Appendix 25
Climate Change and Greenhouse Gas Emissions

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.”

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Contents

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Appendix 25A
Climate Change and Sea Level Rise Sensitivity Analysis

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.”

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APPENDIX 25A
Climate Change and Sea Level Rise Sensitivity Analysis

25A.1 Introduction

This appendix presents a sensitivity analysis performed to assess how uncertainty in future climate conditions might affect performance of the Sites Reservoir.

Modeling was prepared for the Sites Reservoir Administrative Draft Environmental Impact Report/ Environmental Impact Statement (EIR/EIS) and the Administrative Draft Feasibility Report (FR). Modeling was prepared, assuming current climate and sea level conditions, for detailed evaluation of the impacts and benefits of the No Project/No Action Alternative and Sites Reservoir action Alternatives A, B, C, and D. This modeling is summarized in Chapter 5 Guide to the Resource Analyses and Appendix 6B Water Resources System Modeling of the EIR/EIS. This appendix is part of the EIR/EIS. Throughout this document, unless otherwise noted, all references to other chapters and appendixes of the EIR/EIS are implied.

A sensitivity analysis was prepared to assess the impacts of climate change and sea level rise on the modeling prepared for the Sites Reservoir EIR/EIS. The sensitivity analysis included simulation of the alternatives under a range of climate and sea level scenarios and the comparison of results of these scenarios with the "without climate change" modeling used for the detailed evaluation in the Sites Reservoir FR and EIR/EIS.

25A.1.1 Background

It has been assumed that the detailed evaluation of the Sites Reservoir EIR/EIS, using modeling that assumed current climate and sea level conditions, is sufficient to identify the potential impacts of the Sites Reservoir Project (Project). This was based on the expectation that the Project would generally have the greatest adverse impact under current climate conditions than under future climate conditions that are likely to be warmer and have significantly altered snowpack and runoff conditions and higher sea levels than current conditions. The incremental changes in the flow and storage operations (and, therefore, other resources) for the Sites Reservoir with-Project conditions, when compared to the No Project/No Action Alternative under projected climate and sea level conditions, were expected to trend similar to those simulated under the current climate scenario.

Similarly, it has been assumed that the feasibility analysis of the Sites Reservoir FR, using modeling that assumed current climate and sea level conditions, is a more conservative estimate of economic and noneconomic benefits of the Project, assuming the continuation of current trends in the socioeconomic conditions. This was based on the expectation that the Project would have the least beneficial impact under current climate conditions than under future climate conditions that are likely to have poorer habitat conditions for anadromous and Sacramento-San Joaquin River Delta (Delta) fisheries, lower water supply reliability, and higher potential flow requirements for maintaining Delta water quality conditions than current conditions assuming that current Delta regulations are unchanged.

25A.1.2 Sensitivity Analysis Objective

The Project climate change and sea level rise sensitivity analysis has been prepared as a tool for planners, resources specialists, stakeholders, and the public to consider the influence of climate change and sea level rise on the Project and verify that the EIR/EIS and FR findings are adequate and meet these expectations. The results of the Project climate change and sea level rise sensitivity analysis generally confirm these expectations and, therefore, support the findings of the EIR/EIS and FR.

The analysis also provides a context for consideration of uncertainty and anticipated trends due to climate change throughout the planning horizon for the Project, and the potential role of the Project in adaptation of the California water resources system to the impacts of climate change and sea level rise. A comparison of the No Project/No Action Alternative, with and without climate change and sea level rise, will help the reader to understand the potential range of effects upon California's major water systems from climate change and sea level rise. In addition, the sensitivity analysis will help the reader to understand how the range of potential climate change and sea level rise effects will impact the performance of the Project alternatives more specifically.

This appendix documents the approach and assumptions used for the sensitivity analysis and the results and findings of the analysis. The results of the sensitivity analysis are presented in figures and tables. The results of the sensitivity analysis are not intended to be used for detailed evaluation of alternatives; they are subject to some limitations. Limitations of the approach are also discussed in this appendix.

25A.2 Approach and Assumptions

25A.2.1 Sites Reservoir Scenarios

In the detailed evaluation of Project alternatives in the EIR/EIS and FR, the State Water Project (SWP) and Central Valley Project (CVP) operations model (CALSIM II) was used to simulate the following scenarios assuming current climate and sea level condition:

- Existing Conditions
- No Project/No Action Alternative
- Alternative A: includes a 1.27-million acre-foot (MAF) Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa and Glenn-Colusa Irrigation District (GCID) canals, and a new Delevan Pipeline (2,000-cubic feet per second (cfs) diversion/1,500-cfs release).
- Alternative B: includes a 1.81-MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa and GCID canals, and a new release-only Delevan Pipeline (1,500-cfs release).
- Alternative C: includes a 1.81-MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa and GCID canals, and a new Delevan Pipeline (2,000-cfs diversion/1,500-cfs release).
- Alternative D: includes a 1.81-MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa and GCID canals, and a new Delevan Pipeline (2,000-cfs diversion/1,500-cfs release). A total of 480 thousand acre-feet (TAF) of Sites Reservoir storage is reserved for Project participants local to the Colusa Basin.

The detailed evaluation of Project alternatives also included the application of a larger suite of hydrologic, operations, water quality, fisheries, riverine geomorphic and sediment, power, and economics models to the alternatives. The detailed evaluation involved the simulation and analysis of over 100 parameters describing water flow, storage, diversion, temperature, salinity, fish population and mortality, power generation and use, and various revenues and costs throughout the water system included in the three study areas. A fuller description of the suite of models applied can be found in Appendix 6B Water Resources System Modeling.

For the climate change and sea level rise sensitivity analysis, the No Project/No Action Alternative and Alternatives A, B, and C were simulated for four climate and sea level scenarios in addition to the current climate conditions simulated for the detailed evaluation in the EIR/EIS. The modeling for the sensitivity analysis included only the CALSIM II model. CALSIM II is used to describe the storage, flow, and operations of the California water resources system. The model simulates the water resources system of the Central Valley, including existing and proposed facilities, flow and water quality related regulatory and operational agreements, demands and contracts for water diversions, and hydrology. The model includes the major components of the SWP, CVP, and selected water districts, and the Project features, which include additional storage, intake, and conveyance facilities. A description of the modeling of Project features and each of the alternatives and the CALSIM II model can be found in Appendix 6A Modeling of Alternatives and Appendix 6B Water Resources System Modeling.

25A.2.2 Climate and Sea Level Scenarios

The climate and sea level scenarios used in this sensitivity analysis were previously developed for the Bay Delta Conservation Plan (BDCP) Effects Analysis and Administrative Draft EIR/EIS and documented in the BDCP Effects Analysis Appendix 5.A.2 (DWR, 2013a) and the BDCP Administrative Draft EIR/EIS Appendix 5A (DWR, 2013b). The California Department of Water Resources (DWR) modeling team had developed climate and sea level scenarios for evaluation of the BDCP alternatives. The lead and co-lead agencies for the BDCP collaborated on the methodology, and approved the selection and use of scenarios for the BDCP Effects Analysis and Administrative Draft EIR/EIS. The required inputs and modifications for the CALSIM II model for various climate and sea level scenarios were developed. The BDCP appendix describes the methodology and selection of the climate and sea level scenarios and the development of the inputs and modifications for the CALSIM II model.

