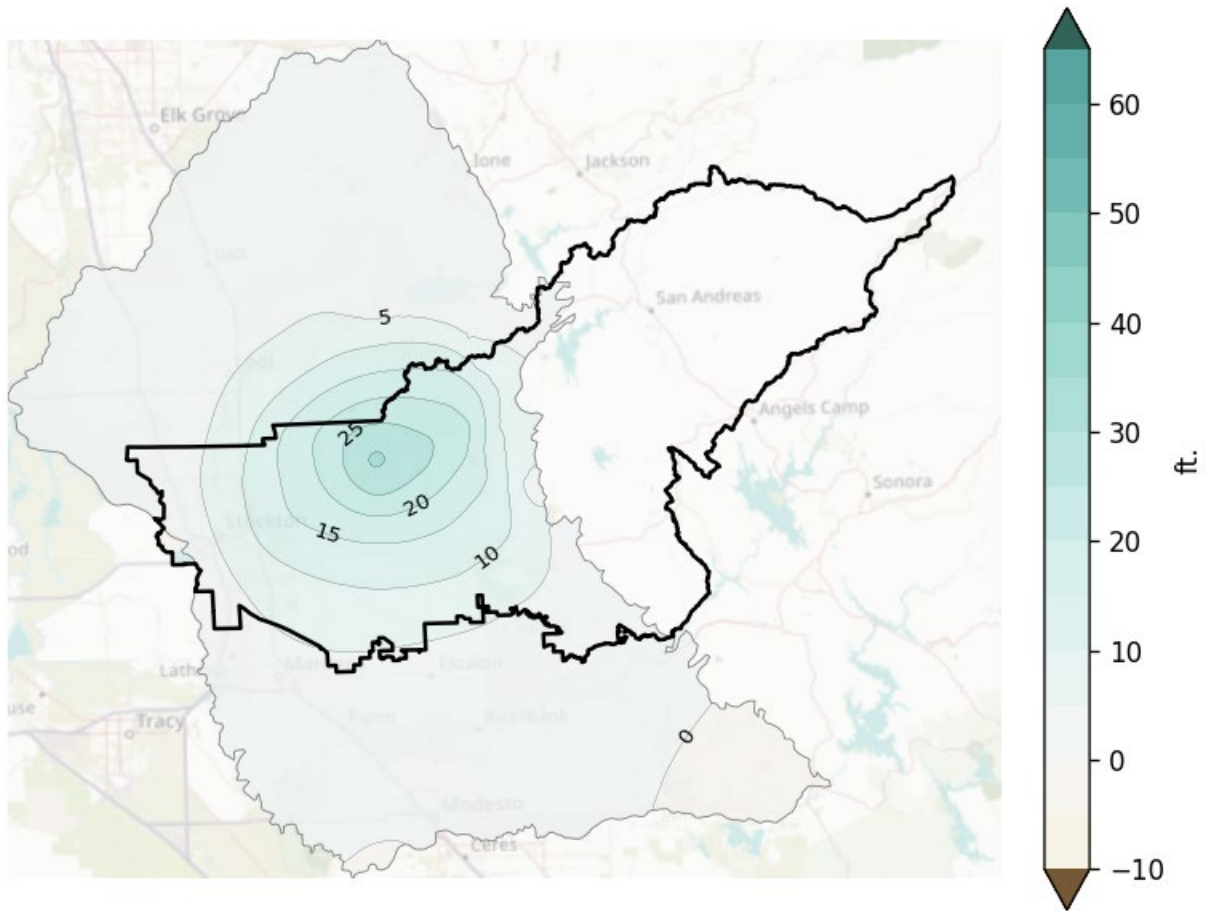
Figure 56 depicts the impact of Tier 2 on groundwater levels, showing a similar trend to Tier 1 but with more pronounced effects. In the Calaveras River Watershed, the average groundwater level difference is 20 feet, with areas near the project locations experiencing differences up to 55 feet. The greatest differences are again found downstream of Bellota, where the projects are situated.

Figure 57 and Figure 58 present the time series of average groundwater levels for the SEWD and CCWD areas, respectively. Figure 27 reveals a more variable time series, reflecting the influence of surface water deliveries and recharge projects which result in greater fluctuations in groundwater levels. In contrast, Figure 28 displays a smoother time series, as the CCWD area receives minimal surface water deliveries, resulting in more stable groundwater conditions.

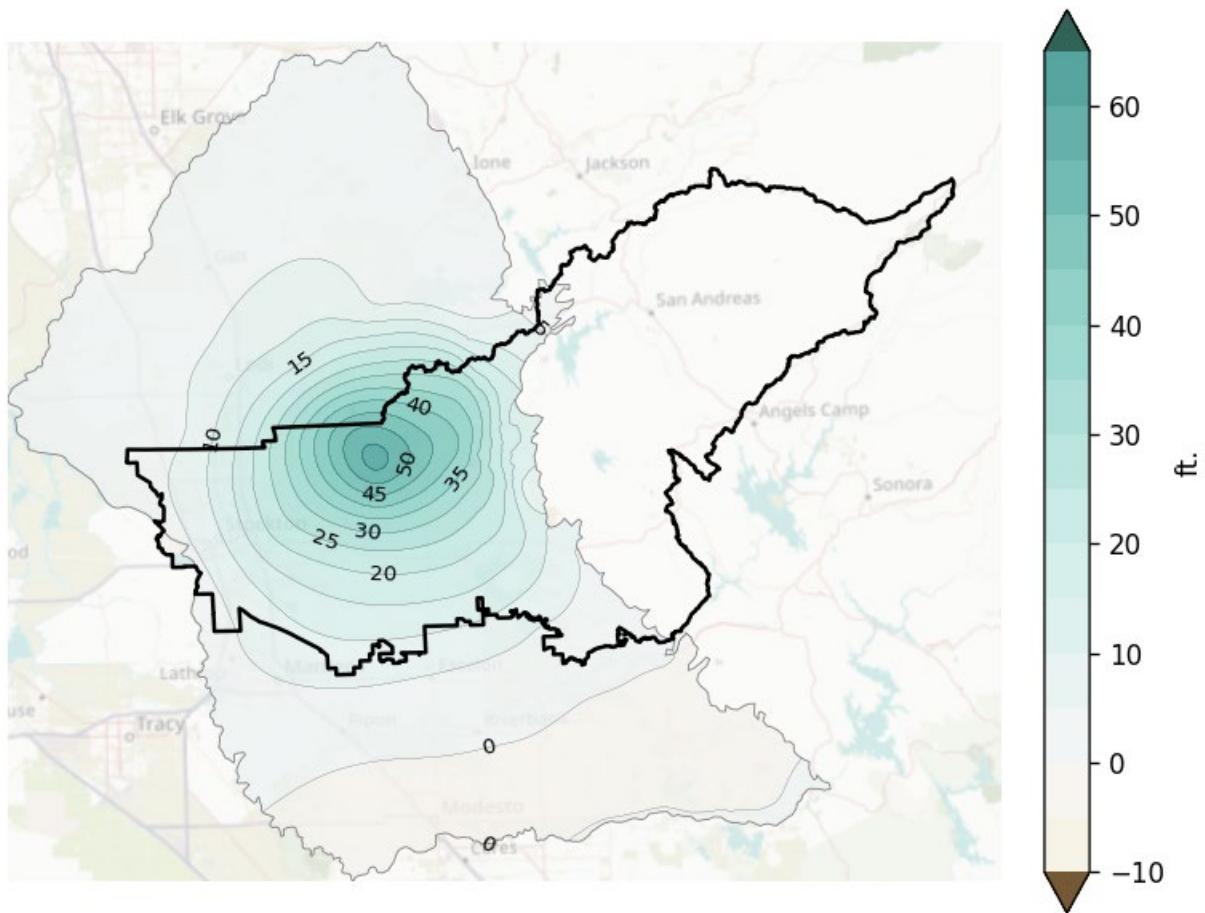
Under existing conditions, groundwater levels in the Calaveras River Watershed are expected to be reduced by 20 ft on average over the next 50 years. This decline will be compounded by climate change conditions (T2P100), which will further reduce groundwater levels an additional 20 ft. The adaptation strategies mitigate this reduction by 11 ft in Tier 1 scenario and by 20 ft in the Tier 2 scenario. Table 7 shows the comparison of average groundwater levels at the end of the 50-year simulation period against the no action climate change conditions, showing the impact of both climate change and adaptation strategies on the

Calaveras River Watershed, as well as SEWD and CCWD areas of operation, plus the non-district areas in the watershed.

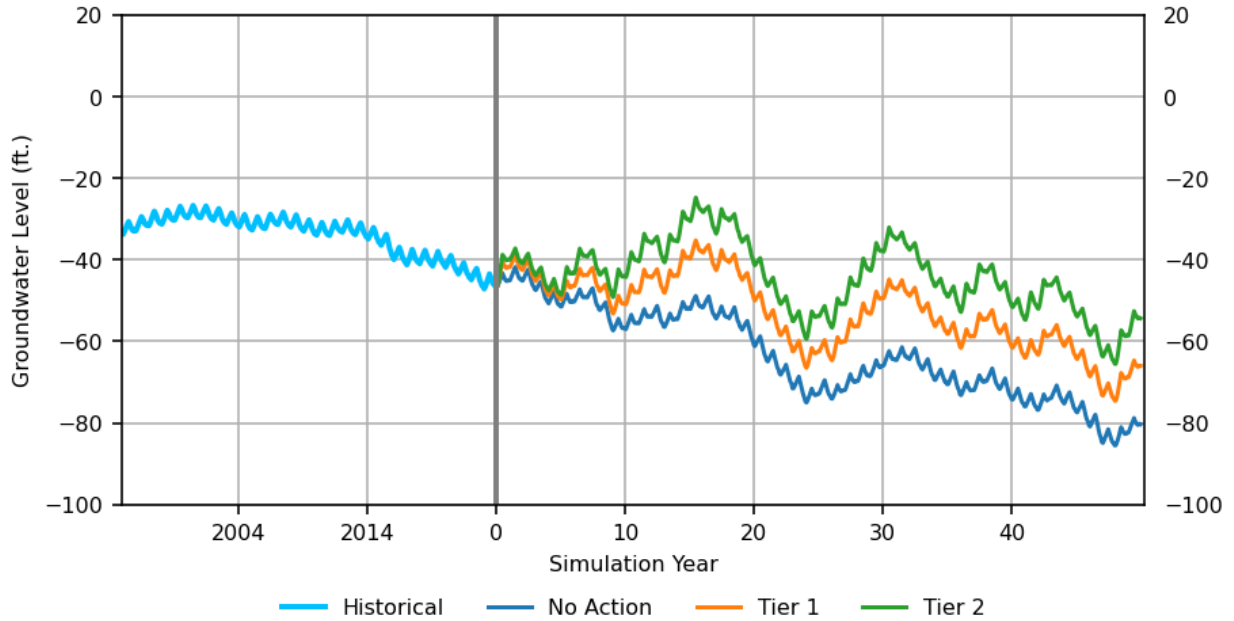
**FIGURE 55. CONTOURS OF GROUNDWATER LEVEL DIFFERENCES AT THE END OF SIMULATION BETWEEN TIER 1 ADAPTATION STRATEGIES AND NO-ACTIONS UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



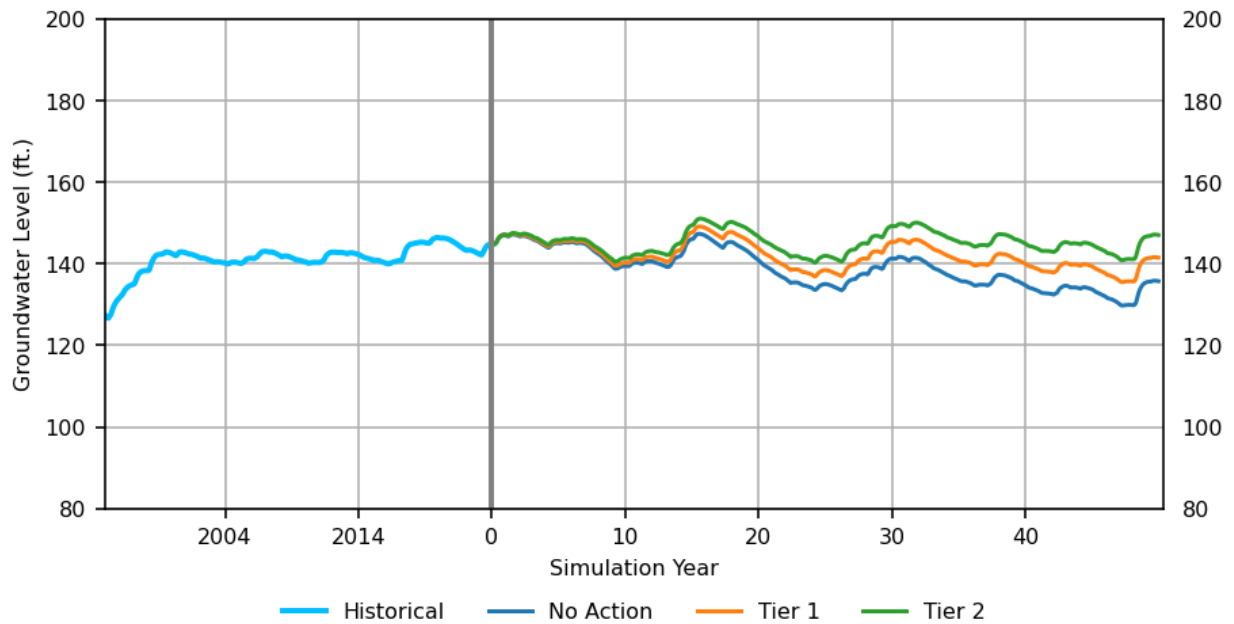
**FIGURE 56. CONTOURS OF GROUNDWATER LEVEL DIFFERENCES AT THE END OF SIMULATION BETWEEN TIER 2 ADAPTATION STRATEGIES AND NO-ACTIONS UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



**FIGURE 57. AVERAGE GROUNDWATER LEVEL IN THE SWED UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



**FIGURE 58. AVERAGE GROUNDWATER LEVEL IN THE CCWD UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



**TABLE 7. AVERAGE GROUNDWATER LEVELS COMPARED AGAINST EXISTING CONDITIONS AFTER THE 50-YEAR SIMULATION (UNITS: FEET)**

Climate Condition	Scenario	Calaveras Watershed (Feet)	SEWD (Feet)	CCWD (Feet)	Non-District (Feet)
TOP100	No-Action	0	0	0	0
	Tier 1	+11	+15	+6	+9
	Tier 2	+21	+27	+13	+16
T2P100	No-Action	-20	-20	-9	-20
	Tier 1	-9	-6	-3	-11
	Tier 2	0	+6	+2	-5

### 3.4.5.3 Impact on Monitoring Network

Groundwater level monitoring is a key component of groundwater management under the Eastern San Joaquin Subbasin GSP). The Eastern San Joaquin Groundwater Sustainability Agency (ESJGSA) currently monitors 20 wells in the groundwater basin to track conditions across the Subbasin, eight of which are in the Calaveras River Watershed.

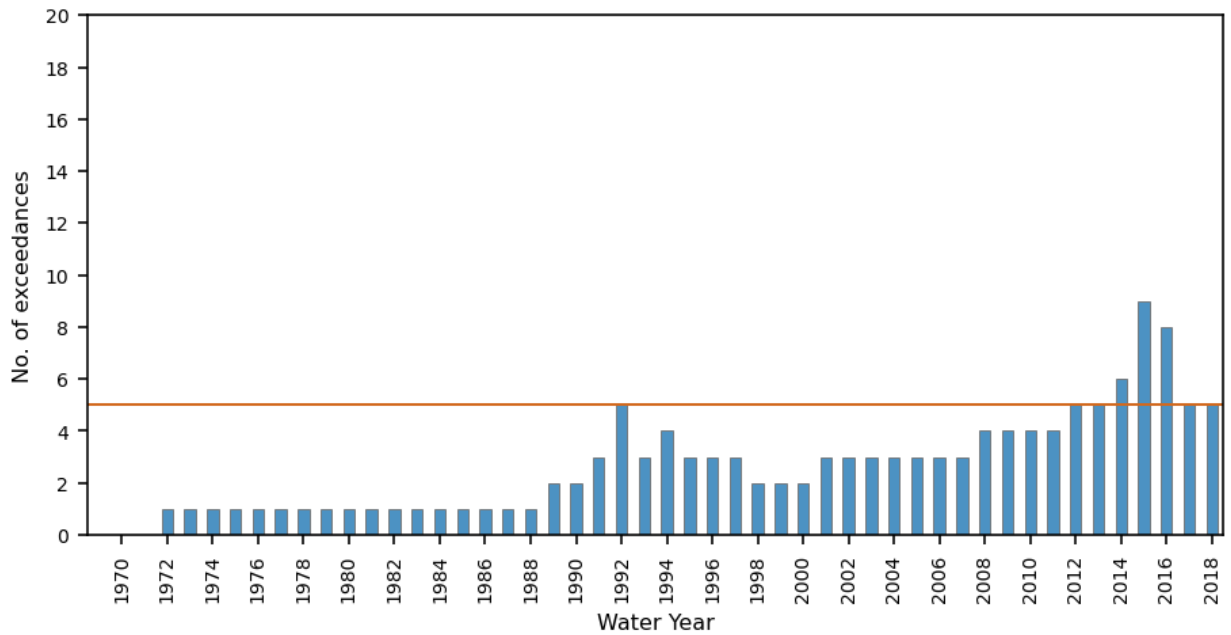
Groundwater levels at the eight monitoring locations within the Calaveras River Watershed were simulated using results from the CWRP model for the no-action, Tier 1, and Tier 2 scenarios, each evaluated under the 16 climate conditions. It is important to note that the climate change scenarios assessed in this study differ from those presented in the ESJ GSP because they exclude projects and management actions located within the Eastern San Joaquin Subbasin but outside the watershed.