For the Project sensitivity analysis, four climate and sea level scenarios, in addition to the current climate and sea level scenario (Current), were selected for sensitivity analyses:

- The Early Long-Term (**ELT Q5**) scenario represents the median conditions (Q5) and includes an ensemble of global climate models (GCM) projections at a point in time 15 years into the future (~2025) and a sea level rise of 15 centimeters (cm) (6 inches).
- The Late Long-Term (**LLT Q5**) scenario represents the median conditions (Q5) and includes an ensemble of GCM projections at a point in time 50 years into the future (~2060) and a sea level rise of 45 cm (18 inches).
- The Late Long-Term (**LLT Q2**) scenario represents the "drier, more warming" or the lower bound (Q2) and includes an ensemble of GCM projections at a point in time 50 years into the future (~2060) and a sea level rise of 45 cm (18 inches).

- The Late Long-Term (**LLT Q4**) scenario represents the "wetter, less warming" or the upper bound (Q4) and includes an ensemble of GCM projections at a point in time 50 years into the future (~2060) and a sea level rise of 45 cm (18 inches).

Using these climate and sea level scenarios, the No Project/No Action Alternative and Alternatives A, B, C, and D were re-simulated for the range of ELT and LLT conditions. Section 25A.3 describes the climate and sea level scenarios in more detail.

An example parameter is used to demonstrate the relationship between the Current, ELT Q5, LLT Q5, LLT Q2, and LLT Q4 scenarios in Figure 25A-A. Figure 25A-A shows the CALSIM II model results for the No Project/No Action Alternative for Shasta Lake end-of-September storage conditions, and how these conditions are impacted by climate change. This graphic indicates an anticipated climate change effect on the Shasta Lake end-of-September storage. It is expected that CALSIM II model results for Project alternatives for Shasta Lake end-of-September storage conditions would be impacted in a similar way. That analysis was also completed and is shown later in this appendix. A wide range of results has been compiled and included in this appendix to support discussion and evaluation of these types of questions.

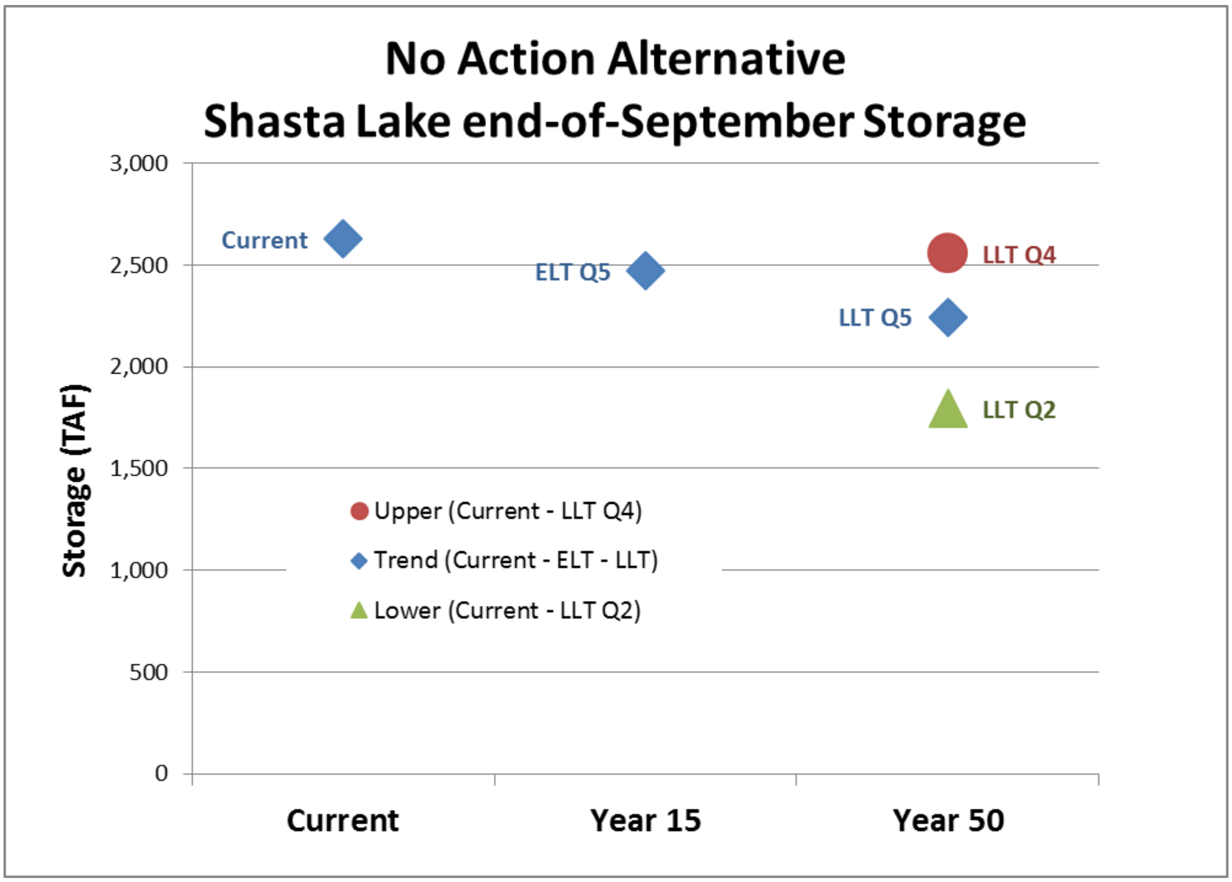

Figure 25A-A Example CALSIM II Model Results for the No Project/No Action Alternative Showing the Expected Changes Under ELT (Q5), LLT (Q5), and LLT Q2 and LLT Q4 Climate Change and Sea Level Rise Scenarios on Shasta Lake End-of-September Storage Compared to the Current Climate and Sea Level Conditions

25A.2.3 Current, ELT Q5, and LLT Q5 Scenarios

The expected changes in climate and sea level conditions over the next 50 years is shown by the relative changes in results at Current, ELT Q5, and LLT Q5 climate and sea level conditions. For example, the expected change in climate and sea level conditions, and the expected change (median, 50 percent probability) in the impacts of the Project alternatives, are determined by the differences in results and the incremental changes in differences across these three comparisons:

- Project alternative minus the No Project/No Action Alternative
- Project alternative at ELT Q5 minus the No Project/No Action Alternative at ELT Q5
- Project alternative at LLT Q5 minus the No Project/No Action Alternative at LLT Q5

Based on the methodology for selection of climate and sea level scenarios described in Section 25A.3, the relative differences indicating the changes across Current, ELT Q5, and LLT Q5 scenarios are primarily the result of increases in temperature in the inner quartiles (25th to 75th percentile) of the ensemble of climate projections used and the sea levels selected.

25A.2.4 LLT Q2 and LLT Q4 Scenarios

The range of uncertainty in the climate change projections at 50 years, near the midpoint of the Project planning period, is captured by LLT Q2 (more warming-drier), and LLT Q4 (less warming-wetter) scenarios. The range of effects on the Project alternatives due to uncertainty in the climate change projections at 50 years is demonstrated by the differences in results and the incremental changes in differences across these three comparisons:

- Project alternative minus the No Project/No Action Alternative
- Project alternative at LLT Q2 minus the No Project/No Action Alternative at LLT Q2 (lower, 10 percent joint temperature-precipitation probability)
- Project alternative at LLT Q4 minus the No Project/No Action Alternative at LLT Q4 (higher, 90 percent joint temperature-precipitation probability)

Based on the methodology described in Section 25A.3 for selection of climate and sea level scenarios, the potential range of differences in LLT Q2 and Q4 scenarios is primarily the result of uncertainty in total precipitation and expected warming in the ensemble of climate projections used. As indicated previously, LLT Q2 reflects a drier future and LLT Q4 reflects wetter conditions. In addition, LLT Q2 is relatively warmer than LLT Q4. The LLT Q5, LLT Q2, and LLT Q4 scenarios included the same sea level rise projections at 50 years as described in Section 25A.3.2.