Figure 59 presents the time series of monitoring wells exceeding minimum thresholds under the no-action scenario for the T2P100 climate condition. Exceedances are defined as simulated groundwater levels that fall below the minimum threshold during September of each water year. Under the applicable standard, an undesirable (exceedance) condition for the Subbasin is triggered when 25 percent of the representative monitoring network, equivalent to five wells, falls below their associated minimum thresholds for two consecutive years.

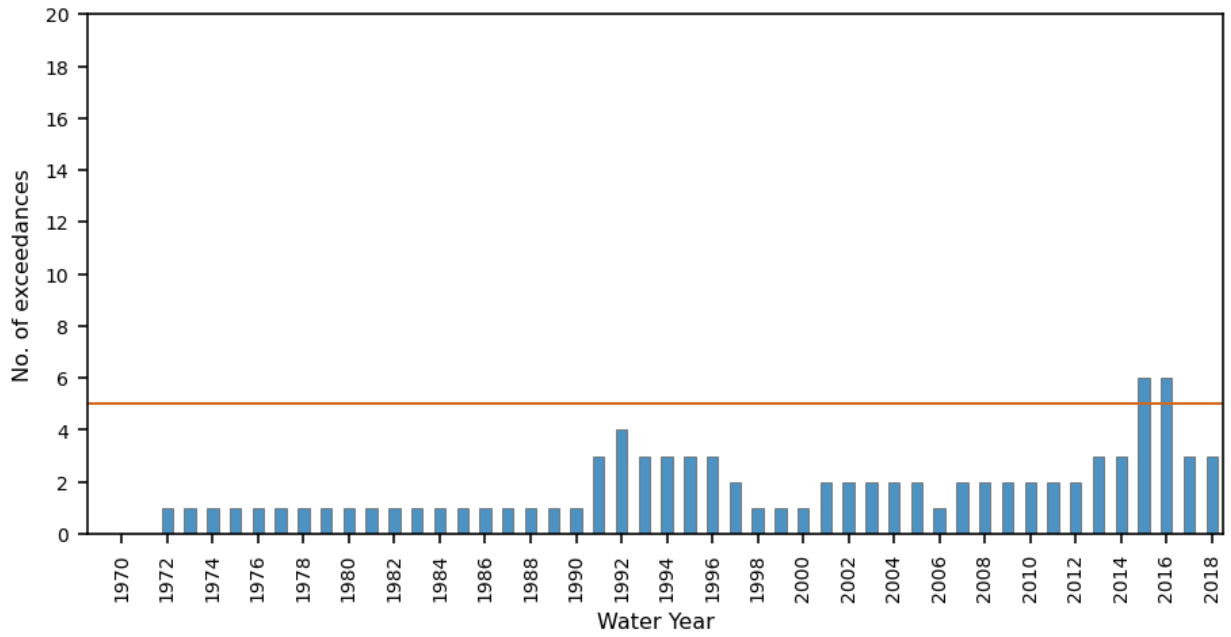
As shown in Figure 59, only one well falls below the minimum threshold during the first 20 years of the simulation. However, consistent with the declining groundwater levels observed in previous figures, groundwater elevations continue to decrease over time, resulting in an increasing number of wells exceeding their associated minimum thresholds. Over the full 50-year simulation period, minimum threshold exceedances above the five-well threshold occur in three years, with a maximum of nine wells in exceedance in simulation year 47.

When Tier 1 and Tier 2 projects are incorporated, the number of years with more than five wells in exceedance of their minimum thresholds decreases to two and zero, respectively, demonstrating the effectiveness of these projects in mitigating groundwater level declines across the Subbasin. Figure 60 and Figure 61 show the corresponding time series of exceedances for the Tier 1 and Tier 2 scenarios.

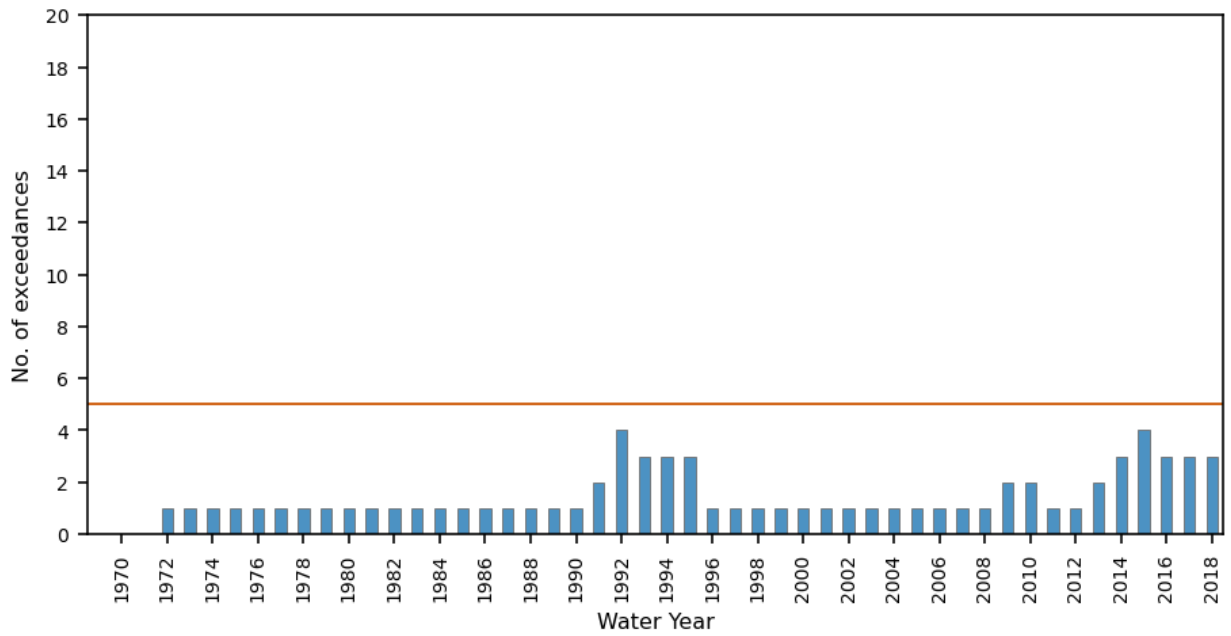
**FIGURE 59. MINIMUM THRESHOLD EXCEEDANCES UNDER CLIMATE CHANGE CONDITIONS (T2P100)**



**FIGURE 60. MINIMUM THRESHOLD EXCEEDANCES UNDER CLIMATE CHANGE CONDITIONS WITH TIER 1 ADAPTATION STRATEGIES (TIER 1-T2P100)**



**FIGURE 61. MINIMUM THRESHOLD EXCEEDANCES UNDER CLIMATE CHANGE CONDITIONS WITH TIER 2 ADAPTATION STRATEGIES (TIER 2-T2P100)**



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## 4. CALAVERAS RIVER WATERSHED WATER BUDGET

The water budget tables in this section provide the integrated accounting framework for the Calaveras Watershed Resiliency Plan (CWRP) Model, summarizing the hydrologic interactions and management scenarios simulated throughout this Technical Memorandum. These budgets represent the culmination of the integrated modeling effort and include direct output from the Sacramento Soil Moisture Accounting Model (SAC-SMA), and the Integrated Water Flow Model (IWFM) platforms, linking the land surface, surface water, and groundwater systems.

**Modeling Framework and Spatial Context** - The water budgets are organized to reflect the geographic and structural divisions of the modeling domain. The analysis distinguishes between the Upper Watershed (the catchment area upstream of New Hogan Dam) and the Lower Watershed (the area downstream of the dam intersecting the Eastern San Joaquin Groundwater Subbasin).

**Structure of the Water Budget Tables** - To provide a holistic view of watershed health, results are categorized into four interconnected physical systems.

- **Upper Watershed Total Water Budget:** Focuses on headwater precipitation, evapotranspiration, and the resulting inflows to the lower watershed.
- **Land Surface System:** Tracks the water balance at the field level, including precipitation, surface and groundwater use, and the eventual fate of that water as evapotranspiration, runoff, return flow, or deep percolation.
- **Surface Water System:** Documents the volumetric flow through the expanded stream and conveyance networks. This budget includes the Calaveras and San Joaquin Rivers, local tributaries, reservoir conditions, and conveyance dynamics.
- **Groundwater System:** Quantifies the aquifer dynamics, specifically focusing on operational and hydrologic dynamics. This includes pumping, managed and natural recharge, subsurface inflows from neighboring watersheds, interconnected surface water, and groundwater storage.

**Management Scenarios** - Each table evaluates three management scenarios to assess adaptation performance. No Action represents existing operations without new projects. Tier 1 includes near-term adaptation strategies, including existing infrastructure projects and utilization of the MAR 90/20 regulatory framework. Tier 2 represents longer-term investments, including the Farmington Reservoir Project and I-FIRM reservoir operations.

**Climate Conditions** - The tables summarize two primary climate conditions: Table 8 presents existing hydrologic conditions (TOP100), while Table 9 represents climate change conditions, which assume a 2°C temperature increase with no change in mean precipitation.

All values in these tables are reported as annual averages over the 50-year simulation period and expressed in acre-feet (AF). This organizational structure allows stakeholders to evaluate how specific adaptation strategies mitigate climate-driven impacts on hydrologic conditions, water supply operations, and overall watershed sustainability. Additional water budget tables showing the results for all 16 climate change conditions are available in Appendix A.

**TABLE 8. WATER BUDGET FOR EXISTING CONDITIONS (TOP100)**

Existing Conditions (TOP100)		No Action	Tier 1	Tier 2
<b>Upper Watershed Total Water Budget<sup>1</sup></b>				
Inflow	Precipitation	846,000	846,000	846,000
Outflow	Evapotranspiration	611,000	611,000	611,000
	Stream Inflow – Calaveras River	156,000	157,000	158,000
	Stream Inflow – Small Streams <sup>2</sup>	12,000	12,000	12,000
	Subsurface Flow – Lower Watershed	70,000	70,000	70,000
	Model Discrepancies <sup>2</sup>	-3,000	-4,000	-5,000
Storage Change	<i>Change in Storage</i>	0	0	0
<b>Land Surface System</b>				
Inflow	Precipitation	449,000	449,000	449,000
	Surface Water Deliveries – Local	40,000	40,000	40,000
	Surface Water Deliveries – Import <sup>3</sup>	79,000	88,000	88,000
	Groundwater Extraction – Local	432,000	425,000	424,000
	Riparian Uptake from Stream	3,000	3,000	3,000
Outflow	Evapotranspiration	536,000	536,000	536,000
	Runoff	301,000	301,000	301,000
	Return Flow	46,000	46,000	46,000
	Recharge – Applied Water and Precipitation	118,000	120,000	120,000
Storage Change	<i>Change in Storage</i>	2,000	2,000	1,000
<b>Surface Water System</b>				
Inflow	Stream Inflow – Calaveras River	156,000	157,000	158,000
	Stream Inflow – Small Streams	12,000	12,000	12,000
	Stream Inflow – San Joaquin River	2,737,000	2,739,000	2,739,000
	Runoff	301,000	301,000	301,000
	Return Flow	46,000	46,000	46,000
	Net Surface Flow – Other Watersheds	24,000	24,000	24,000
	Storage Change	<i>Change in Storage</i>	0	0
Outflow	Stream Outflow – San Joaquin River	3,131,000	3,140,000	3,144,000
	Stream Loss to Groundwater	60,000	54,000	51,000
	Surface Water Deliveries – Local	40,000	40,000	40,000
	Conveyance Loss to Groundwater	40,000	40,000	40,000
	Conveyance Evaporation	2,000	2,000	2,000
	Riparian Uptake from Stream	3,000	3,000	3,000
Storage Change	<i>Change in Storage</i>	0	0	0
<b>Groundwater System</b>				
Inflow	Subsurface Flow – Other Watersheds	132,000	111,000	96,000
	Subsurface Flow – Upper Watershed	70,000	70,000	70,000
	Recharge – Applied Water and Precipitation	118,000	120,000	120,000
	Recharge – Managed <sup>4</sup>	0	29,000	54,000
	Groundwater Gain from Stream	60,000	54,000	51,000
	Groundwater Gain from Conveyance	40,000	40,000	40,000
Outflow	Groundwater Extraction – Local	432,000	425,000	424,000
	Groundwater Extraction – Export	4,000	4,000	4,000
Storage Change	<i>Change in Storage</i>	-16,000	-5,000	3,000

**TABLE 9. WATER BUDGET FOR CLIMATE CHANGE CONDITIONS (T2P100).**

Climate Change Conditions (T2P100)		No Action	Tier 1	Tier 2
<b>Upper Watershed Total Water Budget<sup>1</sup></b>				
Inflow	Precipitation	848,000	848,000	848,000
Outflow	Evapotranspiration	629,000	629,000	629,000
	Stream Inflow – Calaveras River	144,000	145,000	146,000
	Stream Inflow – Small Streams <sup>2</sup>	12,000	12,000	12,000
	Subsurface Flow – Lower Watershed	69,000	69,000	69,000
	Model Discrepancies <sup>2</sup>	-6,000	-7,000	-8,000
Storage Change	<i>Change in Storage</i>	0	0	0
<b>Land Surface System</b>				
Inflow	Precipitation	450,000	450,000	450,000
	Surface Water Deliveries – Local	38,000	38,000	39,000
	Surface Water Deliveries – Import <sup>3</sup>	65,000	72,000	74,000
	Groundwater Extraction – Local	467,000	461,000	459,000
	Riparian Uptake from Stream	3,000	3,000	3,000
Outflow	Evapotranspiration	555,000	555,000	555,000
	Runoff	303,000	303,000	303,000
	Return Flow	45,000	45,000	45,000
	Recharge – Applied Water and Precipitation	118,000	119,000	120,000
Storage Change	<i>Change in Storage</i>	2,000	2,000	2,000
<b>Surface Water System</b>				
Inflow	Stream Inflow – Calaveras River	144,000	145,000	146,000
	Stream Inflow – Small Streams	12,000	12,000	12,000
	Stream Inflow – San Joaquin River	2,534,000	2,536,000	2,536,000
	Runoff	303,000	303,000	303,000
	Return Flow	45,000	45,000	45,000
	Net Surface Flow – Other Watersheds	25,000	25,000	25,000
	Storage Change	<i>Change in Storage</i>	0	0
Outflow	Stream Outflow – San Joaquin River	2,920,000	2,927,000	2,930,000
	Stream Loss to Groundwater	65,000	60,000	58,000
	Surface Water Deliveries – Local	38,000	38,000	39,000
	Conveyance Loss to Groundwater	35,000	36,000	35,000
	Conveyance Evaporation	2,000	2,000	2,000
	Riparian Uptake from Stream	3,000	3,000	3,000
Storage Change	<i>Change in Storage</i>	0	0	0
<b>Groundwater System</b>				
Inflow	Subsurface Flow – Other Watersheds	151,000	133,000	119,000
	Subsurface Flow – Upper Watershed	69,000	69,000	69,000
	Recharge – Applied Water and Precipitation	118,000	119,000	120,000
	Recharge – Managed <sup>4</sup>	0	25,000	47,000
	Groundwater Gain from Stream	65,000	60,000	58,000
	Groundwater Gain from Conveyance	35,000	36,000	35,000
Outflow	Groundwater Extraction – Local	467,000	461,000	459,000
	Groundwater Extraction – Export	5,000	5,000	5,000
Storage Change	<i>Change in Storage</i>	-34,000	-24,000	-16,000

**TABLE 10. TOTAL WATER BUDGET TABLE FOR CALAVERAS (UPPER AND LOWER) WATERSHED**

Lower Watershed Total Water Budget		TOP100	T2P100
<b>No Action Scenarios</b>			
Inflow	Precipitation	1,295,000	1,298,000
	Stream Inflows – San Joaquin River	2,737,000	2,534,000
	Surface Water Deliveries – Import <sup>3</sup>	79,000	65,000
	Net Surface Flow - Other Watersheds	24,000	25,000
	Recharge – Managed <sup>4</sup>	0	0
	Net Subsurface Flow - Other Watersheds	132,000	151,000
Outflow	Evapotranspiration	1,147,000	1,184,000
	Conveyance Evaporation	2,000	2,000
	Stream Outflows – San Joaquin River	3,131,000	2,920,000
	Groundwater Extraction (export)	4,000	5,000
	Model Discrepancies <sup>2</sup>	-3,000	-6,000
Storage Change	<i>Change in Storage</i>	-14,000	-32,000
<b>Tier 1 Scenarios</b>			
Inflow	Precipitation	1,295,000	1,298,000
	Stream Inflows – San Joaquin River	2,739,000	2,536,000
	Surface Water Deliveries – Import <sup>3</sup>	88,000	72,000
	Net Surface Flow - Other Watersheds	24,000	25,000
	Recharge – Managed <sup>4</sup>	29,000	25,000
	Net Subsurface Flow - Other Watersheds	111,000	133,000
Outflow	Evapotranspiration	1,147,000	1,184,000
	Conveyance Evaporation	2,000	2,000
	Stream Outflows - San Joaquin River	3,140,000	2,927,000
	Groundwater Extraction (export)	4,000	5,000
	Model Discrepancies <sup>2</sup>	-4,000	-7,000
Storage Change	<i>Change in Storage</i>	-3,000	-22,000
<b>Tier 2 Scenarios</b>			
Inflow	Precipitation	1,295,000	1,298,000
	Stream Inflows – San Joaquin River	2,739,000	2,536,000
	Surface Water Deliveries – Import <sup>3</sup>	88,000	74,000
	Net Surface Flow - Other Watersheds	24,000	25,000
	Recharge – Managed <sup>4</sup>	54,000	47,000
	Net Subsurface Flow - Other Watersheds	96,000	119,000
Outflow	Evapotranspiration	1,147,000	1,184,000
	Conveyance Evaporation	2,000	2,000
	Stream Outflows - San Joaquin River	3,144,000	2,930,000
	Groundwater Extraction (export)	4,000	5,000
	Model Discrepancies <sup>2</sup>	-5,000	-8,000
Storage Change	<i>Change in Storage</i>	4,000	-14,000