Selected model inputs and results for the No Project/No Action Alternative are compiled in Section 25A.7. This compilation is helpful to understand the magnitude of potential changes associated exclusively with climate change and sea level rise.

Selected model results for all alternatives are compiled in Section 25A.8. This compilation is helpful to understand the magnitude of potential changes in the Project alternatives due to climate change and sea level rise.

The format of figures and tables, and guidance for interpretation of results, is discussed in Section 25A.5. Selected results and findings are highlighted and presented in Section 25A.5.

The results of the sensitivity analysis are not intended to be used for detailed evaluation of alternatives, and are subject to some limitations. The format of figures and tables included in Sections 25A.7 and 25A.8 has been selected to support full use of the sensitivity analysis, but is consistent with the limitations of the analysis. Limitations of the approach are also addressed in Section 25A.4.

25A.3 Climate and Sea Level Scenarios

The climate and sea level scenarios used for this sensitivity analysis were selected from scenarios developed for the BDCP Effects Analysis (DWR, 2013a) and BDCP Administrative Draft EIR/EIS (DWR, 2013b). The following discussion is a summary of this methodology as it pertains to the sensitivity analysis developed for the Project EIR/EIS and FR. The reader is referred to the BDCP documents for more detailed information related to the scenarios.

The analytical process for incorporating climate and sea level scenario into the CALSIM II simulation model includes the use of several sequenced analytical tools. These tools and the analytical process are shown conceptually in Figure 25A-B. This process includes modified hydrologic inputs (inflow time-series) and modified flow-salinity relationships for Delta salinity compliance modeling (revised Artificial Neural Networks [ANNs]).

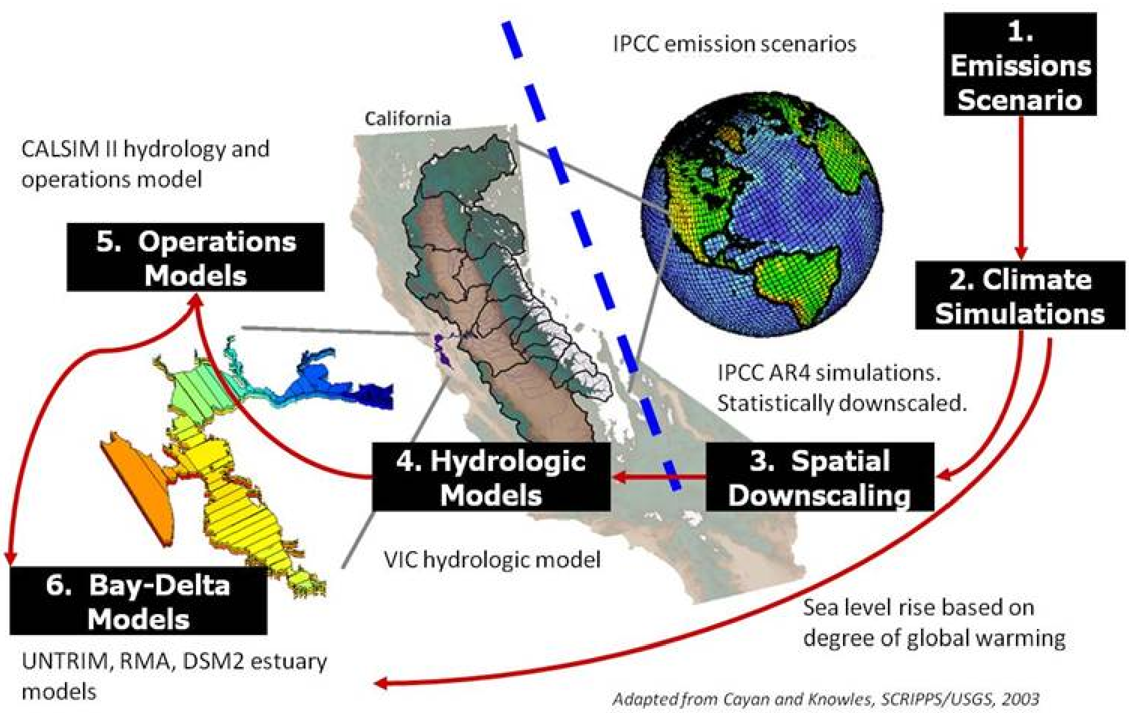

Figure 25A-B Graphical Depiction of the Analytical Process for Incorporating Climate Change into the CALSIM II Model for Water Resources Planning Purposes

25A.3.1 Climate Scenarios

For the Project sensitivity analysis, ELT and LLT scenarios were selected based on ensembles of climate projections. The ELT scenario considers climate conditions (temperature and precipitation) for a period of 30 years centered on analysis year 2025 (years 2011 to 2040) and projected sea level conditions at year

2025. The LLT scenario, likewise, considers climate conditions for a period of 30 years centered on analysis year 2060 (years 2046 to 2075) and projected sea level conditions at year 2060.

A collection of 112 future climate projections, based on multiple GCMs and multiple emission scenarios, was grouped into five ensembles (Q1 to Q5) and used in the development of the ELT and LLT scenarios.

These projections were used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007) and were generated from 16 different GCMs developed by national climate centers and potential emission scenarios A2, A1b, and B1 from IPCC's Special Report on Emission Scenarios (IPCC, 2000). For any given 30-year future climate period, each projection represents one point of change amongst the others. The 112 future climate projections and the resultant five ensembles of the climate projections (Q1 through Q5) are graphically depicted in an example in Figure 25A-C using downscaled climate projections for a region in the Feather River watershed.