- 
1. *The Upper Watershed area analysis includes catchments contributing to the New Hogan reservoir and small streams catchments (Duck Creek, Rock Creek, Littlejohns Creek) that are outside of the domain of the CWRP Model. The Land Surface, Stream and Groundwater systems, on the other hand, are analyzed in the Calaveras Watershed area inside the CWRP Model domain.*
  2. *Upper Watershed flows are estimated by the Sacramento Soil Moisture Accounting Model (SAC-SMA), while the Lower Watershed flows are estimated by the CWRP model, an application of IWFEM.*
  3. *Imported water includes surface water supplies sourced from outside of the Calaveras River Watershed and may include water sources from the Mokelumne and/or Stanislaus River.*
  4. *Includes recharge from local stream systems and imported recharge water from the Mokelumne and/or Stanislaus River Watersheds.*

## **5. CONCLUSIONS AND NEXT STEPS**

This section provides a summary of the key findings and insight of the Calaveras Resiliency Plan, focusing on the results of the CWRP model, highlighting the benefits and results of the adaptation strategies under different climate conditions. Results were analyzed regarding their impact on the surface water and aquifer health in the watershed. This section also addresses the strengths and limitations of the CWRP model and the modeling approach used in the study.

### **5.1 Highlights**

The results of the CWRP model focus on two categories: climate vulnerability and climate adaptation. In both cases the analysis was performed based on the impact of climate and the adaptation strategies on a series of metrics focusing on surface water supply, flood risk, and groundwater conditions, which are listed in Table 4.

#### **5.1.1 Climate Vulnerability**

Climate change analysis simulated 15 different climate scenarios adjusting for changes in hydrologic conditions, increasing air temperature and varying precipitation rates across the watershed. Model results across the upper watershed showed that expected results of low runoff that contributed to New Hogan Reservoir inflows under high temperature conditions, and higher runoff volumes in low temperature – high precipitation conditions. On average, New Hogan Reservoir inflow was found to decrease by about 5 TAFY for every 1C increment and an increase of 3 TAFY for each 1% rise in precipitation. Consequently, surface water deliveries, as dependent on New Hogan releases, were similarly affected by climate conditions, mitigated slightly by the regulating nature of the reservoir. Additional water supply, coming from groundwater pumping, was similarly impacted by climate conditions, but was affected at a higher rate by temperature increases, given the increase in agricultural water demand with increase in temperature and the decreasing volumes of surface water supply.

Changes in groundwater pumping due to climate conditions consequently affect groundwater storage and groundwater levels. Groundwater storage, as a result, shows a reduction of 9.5 TAFY for every 1°C temperature increase, and an increase of 1.6 TAFY for each 1% rise in precipitation. Additional impacts are seen in stream aquifer interaction and subsurface flows due to changes in groundwater levels, with lower groundwater levels increasing stream seepage and subsurface flow into the aquifer. Subsurface flow shows

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a higher impact from climate conditions (about 75% of the impact in groundwater storage) compared to the impact in stream seepage (about 25% of the impact in groundwater storage).

### **5.1.2 Adaptation Strategies**

The adaptation strategies simulated in this study were divided into Tier 1 and Tier 2 scenarios, both of which were assessed under the 15 climate conditions. This allowed for an evaluation of how both climate factors and adaptation measures would simultaneously affect the watershed. Tier 1 includes near-term actions or projects that are either already underway or can be implemented within existing infrastructure and operational frameworks. Tier 2 represents long-term strategies, involving significant investments such as major infrastructural improvements, changes in reservoir operations, and more advanced water management approaches.

Both Tier 1 and Tier 2 scenarios focus on enhancing surface water supply through in-lieu recharge (providing surface water during the irrigation season) and direct recharge (supporting aquifer replenishment). Under existing conditions, the Tier 1 scenario results in an additional 36.5 TAFY of water, while the Tier 2 scenario contributes an additional 63.4 TAFY of both in-lieu and direct recharge.

Annual streamflow patterns below New Hogan Dam remain consistent across all scenarios (No-Action, Tier 1, and Tier 2). However, the distribution of flows changes significantly, particularly under the Tier 2 scenarios. Operations in these scenarios reduce peak daily flows to approximately 7,000 CFS, compared to a maximum of 12,400 CFS under the No-Action and Tier 1 scenarios. This results in a 44% reduction in peak discharge, which in turn lowers the flood risk for downstream communities and infrastructure along the lower Calaveras River.

Tier 2 projects also improve stream ecological conditions by increasing baseflows and reducing stream depletions. During high-flow periods, diversions to recharge facilities help manage excess downstream flows that could otherwise lead to erosion and habitat disturbance. In the subsequent low-flow periods, the groundwater stored from these diversions is released back into the stream as enhanced baseflow, helping maintain higher streamflow when it is most needed. Specifically, outflow from the Calaveras River is expected to increase by 5 TAFY during the critical period from April to September, thereby providing a more reliable streamflow during the dry months.

The adaptation strategies reinforce aquifer health, increasing both groundwater storage and groundwater levels. Notably, the implementation of Tier 2 projects under the T2P100 climate scenario is expected to result in a change in groundwater storage like those observed under the existing conditions (TOP100) scenario. This suggests that in future scenarios, the implementation of Tier 2 projects will be necessary to maintain groundwater storage levels comparable to existing conditions without any project implementations. Regarding groundwater levels under SGMA, when Tier 1 and Tier 2 projects are incorporated, the number of years with more than 25% of wells in exceedance decreases to two and zero, respectively, demonstrating the effectiveness of these projects in mitigating groundwater level declines across the subbasin.

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## 5.2 Model Considerations

The development of the CWRP model is based on key assumptions that should be acknowledged for a clearer understanding of its limitations and potential improvements.

**Upper Watershed:** The CWRP model boundary does not extend to the Upper Watershed or the catchment area of the New Hogan Reservoir. The runoff analysis was conducted with the assumption of minimal change in storage within the aquifer and root zone in this region. As a result, the analysis focused primarily on precipitation, evapotranspiration, and the inflows to the reservoir, with data obtained from DWR's Watershed Studies. Future model refinements could incorporate more detailed storage dynamics within the Upper Watershed to improve accuracy.

**Boundary Conditions:** The CWRP model utilizes boundary conditions from the ESJWRM Projected Conditions Baseline, representing groundwater levels from water years 2013–2024. While these conditions provide a reasonable assumption, future analysis could quantify regional uncertainties by assessing a range of boundary conditions between SGMA measurable objectives (MOs) and minimum thresholds (MTs). This sensitivity analysis would reveal how neighboring basin management decisions affect Calaveras Watershed vulnerability and whether regional coordination could provide mutual benefits under a variety of climate and hydrological conditions.

**Reservoir Operations:** Stream inflows and surface water deliveries were derived from DWR Watershed Studies, which provided time series data reflecting MAR 90/20 and I-FIRM strategies adapted for both Tier 1 and Tier 2 scenarios. Study refinements could include a watershed-specific reservoir operations model tailored to local conditions and planned management objectives. A dedicated operations model would enable more precise evaluation of upstream conditions, contract modifications, and project impacts on water supply reliability and downstream flow conditions.

**New Melones Reservoir:** The Stanislaus River Watershed, managed through New Melones Reservoir, represents a critical water supply source for the lower Calaveras Watershed through SEWD's contractual allocations. While the CWRP model incorporates surface water deliveries from New Melones as derived from DWR Watershed Studies, it does not explicitly simulate reservoir operations or conditions within the Stanislaus River system. Climate change impacts on Stanislaus River hydrology, including altered snowmelt timing, reduced inflows, and modified flood operations, directly affect water availability in the Calaveras Watershed. Future refinements could include an integrated operations model spanning both watersheds to assess how climate vulnerabilities in the Stanislaus system propagate to the Calaveras, and how coordinated adaptation strategies may optimize conjunctive use across both reservoir systems.

## 5.3 Policy Refinements

**Inter-Watershed Coordination:** The strategies and projects presented in the study focus on the Calaveras Watershed, with the assumption that the adjacent watersheds will maintain their existing conditions. Future model refinements could benefit from integrating data and projections from neighboring watersheds to better represent cross-boundary hydrological and policy interactions, particularly in relation to groundwater and surface water flow.

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Expansion of Projects: As additional information and implementation timeline for adaptation strategies becomes available, the details of these projects should be incorporated into the model to reflect the evolving landscape of watershed management. Ongoing project updates can refine predictions of water availability, demand, and resilience.

Demand Management: To manage and plan for the more extreme climate scenarios, it would be beneficial to include demand management strategies as part of the broader adaptation plan for the watershed. These strategies could help balance water use and availability, particularly during periods of drought or reduced supply, ensuring the sustainability of the region's water resources.

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## 6. REFERENCES

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## **Appendix A: Water Budget for All Climate Scenarios**

**Table A.1 Water Budget – No Action Scenarios**

No Action Scenarios (AF/y)		TOP100	T1P088	T2P088	T3P088	T4P088	T5P088	T1P100	T2P100	T3P100	T4P100	T5P100	T1P113	T2P113	T3P113	T4P113	T5P113	
<b>Upper Watershed Total Water Budget<sup>1</sup></b>																		
Inflow	Precipitation	846,000	743,000	744,000	752,000	724,000	745,000	847,000	848,000	849,000	866,000	851,000	951,000	952,000	953,000	955,000	956,000	
Outflow	Evapotranspiration	611,000	571,000	578,000	592,000	577,000	594,000	620,000	629,000	637,000	662,000	652,000	662,000	673,000	683,000	693,000	702,000	
	Stream Inflow – Calaveras River	156,000	109,000	105,000	101,000	97,000	93,000	150,000	144,000	138,000	134,000	128,000	196,000	189,000	181,000	175,000	168,000	
	Stream Inflow – Small Streams <sup>2</sup>	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000	14,000
	Subsurface Flow – Lower Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000	74,000
	Model Discrepancies <sup>2</sup>	-3,000	-11,000	-13,000	-13,000	-19,000	-14,000	-5,000	-6,000	-7,000	-12,000	-8,000	3,000	0	1,000	-1,000	-2,000	
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<b>Land Surface System</b>																		
Inflow	Precipitation	449,000	395,000	395,000	396,000	396,000	397,000	450,000	450,000	451,000	456,000	453,000	504,000	505,000	506,000	507,000	508,000	
	Surface Water Deliveries – Local	40,000	35,000	34,000	33,000	32,000	31,000	40,000	38,000	37,000	37,000	36,000	42,000	41,000	41,000	40,000	39,000	
	Surface Water Deliveries – Import <sup>3</sup>	79,000	57,000	53,000	46,000	41,000	38,000	73,000	65,000	61,000	52,000	48,000	90,000	81,000	69,000	66,000	64,000	
	Groundwater Extraction – Local	432,000	469,000	484,000	503,000	520,000	536,000	447,000	467,000	485,000	505,000	520,000	429,000	450,000	470,000	486,000	503,000	
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Outflow	Evapotranspiration	536,000	538,000	547,000	557,000	567,000	578,000	546,000	555,000	565,000	576,000	585,000	552,000	563,000	572,000	582,000	593,000	
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000	
	Return Flow	46,000	45,000	45,000	44,000	44,000	44,000	45,000	45,000	45,000	45,000	44,000	46,000	46,000	45,000	45,000	45,000	
	Recharge – Applied Water and Precipitation	118,000	117,000	117,000	118,000	118,000	119,000	118,000	118,000	119,000	119,000	120,000	119,000	119,000	119,000	120,000	121,000	
Storage Change	<i>Change in Storage</i>	2,000	3,000	3,000	3,000	3,000	3,000	2,000	2,000	3,000	3,000	3,000	2,000	2,000	2,000	2,000	3,000	
<b>Surface Water System</b>																		
Inflow	Stream Inflow – Calaveras River	156,000	109,000	105,000	101,000	97,000	93,000	150,000	144,000	138,000	134,000	128,000	196,000	189,000	181,000	175,000	168,000	
	Stream Inflow – Small Streams	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000	
	Stream Inflow – San Joaquin River	2,737,000	1,595,000	1,519,000	1,452,000	1,411,000	1,361,000	2,629,000	2,534,000	2,434,000	2,372,000	2,299,000	3,792,000	3,651,000	3,556,000	3,434,000	3,352,000	
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000	
	Return Flow	46,000	45,000	45,000	44,000	44,000	44,000	45,000	45,000	45,000	45,000	44,000	46,000	46,000	45,000	45,000	45,000	
	Net Surface Flow – Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	26,000	26,000	26,000	27,000	27,000	27,000	
Outflow	Stream Outflow – San Joaquin River	3,131,000	1,906,000	1,828,000	1,758,000	1,715,000	1,663,000	3,017,000	2,920,000	2,817,000	2,755,000	2,673,000	4,268,000	4,124,000	4,021,000	3,895,000	3,809,000	
	Stream Loss to Groundwater	60,000	61,000	63,000	65,000	67,000	68,000	62,000	65,000	67,000	70,000	72,000	64,000	66,000	69,000	71,000	73,000	
	Surface Water Deliveries – Local	40,000	35,000	34,000	33,000	32,000	31,000	40,000	38,000	37,000	37,000	36,000	42,000	41,000	41,000	40,000	39,000	
	Conveyance Loss to Groundwater	40,000	31,000	29,000	27,000	25,000	24,000	38,000	35,000	33,000	31,000	30,000	44,000	40,000	38,000	37,000	35,000	
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000	
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<b>Groundwater System</b>																		
Inflow	Subsurface Flow – Other Watersheds	132,000	155,000	161,000	168,000	176,000	181,000	139,000	151,000	158,000	168,000	174,000	123,000	135,000	147,000	154,000	161,000	
	Subsurface Flow – Upper Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000	
	Recharge – Applied Water and Precipitation	118,000	117,000	117,000	118,000	118,000	119,000	118,000	118,000	119,000	119,000	120,000	119,000	119,000	119,000	120,000	121,000	
	Recharge – Managed <sup>4</sup>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Groundwater Gain from Stream	60,000	61,000	63,000	65,000	67,000	68,000	62,000	65,000	67,000	70,000	72,000	64,000	66,000	69,000	71,000	73,000	
	Groundwater Gain from Conveyance	40,000	31,000	29,000	27,000	25,000	24,000	38,000	35,000	33,000	31,000	30,000	44,000	40,000	38,000	37,000	35,000	
Outflow	Groundwater Extraction – Local	432,000	469,000	484,000	503,000	520,000	536,000	447,000	467,000	485,000	505,000	520,000	429,000	450,000	470,000	486,000	503,000	
	Groundwater Extraction – Export	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	5,000	
Storage Change	<i>Change in Storage</i>	-16,000	-46,000	-55,000	-67,000	-79,000	-87,000	-24,000	-34,000	-44,000	-52,000	-61,000	-8,000	-19,000	-28,000	-35,000	-44,000	