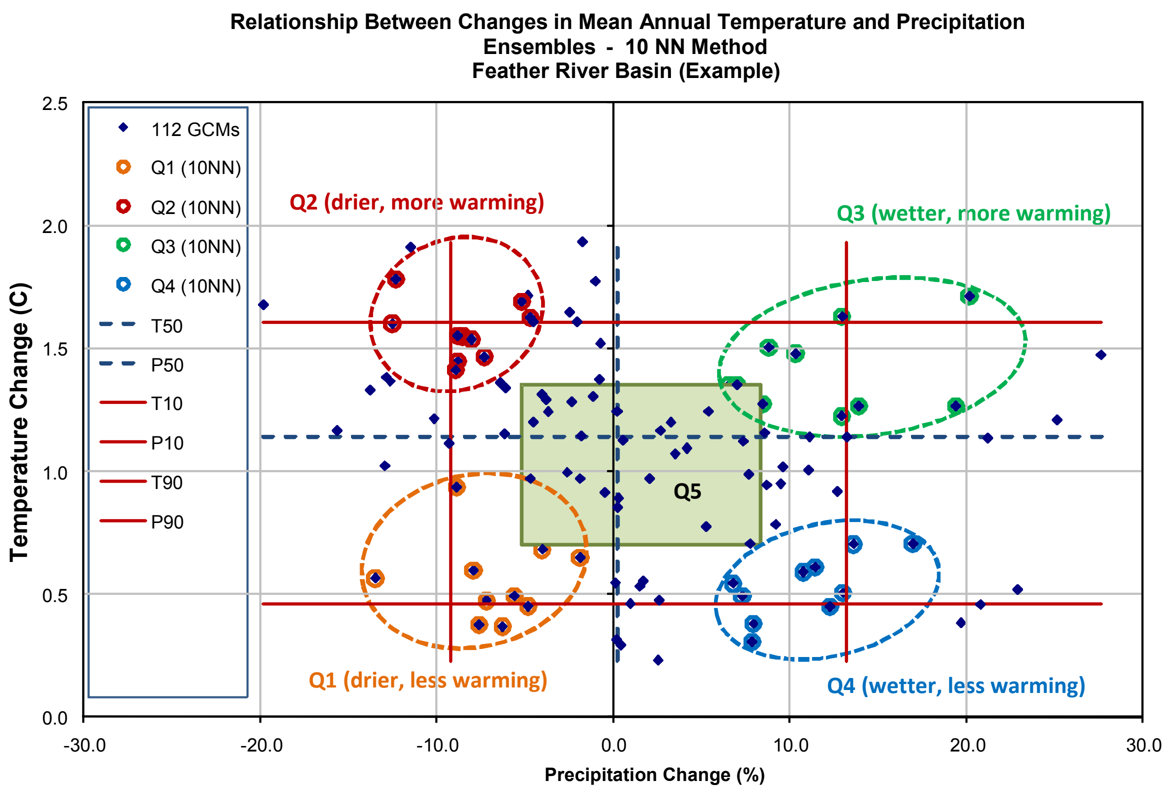

Figure 25A-C Example Downscaled Climate Projections used for Deriving Climate Ensembles (Q1 to Q5) for the Feather River Basin for the ELT Scenario (Year 2025, Climate Period 2011 to 2040). The Q5 Ensemble is Bounded by the 25th and 75th Percentile Joint Temperature-Precipitation Change. Ensembles Q1 to Q4 are Selected to Reflect the Results of the 10 Projections Nearest Each of 10th and 90th Joint Temperature-Precipitation Change Bounds.

Based on the median (50th percentile) change for a 30-year climatological period of both annual temperature and annual precipitation (dashed blue lines in Figure 25A-C), computed by comparing to a historical reference period, the collection of 112 climate projections can be sorted into quadrants representing Q1 (drier, less warming), Q2 (drier, more warming), Q3 (wetter, more warming), and Q4 (wetter, less warming than the ensemble median). These quadrants are labeled Q1 to Q4 in Figure 25A-C.

In addition, a fifth region (Q5) can be described using the climate projections from inner-quartiles (25th to 75th percentile) of the collection. In each of the five regions, the ensemble of climate change projections (made up of those contained within the region bounds) is identified. The Q5 ensemble is derived from the central tending climate projections, and thus favors the consensus of the collection. The bounding ensembles (Q1 to Q4) are derived using a “nearest neighbor” (k to NN) approach assuming 10 neighboring projections (k = 10). In this approach, a certain joint projection probability is selected based on the annual temperature change-precipitation change (i.e., 90th percentile of temperature and 90th percentile of precipitation change). From this statistical point, the “k” nearest neighbors were selected.

Using these ensembles, one ELT scenario and three LLT scenarios were selected to describe the sensitivity of California’s water resources systems in general and the sensitivity of the Project alternatives specifically. For evaluating the Project alternatives along the trend in climate and sea level conditions over the next 50 years, the ELT (Q5) and LLT (Q5) scenarios were selected using the respective Q5 ensembles. For evaluating the Project alternatives throughout the potential range of climate and sea level conditions at 50 years, near the midpoint of the Project planning period, the LLT Q2 (drier, more warming) and LLT Q4 (wetter, less warming) scenarios were selected using the respective Q2 and Q4 ensembles. These scenarios were selected because they would likely capture the effect of uncertainty within the range of climate change projections relevant to the Project alternatives being considered.

For a climate scenario, the statistics of the appropriate ensemble of downscaled climate change projections are used to develop modified hydrology for the 22 tributary watersheds of the Central Valley. The downscaled climate projections are used to create modified temperature and precipitation inputs for the Variable Infiltration Capacity (VIC) hydrology model. The VIC model simulates hydrologic processes on the 1/8th degree scale spatial resolution to produce statistics of watershed runoff. The changes in reservoir inflows and downstream accretions/depletions are translated into modified input time series for the CALSIM II model. The approach used is a technique called “quantile mapping,” which maps the statistical properties of climate variables from one data subset with the time series of events from a different subset. The “quantile mapping” was performed on a monthly basis consistent with the inputs of the CALSIM II hydrology. This procedure allowed for the use of a shorter VIC simulation period to define the climate state, yet maintain the variability of the longer historic record required for the hydrology inputs for the CALSIM II 82-year simulation period.

25A.3.2 Sea Level Scenarios

Sea level projections were based on an empirical method developed by Rahmstorf (Rahmstorf, 2007). This method better reproduces historical sea levels and generally produces larger estimates of sea level rise than those indicated by the IPCC (IPCC, 2007). When evaluating all projections of global air temperature, Rahmstorf projects a mid-range sea level rise of 70 to 100 cm (28 to 40 inches) by the end of the century; and when factoring in the full range of uncertainty, the projected rise is 50 to 140 cm (20 to 55 inches), as shown in Figure 25A-D. Using the work conducted by Rahmstorf, the projected sea level rise at year 2025 is approximately 12 to 18 cm (5 to 7 inches). The projected sea level rise at year 2060 is approximately 30 to 60 cm (12 to 24 inches). These sea level rise estimates are also consistent with those outlined in the recent U.S. Army Corps of Engineers (USACE) guidance circular for incorporating sea-level changes in civil works programs (USACE, 2009).

For the Project sensitivity analysis, a sea level rise of 15 cm (6 inches) was assumed for the ELT scenario, and a sea level rise of 45 cm (18 inches) was assumed for all LLT scenarios, corresponding to approximately median values within the uncertainty range spanning the range of temperature rise of 1.4 to 5.8 degrees Celsius (ºC) per Rahmstorf, as shown in Figure 25A-D.