**Table A.2 Water Budget – Tier 1 Scenarios**

Tier 1 Scenarios (AF/y)		T0P100	T1P088	T2P088	T3P088	T4P088	T5P088	T1P100	T2P100	T3P100	T4P100	T5P100	T1P113	T2P113	T3P113	T4P113	T5P113
<b>Upper Watershed Total Water Budget<sup>1</sup></b>																	
Inflow	Precipitation	846,000	743,000	744,000	752,000	724,000	745,000	847,000	848,000	849,000	866,000	851,000	951,000	952,000	953,000	955,000	956,000
Outflow	Evapotranspiration	611,000	571,000	578,000	592,000	577,000	594,000	620,000	629,000	637,000	662,000	652,000	662,000	673,000	683,000	693,000	702,000
	Stream Inflow – Calaveras River	157,000	109,000	105,000	101,000	97,000	94,000	150,000	145,000	139,000	135,000	129,000	197,000	189,000	182,000	176,000	169,000
	Stream Inflow – Small Streams <sup>2</sup>	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000
	Subsurface Flow – Lower Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000
	Model Discrepancies <sup>2</sup>	-4,000	-11,000	-13,000	-13,000	-19,000	-15,000	-5,000	-7,000	-8,000	-13,000	-9,000	2,000	0	0	-2,000	-3,000
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Land Surface System</b>																	
Inflow	Precipitation	449,000	395,000	395,000	396,000	396,000	397,000	450,000	450,000	451,000	456,000	453,000	504,000	505,000	506,000	507,000	508,000
	Surface Water Deliveries – Local	40,000	35,000	34,000	33,000	32,000	31,000	40,000	38,000	37,000	37,000	36,000	42,000	41,000	41,000	40,000	39,000
	Surface Water Deliveries – Import <sup>3</sup>	88,000	63,000	59,000	50,000	45,000	42,000	82,000	72,000	65,000	58,000	53,000	99,000	89,000	76,000	73,000	68,000
	Groundwater Extraction – Local	425,000	463,000	479,000	499,000	517,000	532,000	440,000	461,000	480,000	500,000	515,000	421,000	443,000	464,000	480,000	498,000
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Outflow	Evapotranspiration	536,000	538,000	547,000	557,000	567,000	578,000	546,000	555,000	565,000	576,000	585,000	552,000	563,000	572,000	582,000	593,000
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000
	Return Flow	46,000	45,000	45,000	44,000	44,000	44,000	45,000	45,000	45,000	45,000	45,000	44,000	46,000	46,000	45,000	45,000
	Recharge – Applied Water and Precipitation	120,000	118,000	118,000	118,000	119,000	119,000	120,000	119,000	119,000	120,000	120,000	121,000	120,000	120,000	121,000	121,000
Storage Change	<i>Change in Storage</i>	2,000	2,000	3,000	3,000	3,000	3,000	2,000	2,000	2,000	3,000	3,000	1,000	2,000	2,000	2,000	2,000
<b>Surface Water System</b>																	
Inflow	Stream Inflow – Calaveras River	157,000	109,000	105,000	101,000	97,000	94,000	150,000	145,000	139,000	135,000	129,000	197,000	189,000	182,000	176,000	169,000
	Stream Inflow – Small Streams	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000
	Stream Inflow – San Joaquin River	2,739,000	1,596,000	1,520,000	1,453,000	1,412,000	1,361,000	2,630,000	2,536,000	2,436,000	2,373,000	2,300,000	3,794,000	3,653,000	3,557,000	3,436,000	3,354,000
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000
	Return Flow	46,000	45,000	45,000	44,000	44,000	44,000	45,000	45,000	45,000	45,000	45,000	44,000	46,000	46,000	45,000	45,000
	Net Surface Flow – Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	25,000	26,000	26,000	26,000	27,000	27,000
Outflow	Stream Outflow – San Joaquin River	3,140,000	1,911,000	1,832,000	1,762,000	1,719,000	1,666,000	3,024,000	2,927,000	2,824,000	2,761,000	2,678,000	4,281,000	4,133,000	4,029,000	3,904,000	3,817,000
	Stream Loss to Groundwater	54,000	57,000	60,000	62,000	64,000	66,000	56,000	60,000	63,000	66,000	69,000	55,000	59,000	63,000	65,000	68,000
	Surface Water Deliveries – Local	40,000	35,000	34,000	33,000	32,000	31,000	40,000	38,000	37,000	37,000	36,000	42,000	41,000	41,000	40,000	39,000
	Conveyance Loss to Groundwater	40,000	31,000	29,000	27,000	25,000	24,000	38,000	36,000	33,000	31,000	30,000	43,000	40,000	38,000	37,000	35,000
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Groundwater System</b>																	
Inflow	Subsurface Flow – Other Watersheds	111,000	140,000	148,000	159,000	169,000	174,000	119,000	133,000	144,000	155,000	163,000	99,000	115,000	128,000	137,000	147,000
	Subsurface Flow – Upper Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000
	Recharge – Applied Water and Precipitation	120,000	118,000	118,000	118,000	119,000	119,000	120,000	119,000	119,000	120,000	120,000	121,000	120,000	120,000	121,000	121,000
	Recharge – Managed <sup>4</sup>	29,000	19,000	17,000	15,000	12,000	11,000	28,000	25,000	22,000	20,000	17,000	37,000	31,000	30,000	27,000	24,000
	Groundwater Gain from Stream	54,000	57,000	60,000	62,000	64,000	66,000	56,000	60,000	63,000	66,000	69,000	55,000	59,000	63,000	65,000	68,000
	Groundwater Gain from Conveyance	40,000	31,000	29,000	27,000	25,000	24,000	38,000	36,000	33,000	31,000	30,000	43,000	40,000	38,000	37,000	35,000
Outflow	Groundwater Extraction – Local	425,000	463,000	479,000	499,000	517,000	532,000	440,000	461,000	480,000	500,000	515,000	421,000	443,000	464,000	480,000	498,000
	Groundwater Extraction – Export	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	
Storage Change	<i>Change in Storage</i>	-5,000	-39,000	-48,000	-60,000	-73,000	-81,000	-13,000	-24,000	-35,000	-43,000	-53,000	5,000	-7,000	-16,000	-24,000	-34,000

**Table A.3 Water Budget – Tier 2 Scenarios**

Tier 2 Scenarios (AF/y)		TOP100	T1P088	T2P088	T3P088	T4P088	T5P088	T1P100	T2P100	T3P100	T4P100	T5P100	T1P113	T2P113	T3P113	T4P113	T5P113	
<b>Upper Watershed Total Water Budget<sup>1</sup></b>																		
Inflow	Precipitation	846,000	743,000	744,000	752,000	724,000	745,000	847,000	848,000	849,000	866,000	851,000	951,000	952,000	953,000	955,000	956,000	
Outflow	Evapotranspiration	611,000	571,000	578,000	592,000	577,000	594,000	620,000	629,000	637,000	662,000	652,000	662,000	673,000	683,000	693,000	702,000	
	Stream Inflow – Calaveras River	158,000	111,000	107,000	103,000	98,000	95,000	152,000	146,000	141,000	136,000	131,000	198,000	190,000	184,000	177,000	171,000	
	Stream Inflow – Small Streams <sup>2</sup>	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000	14,000
	Subsurface Flow – Lower Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000	74,000
	Model Discrepancies <sup>2</sup>	-5,000	-13,000	-15,000	-15,000	-20,000	-16,000	-7,000	-8,000	-10,000	-14,000	-11,000	1,000	-1,000	-2,000	-3,000	-5,000	
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<b>Land Surface System</b>																		
Inflow	Precipitation	449,000	395,000	395,000	396,000	396,000	397,000	450,000	450,000	451,000	456,000	453,000	504,000	505,000	506,000	507,000	508,000	
	Surface Water Deliveries – Local	40,000	35,000	35,000	34,000	33,000	32,000	40,000	39,000	38,000	37,000	37,000	42,000	42,000	41,000	41,000	40,000	
	Surface Water Deliveries – Import <sup>3</sup>	88,000	64,000	58,000	52,000	46,000	43,000	83,000	74,000	66,000	57,000	55,000	102,000	90,000	79,000	74,000	70,000	
	Groundwater Extraction – Local	424,000	462,000	478,000	498,000	515,000	531,000	439,000	459,000	479,000	499,000	514,000	419,000	441,000	462,000	478,000	496,000	
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Outflow	Evapotranspiration	536,000	538,000	547,000	557,000	567,000	578,000	545,000	555,000	565,000	575,000	585,000	552,000	563,000	572,000	582,000	593,000	
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000	
	Return Flow	46,000	45,000	45,000	45,000	44,000	44,000	46,000	45,000	45,000	45,000	45,000	46,000	46,000	45,000	45,000	45,000	
	Recharge – Applied Water and Precipitation	120,000	118,000	118,000	119,000	119,000	120,000	120,000	120,000	120,000	120,000	120,000	121,000	122,000	121,000	121,000	121,000	122,000
Storage Change	<i>Change in Storage</i>	1,000	2,000	2,000	3,000	3,000	3,000	2,000	2,000	2,000	2,000	3,000	1,000	1,000	2,000	2,000	2,000	
<b>Surface Water System</b>																		
Inflow	Stream Inflow – Calaveras River	158,000	111,000	107,000	103,000	98,000	95,000	152,000	146,000	141,000	136,000	131,000	198,000	190,000	184,000	177,000	171,000	
	Stream Inflow – Small Streams	12,000	10,000	10,000	9,000	9,000	9,000	12,000	12,000	12,000	12,000	12,000	11,000	15,000	15,000	14,000	14,000	
	Stream Inflow – San Joaquin River	2,739,000	1,597,000	1,520,000	1,454,000	1,412,000	1,362,000	2,631,000	2,536,000	2,436,000	2,374,000	2,300,000	3,795,000	3,653,000	3,558,000	3,436,000	3,354,000	
	Runoff	301,000	256,000	257,000	259,000	260,000	261,000	302,000	303,000	305,000	310,000	308,000	349,000	350,000	351,000	353,000	355,000	
	Return Flow	46,000	45,000	45,000	45,000	44,000	44,000	46,000	45,000	45,000	45,000	45,000	46,000	46,000	45,000	45,000	45,000	
	Net Surface Flow – Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	25,000	26,000	26,000	26,000	27,000	27,000	27,000
Outflow	Stream Outflow – San Joaquin River	3,144,000	1,916,000	1,834,000	1,766,000	1,719,000	1,668,000	3,030,000	2,930,000	2,826,000	2,765,000	2,681,000	4,286,000	4,135,000	4,035,000	3,906,000	3,819,000	
	Stream Loss to Groundwater	51,000	55,000	58,000	61,000	63,000	65,000	53,000	58,000	61,000	64,000	68,000	51,000	56,000	60,000	63,000	66,000	
	Surface Water Deliveries – Local	40,000	35,000	35,000	34,000	33,000	32,000	40,000	39,000	38,000	37,000	37,000	42,000	42,000	41,000	41,000	40,000	
	Conveyance Loss to Groundwater	40,000	31,000	30,000	27,000	26,000	24,000	39,000	35,000	34,000	31,000	30,000	44,000	41,000	38,000	37,000	36,000	
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000	
	Riparian Uptake from Stream	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Storage Change	<i>Change in Storage</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<b>Groundwater System</b>																		
Inflow	Subsurface Flow – Other Watersheds	96,000	128,000	138,000	150,000	161,000	167,000	101,000	119,000	132,000	147,000	154,000	76,000	97,000	113,000	123,000	134,000	
	Subsurface Flow – Upper Watershed	70,000	64,000	64,000	63,000	60,000	63,000	70,000	69,000	69,000	70,000	68,000	75,000	75,000	74,000	74,000	74,000	
	Recharge – Applied Water and Precipitation	120,000	118,000	118,000	119,000	119,000	120,000	120,000	120,000	120,000	120,000	120,000	121,000	122,000	121,000	121,000	121,000	122,000
	Recharge – Managed <sup>4</sup>	54,000	39,000	34,000	29,000	24,000	22,000	55,000	47,000	40,000	36,000	30,000	71,000	56,000	53,000	49,000	42,000	
	Groundwater Gain from Stream	51,000	55,000	58,000	61,000	63,000	65,000	53,000	58,000	61,000	64,000	68,000	51,000	56,000	60,000	63,000	66,000	
	Groundwater Gain from Conveyance	40,000	31,000	30,000	27,000	26,000	24,000	39,000	35,000	34,000	31,000	30,000	44,000	41,000	38,000	37,000	36,000	
Outflow	Groundwater Extraction – Local	424,000	462,000	478,000	498,000	515,000	531,000	439,000	459,000	479,000	499,000	514,000	419,000	441,000	462,000	478,000	496,000	
	Groundwater Extraction – Export	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	5,000	
Storage Change	<i>Change in Storage</i>	3,000	-32,000	-41,000	-54,000	-67,000	-76,000	-5,000	-16,000	-28,000	-36,000	-48,000	16,000	1,000	-8,000	-16,000	-27,000	