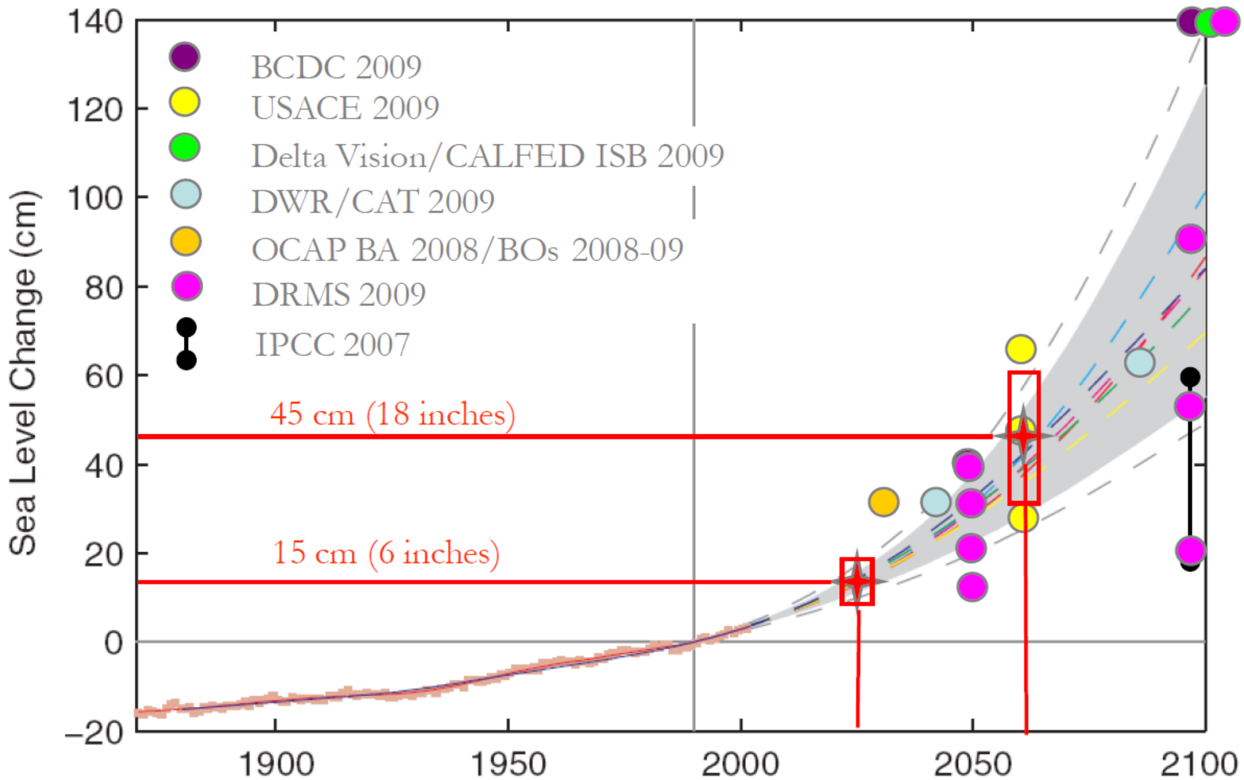

Figure 25A-D Historical and Projected Sea Level Spanning 1990 to 2100 Assuming Global Mean Temperature Rise of 1.4 to 5.8ºC (Rahmstorf, 2007). Various Markers Indicate the Selected Sea Level Rise Assumptions in Recent Bay-Delta Studies (DWR, 2013b). The Red Markers Indicate the Median Sea Level Rise Value of 15 cm (6 inches) Selected for the ELT Scenario at About 2025, and the Median Sea Level Rise Value of 45 cm (18 inches) Selected for all of the LLT Scenarios at About 2060.

CALSIM II uses ANN models to estimate salinity at selected compliance stations in the Delta estuary. The ANN models are used to describe flow salinity relationships to determine water operations suitable for compliance with Delta salinity standards based on State Water Resources Control Board (SWRCB) D-1641. The ANN models are calibrated based on detailed hydrodynamics and salinity modeling of the Delta using the Delta Simulation Model (DSM2). DSM2 model simulations were developed for each sea level rise scenario, with modified dispersion coefficients to simulate the salinity transport under sea level rise conditions based on the results from the three-dimensional UnTRIM model of the Bay-Delta (DWR, 2013b). For each scenario, new ANNs were developed based on the flow salinity response simulated by the DSM2 model. These sea level rise ANNs were verified and implemented in the CALSIM II models for the ELT (with 6 inches sea level rise in 2025) and the LLT (with 18 inches sea level rise in 2060) scenarios.

25A.4 Limitations

The Project climate change and sea level rise sensitivity analysis has been developed to consider the influence of climate change and sea level rise on the Project and the detailed analysis used in the EIR/EIS and FR. However, the sensitivity analysis has limitations that need to be considered.

The results from the sensitivity analysis are reasonable if the purpose and use of the results are limited appropriately. The detailed evaluation of Project alternatives in the EIR/EIS and FR analyses are necessarily quantitative. The detailed evaluation relied on modeling of current climate and sea level conditions. Even though there are quantitative model results (figures and tables of numerical quantities) for this sensitivity analysis, these results should be considered qualitative. Due to the limitations of the modeling used in the sensitivity analysis, the results are not comparable in quality or scope to modeling performed for the detailed evaluation. More specifically, the modeling associated with the detailed evaluation of the EIR/EIS and FR is more finely tuned and more precisely depicts the changes that would occur in the CVP and/or SWP water resources systems in scenarios with and without the Project-related operations rather than that associated with the climate change sensitivity analyses.

There are several considerations that specifically limit the use of the Project sensitivity analysis:

- Climate and sea level assumptions and model uncertainty
- No Project/No Action Alternative assumptions and dead pool storage conditions
- Project alternatives assumptions and operating criteria

25A.4.1 Climate Assumptions and Model Uncertainty

The Project sensitivity analysis relies on climate and sea level scenarios developed and documented by the BDCP program (DWR, 2013a and DWR, 2013b). The BDCP document identifies several concerns related to these scenarios. Based on this document and consideration of the objective of this analysis, the following limitations regarding the climate and sea level scenario assumptions should be recognized.

The climate scenario assumes selection of temperature and precipitation statistics for an ensemble of climate projections based on multiple GCMs and multiple emission scenarios. The projection of climate (temperature and precipitation statistics) will vary temporally and regionally as a result of the selected ensemble. The range of projections, especially beyond year 2030, is governed primarily by the assumed future global emissions scenarios used to create the climate projections, and the uncertainty inherent in the GCMs used to create the climate projections.

The GCM simulations of historical climate capture the historical range of variability reasonably well (Cayan et al., 2009), but historical trends are not well captured in these models. Precipitation in most of California is dominated by extreme variability seasonally, annually, and over decade time scales. The 112 climate projections exhibit more variability in the future precipitation changes than the temperature changes because all the projections show increased temperatures (DWR, 2013a and DWR, 2013b).

The coarse scale of GCMs requires that results must be spatially "downscaled," or applied to a region or a watershed. Whether through dynamic or statistical methods, downscaling adds another source of uncertainty to the use of projections in hydrologic models. Due to the coarse scale of GCMs and necessary downscaling, projections are not able to capture the full range of local variability of temperature and precipitation statistics. The extent to which local variability is preserved is not known.

Without strongly calibrated and validated models, the “signal” (trend) of change may not be distinguishable from the “noise” (uncertainty) of model error. The ensemble approach is used to give more weight to the “signal” assuming the approach collapses much of the “noise” of the multiple realizations into several representative climate scenarios used for this analysis. The extent to which the variability of the “signal” of one individual climate projection is preserved depends on whether or not the same variability of the “signal” is present amongst the other climate projections used in the ensemble. This implicit differentiation of “noise” from the variability of the “signal” is dominated by the content of the ensemble and is not due to a rational recognition of the source of the “noise” and the improvement of the models in projecting the “signal.” Each projection is assumed to be of equal likelihood in establishing the consensus that results in the “signal” of the ensemble. The ensemble approach is, therefore, limited in that (1) the selection of climate projections, to be included in an ensemble, is a subset of the overall collection of projections available, (2) the weighting of each projection in the ensemble does not consider the “signal” to “noise” strength of each individual projection, and (3) the resulting ensemble does not distinguish variability due to meaningful “signal” and meaningless “noise.”

25A.4.2 Sea Level Assumptions and Model Uncertainty

When evaluating all projections of global air temperature, Rahmstorf (2007) projects a mid-range sea level rise of 70 to 100 cm (28 to 40 inches) by the end of the century. When factoring the full range of uncertainty, the projected rise is 50 to 140 cm (20 to 55 inches). The Rahmstorf model was used for the sensitivity analysis. However, only two projections were used: 15 cm for the ELT (year 2025) scenario and 45 cm for the LLT (year 2060) scenario, corresponding to approximately median values within the uncertainty range spanning the range of temperature rise of 1.4 to 5.8ºC per Rahmstorf (2007), as shown in Figure 25A-D.

The Project investigation planning horizon extends to the end of the century. The sensitivity analysis does not include the range of potential sea level rise at the end of the century or the range of uncertainty at each of the ELT and LLT points in time. However, the trend in the incremental changes for the with-Project conditions when compared to the No Project/No Action Alternative under the projected sea level at the end of the century is expected to be similar to that presented in this analysis.

In addition, there is considerable uncertainty associated with the tidal amplitude increase and evolving science relating these changes to climate change and mean sea level rise. Tidal amplitude may increase by as much as 5 percent per century, relying on the published observed trends of Jay (2009) and assuming that these trends would continue in the future. This trend was not included in the sensitivity analysis.

25A.4.3 No Project/No Action Alternative Assumptions

In modeling the No Project/No Action Alternative under current climate and sea level conditions, all assumptions are assumed to be "stationary" and represent a level of development and a state of regulations at a point in time. Hydrology is assumed to be stationary in that the 1922 through 2003 hydrologic sequence is assumed for the simulation period, with adjustments to reflect the land use and level of development corresponding to a point in time. Land use and agricultural and municipal and industrial water use and demands, facilities (e.g., reservoirs, conveyance, and diversions), regulatory requirements, policies, and agreements are projected to a future point in time (typically year 2020) and are held stationary throughout the simulation period. The projection of the future point in time is governed by criteria compliant with the requirements of the Project FR as well as the California Environmental Quality Act and the National Environmental Policy Act requirements for the EIR/EIS. A description of the No Project/No Action Alternative assumptions for the CALSIM II model can be found in Appendix 6A Modeling of Alternatives.

The No Project/No Action Alternative CALSIM II model for the current climate and sea level conditions was modified to simulate with the inputs for ELT Q5, LLT Q5, LLT Q2, and LLT Q4 climate and corresponding sea level conditions. The input hydrology for 22 tributary watersheds of the Central Valley and the ANN model for describing flow-salinity relationships for selected compliance stations in the Delta were modified. In addition, water year type indices and related operating criteria were adjusted to be consistent with the revised hydrology according to regulatory requirements used in the model.

25A.4.4 Anticipated Climate Change Effects

Several climate change effects generally anticipated with the California water resources system and other resources that depend on the system are noted here. Many of the observations are based on generally expected changes under modified climate and sea level. A few observations are based on the simulated results, while others are based on the findings from similar studies such as BDCP (DWR, 2013a and DWR, 2013b).

- Runoff:
  - Reduced annual snowpack and natural water storage in late winter and early spring
  - Shift in snowmelt and runoff patterns to occur earlier in the year likely resulting in increased runoff in late winter/early spring and reduced runoff in late spring and summer
  - Uncertain changes in intensity and duration of total precipitation (snow and rain)
  - Uncertain changes in natural recharge and groundwater aquifer storage
- Sea level:
  - Increased sea level
  - Increased salinity in the western and central Delta
- Aquatic Habitat:
  - Increased water temperatures in reservoirs and rivers
  - Reduced riverine habitat for coldwater fish due to warmer water temperatures throughout all seasons and lower flows during late spring and summer

  - Modified peak and natural pulse flow conditions
  - Altered and uncertain ocean and Delta estuary habitat conditions
- Water Use:
  - Reduced river and Delta inflow due to decreases in runoff, specifically in summer months and Dry and Critically Dry year conditions
  - Increased Delta outflow requirements in Dry and Critically Dry year conditions due to increased salinity conditions
  - Increased relative use of reservoir storage to maintain flow, temperature, and Delta salinity requirements
  - Seasonal increases in demands per acre for agricultural use of applied water
  - Decreased relative use of reservoir storage to meet demands for agricultural and urban water use
  - Increased use of groundwater
- Water Operations:
  - Decreased reservoir storage conditions in summer and fall
  - Modified SWP and CVP (and other) reservoir operating criteria to manage changes in intensity and duration of peak runoff conditions
  - Uncertain changes in frequency of annual refilling of reservoirs
  - Increased variability and overall decreased water allocations for SWP and CVP Delta exports and other diversions
  - Increased occurrence of water shortages in storage and firm commitments (i.e., senior water rights)
  - Increased occurrence of water shortages in meeting regulatory standards (i.e., D-1641 [SWRCB, 2000]) and other operation agreements (i.e., Coordinated Operations Agreement [United States and State of California, 1986])

These changes are complex and often interrelated and could lead to significant impacts on the performance of fisheries, water supply, water quality, and power generation of the California water resources system.

In simulating the storage and flows of the No Project/No Action Alternative, the CALSIM II model uses inputs configured for regulations, policies, and other operating criteria. These inputs are based on current water resources system capabilities and feedback from operations experience under current climate and sea level conditions. More simply, both the model and the operations of the water system itself have been “tuned” to what is essentially current climate, hydrology, and system requirements and needs. These inputs were developed through recent history and are implemented to provide a certain level of protection for a beneficial result including, for example, flood damage reduction, water supply reliability, water quality, and environmental protection.

For the No Project/No Action Alternative, the regulations, policies, and other operating criteria assumptions are assumed to be “stationary” in the CALSIM II modeling for the Project climate and sea level sensitivity analysis. It is assumed that the water resources system capabilities and associated operations outcomes are appropriate regardless of climate and sea level scenarios. The changes in the results of the No Project/No Action Alternative under the climate and sea level scenarios are highlighted in Section 25A.5 and in selected results compiled in Section 25A.7. The changes in results under the ELT Q5 climate and sea level scenario are significant; however, the changes are not so large as to warrant reconsideration of these assumptions. The changes under the LLT Q5, and throughout the LLT Q2 though LLT Q4 scenario range, show a substantial alteration of the storage and flows of the No Project/No Action Alternative under potential future climate and sea level conditions. It is reasonable to assume that adaptation (e.g., alteration of water use, additional facilities, and/or modified regulations) will be necessary and desirable such that protections are maintained and priorities are balanced between the competing interests active in California water resources management decisions. The CALSIM II modeling with climate change and sea level rise for the No Project/No Action Alternative did not assume or consider any feedback from the effects of climate change and sea level rise. This sensitivity modeling has not been "tuned" to the new climate change and sea level rise hydrology and effects that are causing some of the undesirable results in the system. One example is the increased occurrence of dead pool storage conditions described below.

25A.4.5 No Project/No Action Alternative Dead Pool Storage Conditions

The CALSIM II model simulations of the No Project/No Action Alternative under all climate and sea level conditions include periods when Shasta Lake and Folsom Lake are at a "dead pool" condition and Delta exports are at minimum health and safety pumping levels. Reservoir storage at or below the elevation of the lowest outlet is considered to be at dead pool levels. Minimum health and safety pumping levels for Delta export are the minimum level of pumping needed to prevent too rapid of a drawdown in San Luis Reservoir, cause interruption of conveyance in the California Aqueduct, or cause risks to health and safety conditions in urban areas due to water shortages.

Table 25A-A identifies the occurrence of dead pool conditions in major CVP and SWP reservoirs under the No Project/No Action Alternative under current climate and sea level conditions. In the CALSIM II model, dead pool conditions are assumed at 240 TAF for Trinity Lake, 550 TAF for Shasta Lake, and 90 TAF for Folsom Lake. The frequency of dead pool conditions increases under ELT and LLT climate and sea level scenarios.

Table 25A-A
Total Number of Months with Dead Pool Conditions at Upstream CVP-SWP Reservoirs

	Total Months with Dead Pool Conditions (out of 984 months)
Trinity Lake	4
Shasta Lake	11
Lake Oroville	0*
Folsom Lake	12

Figures 25A-E, 25A-F, and 25A-G show the effect of the projected climate change and sea level rise on the number of occurrences in dead pool conditions at Trinity, Shasta, and Folsom reservoirs, respectively. The dead pool conditions are shown for the No Project/No Action Alternative and Alternatives A, B, C, and D using the results from the CALSIM II simulations for Current, ELT Q5, and LLT Q5 climate and sea level conditions.