**Table A.4 Calaveras Watershed (Upper and Lower) Total Water Budget**

Calaveras Watershed Total Water Budget		TOP100	T1P088	T2P088	T3P088	T4P088	T5P088	T1P100	T2P100	T3P100	T4P100	T5P100	T1P113	T2P113	T3P113	T4P113	T5P113
<b>No Action Scenarios</b>																	
Inflow	Precipitation	1,295,000	1,138,000	1,139,000	1,148,000	1,120,000	1,142,000	1,297,000	1,298,000	1,300,000	1,322,000	1,304,000	1,455,000	1,457,000	1,459,000	1,462,000	1,464,000
	Stream Inflows	2,737,000	1,595,000	1,519,000	1,452,000	1,411,000	1,361,000	2,629,000	2,534,000	2,434,000	2,372,000	2,299,000	3,792,000	3,651,000	3,556,000	3,434,000	3,352,000
	Surface Water Deliveries - Import	79,000	57,000	53,000	46,000	41,000	38,000	73,000	65,000	61,000	52,000	48,000	90,000	81,000	69,000	66,000	64,000
	Net Surface Flow - Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	26,000	26,000	26,000	26,000	27,000	27,000
	Recharge - Managed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Net Subsurface Flow - Other Watersheds	132,000	155,000	161,000	168,000	176,000	181,000	139,000	151,000	158,000	168,000	174,000	123,000	135,000	147,000	154,000	161,000
Outflow	Evapotranspiration	1,147,000	1,109,000	1,125,000	1,149,000	1,144,000	1,172,000	1,166,000	1,184,000	1,202,000	1,238,000	1,237,000	1,214,000	1,236,000	1,255,000	1,275,000	1,295,000
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000
	Stream Outflows - San Joaquin River	3,131,000	1,906,000	1,828,000	1,758,000	1,715,000	1,663,000	3,017,000	2,920,000	2,817,000	2,755,000	2,673,000	4,268,000	4,124,000	4,021,000	3,895,000	3,809,000
	Groundwater Extraction (export)	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	5,000
	Model Discrepancies	-3,000	-11,000	-13,000	-13,000	-19,000	-14,000	-5,000	-6,000	-7,000	-12,000	-8,000	3,000	0	1,000	-1,000	-2,000
Storage Change	Change in Storage	-14,000	-43,000	-52,000	-64,000	-76,000	-84,000	-22,000	-32,000	-41,000	-49,000	-58,000	-6,000	-17,000	-26,000	-33,000	-41,000
<b>Tier 1 Scenarios</b>																	
Inflow	Precipitation	1,295,000	1,138,000	1,139,000	1,148,000	1,120,000	1,142,000	1,297,000	1,298,000	1,300,000	1,322,000	1,304,000	1,455,000	1,457,000	1,459,000	1,462,000	1,464,000
	Stream Inflows	2,739,000	1,596,000	1,520,000	1,453,000	1,412,000	1,361,000	2,630,000	2,536,000	2,436,000	2,373,000	2,300,000	3,794,000	3,653,000	3,557,000	3,436,000	3,354,000
	Surface Water Deliveries - Import	88,000	63,000	59,000	50,000	45,000	42,000	82,000	72,000	65,000	58,000	53,000	99,000	89,000	76,000	73,000	68,000
	Net Surface Flow - Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	26,000	26,000	26,000	26,000	27,000	27,000
	Recharge - Managed	29,000	19,000	17,000	15,000	12,000	11,000	28,000	25,000	22,000	20,000	17,000	37,000	31,000	30,000	27,000	24,000
	Net Subsurface Flow - Other Watersheds	111,000	140,000	148,000	159,000	169,000	174,000	119,000	133,000	144,000	155,000	163,000	99,000	115,000	128,000	137,000	147,000
Outflow	Evapotranspiration	1,147,000	1,109,000	1,125,000	1,149,000	1,144,000	1,172,000	1,166,000	1,184,000	1,202,000	1,238,000	1,237,000	1,214,000	1,236,000	1,255,000	1,275,000	1,295,000
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000
	Stream Outflows - San Joaquin River	3,140,000	1,911,000	1,832,000	1,762,000	1,719,000	1,666,000	3,024,000	2,927,000	2,824,000	2,761,000	2,678,000	4,281,000	4,133,000	4,029,000	3,904,000	3,817,000
	Groundwater Extraction (export)	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	5,000
	Model Discrepancies	-4,000	-11,000	-13,000	-13,000	-19,000	-15,000	-5,000	-7,000	-8,000	-13,000	-9,000	2,000	0	0	-2,000	-3,000
Storage Change	Change in Storage	-3,000	-37,000	-45,000	-57,000	-70,000	-78,000	-11,000	-22,000	-33,000	-40,000	-50,000	6,000	-5,000	-14,000	-22,000	-32,000
<b>Tier 2 Scenarios</b>																	
Inflow	Precipitation	1,295,000	1,138,000	1,139,000	1,148,000	1,120,000	1,142,000	1,297,000	1,298,000	1,300,000	1,322,000	1,304,000	1,455,000	1,457,000	1,459,000	1,462,000	1,464,000
	Stream Inflows	2,739,000	1,597,000	1,520,000	1,454,000	1,412,000	1,362,000	2,631,000	2,536,000	2,436,000	2,374,000	2,300,000	3,795,000	3,653,000	3,558,000	3,436,000	3,354,000
	Surface Water Deliveries - Import	88,000	64,000	58,000	52,000	46,000	43,000	83,000	74,000	66,000	57,000	55,000	102,000	90,000	79,000	74,000	70,000
	Net Surface Flow - Other Watersheds	24,000	23,000	23,000	23,000	23,000	23,000	24,000	25,000	25,000	25,000	26,000	26,000	26,000	26,000	27,000	27,000
	Recharge - Managed	54,000	39,000	34,000	29,000	24,000	22,000	55,000	47,000	40,000	36,000	30,000	71,000	56,000	53,000	49,000	42,000
	Net Subsurface Flow - Other Watersheds	96,000	128,000	138,000	150,000	161,000	167,000	101,000	119,000	132,000	147,000	154,000	76,000	97,000	113,000	123,000	134,000
Outflow	Evapotranspiration	1,147,000	1,109,000	1,125,000	1,149,000	1,144,000	1,172,000	1,165,000	1,184,000	1,202,000	1,237,000	1,237,000	1,214,000	1,236,000	1,255,000	1,275,000	1,295,000
	Conveyance Evaporation	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	3,000	3,000	2,000	2,000	2,000
	Stream Outflows - San Joaquin River	3,144,000	1,916,000	1,834,000	1,766,000	1,719,000	1,668,000	3,030,000	2,930,000	2,826,000	2,765,000	2,681,000	4,286,000	4,135,000	4,035,000	3,906,000	3,819,000
	Groundwater Extraction (export)	4,000	5,000	5,000	5,000	5,000	6,000	4,000	5,000	5,000	5,000	5,000	4,000	4,000	5,000	5,000	5,000
	Model Discrepancies	-5,000	-13,000	-15,000	-15,000	-20,000	-16,000	-7,000	-8,000	-10,000	-14,000	-11,000	1,000	-1,000	-2,000	-3,000	-5,000
Storage Change	Change in Storage	4,000	-30,000	-39,000	-51,000	-64,000	-73,000	-3,000	-14,000	-26,000	-34,000	-45,000	17,000	2,000	-6,000	-14,000	-25,000