In CALSIM II, when reservoirs are at dead pool conditions, flows may fall short of minimum flow criteria, Delta salinities may exceed standards, diversions may fall short of allocated volumes, and water rights priorities and operating agreements may not be fully met.

The model may reach a numerical solution, but the results of the simulation may not reflect a reasonably expected or feasible outcome. The model solution for the period following these types of events may not be reliable due to these unreasonable or infeasible outcomes.

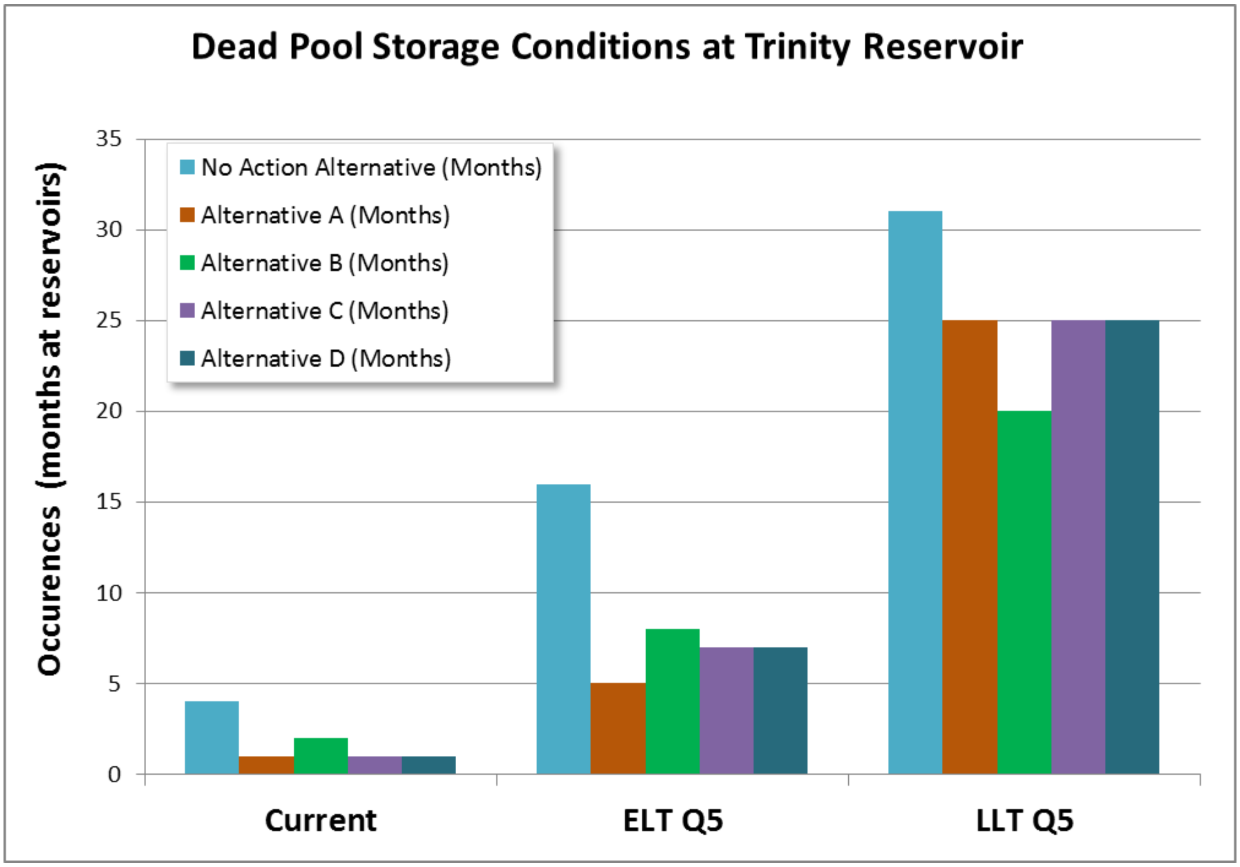

Figure 25A-E Dead Pool Storage Occurrences (Number of Months and Number of Years) at Trinity Reservoir Under Current, ELT (Q5), and LLT (Q5) Climate and Sea Level Conditions for the No Project/No Action Alternative and Alternatives A, B, C, and D

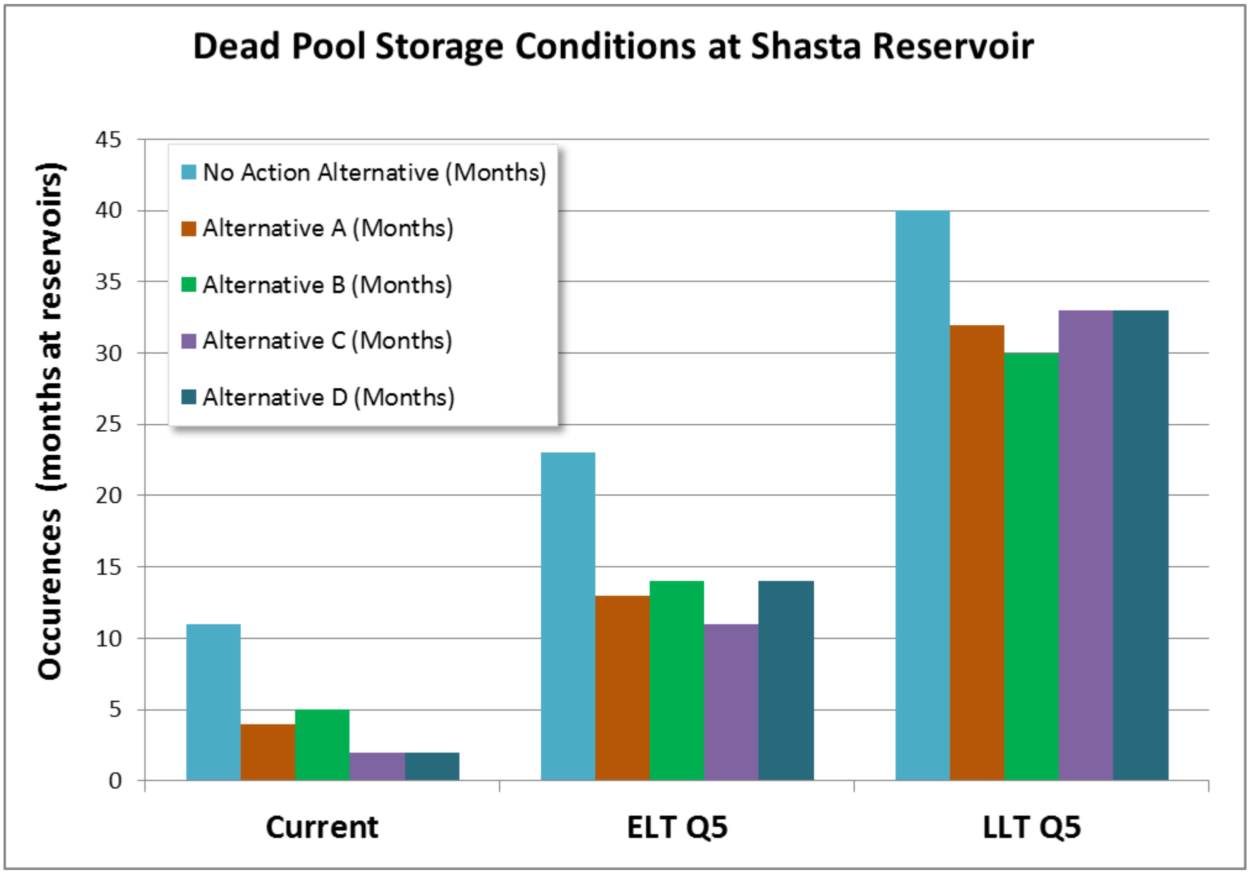

Figure 25A-F Dead Pool Storage Occurrences (Number of Months and Number of Years) at Shasta Reservoir Under Current, ELT (Q5), and LLT (Q5) Climate and Sea Level Conditions for the No Project/No Action Alternative and Alternatives, A, B, C, and D

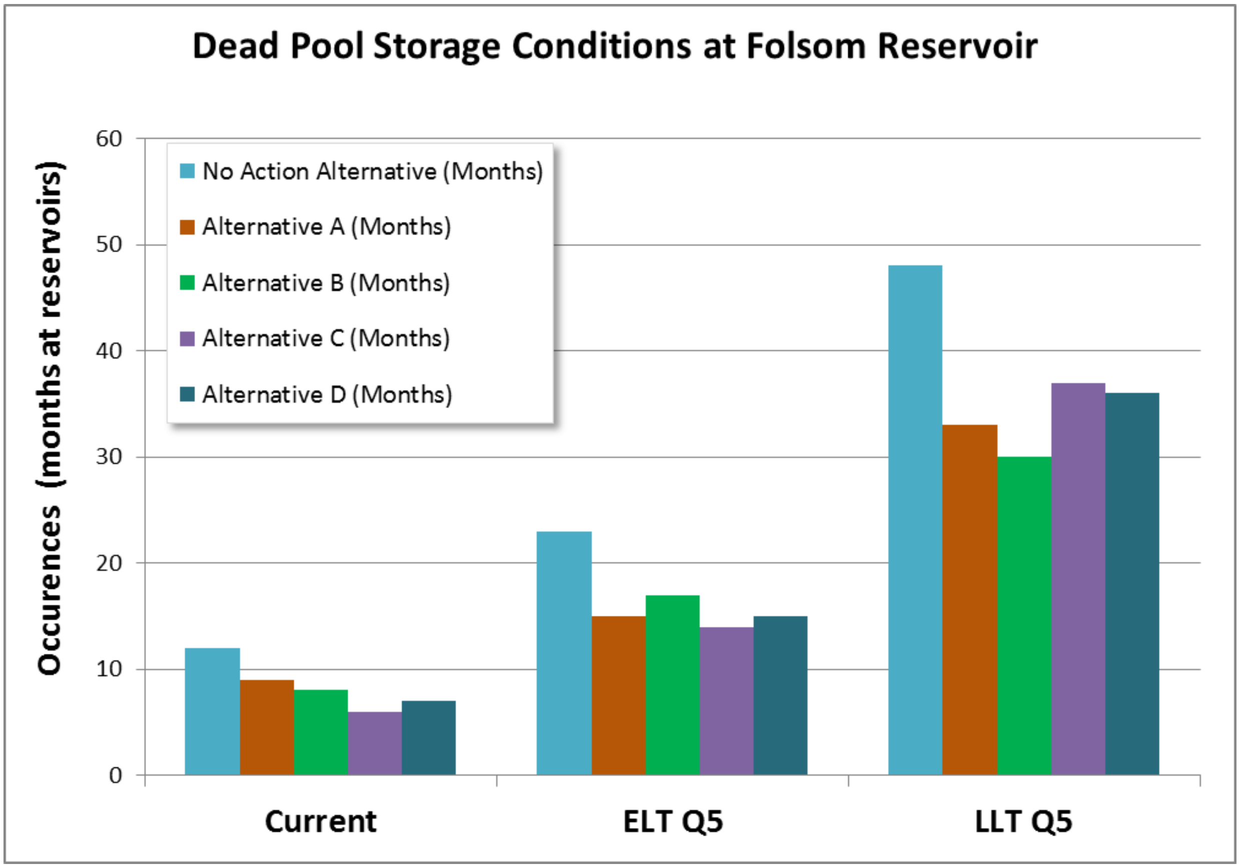

Figure 25A-G Dead Pool Storage Occurrences (Number of Months and Number of Years) at Folsom Reservoir Under Current, ELT (Q5), and LLT (Q5) Climate and Sea Level Conditions for the No Project/No Action Alternative and Alternatives A, B, C, and D

25A.4.6 Sites Reservoir Alternatives Assumptions and Operating Criteria

The assumptions specific to modeling of Project alternatives are documented in Appendix 6A Modeling of Alternatives. All Project alternatives include the Sites Reservoir, a combination of existing and proposed Sacramento River intakes and conveyance. All Project alternatives use the new storage capacity to achieve the Primary and Secondary Objectives described in Chapter 2 Alternatives Analysis. The Primary objectives include:

- Increase survival of anadromous fish populations, as well as the health and survivability of other aquatic species.
- Improve water supply reliability for agricultural, urban, and environmental uses.
- Improve drinking and environmental water quality in the Delta.
- Support flexible hydropower generation.

While the hydropower operation does affect Project operations, the benefits associated with fisheries, water supply, and water quality are not affected. The Project is assumed to be operated in an integrated manner with existing SWP and CVP reservoirs. The foundational idea behind this approach is that operations of the existing system could be improved specifically by increasing the total storage in the water resources system. This integrated storage approach and the Project operations are described in Chapter 3 Description of the Sites Reservoir Project Alternatives.

As described above, the CALSIM II simulations of the Project EIR/EIS alternatives were developed and “tuned” to the conditions of the existing water resources system. In doing so, the performance of the Project alternatives was measured specifically against Existing Conditions and the No Project/No Action Alternative CALSIM II simulations with current climate and sea level conditions. The tuning of the simulations included adjustments to CALSIM II inputs to control the model operations in this order:

1. Operating criteria for diversion of flows from the Sacramento River to fill Sites Reservoir
2. Operating criteria to achieve benefits associated with the primary objectives in specific year types (such as drought or driest periods) and other hydrologic conditions
3. Integrating the operations of Sites Reservoir with the SWP and CVP reservoirs, including Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake

This tuning process was iterative using the full suite of hydrologic, operations, water quality, fisheries, power, and economics models applied to the detailed evaluation of alternatives. A description of the suite of models is in Appendix 6B Water Resources System Modeling. The tuning process involved the following elements and was performed for each individual operational element dependent on the Project:

- Definition of metrics and assessment of alternative for potential beneficiary performance
- Modification of assumptions and model inputs to improve potential beneficiary performance
- Prioritizing potential beneficiary performance according to overall strategy for primary objectives

In this climate and sea level sensitivity analysis, for each of the Project alternatives, the assumptions and tuned inputs related to the Project are assumed to be “stationary” in the CALSIM II modeling, and are not modified.

Only the CALSIM II model was used for the sensitivity analysis; therefore, the information required to provide feedback to the Project operating criteria was not available. There was no reconsideration of how potential beneficiaries may have been impacted due to climate change and sea level rise; therefore, no additional refinements of Project operating criteria were implemented to target specific needs in the water resources system under climate change and sea level rise.

Following the initial set of sensitivity analyses simulations, with only the CALSIM II model results available, it was evident that some significant changes had occurred in the performance of the Project alternatives. The need for storage for Cold Water Pool actions was increased under ELT and substantially more under LLT climate and sea level conditions. A decision was made to limit other operations that would put the higher priority Ecosystem Enhancement Storage Account (EESA) actions related to "coldwater pool" actions at risk. These variations in the Project operating criteria assumed throughout the climate and sea level rise scenarios are shown in Table 25A-B.

Table 25A-B
Variations in Sites Reservoir Operating Criteria Assumed under Various Climate and Sea Level Conditions

Sites Reservoir Primary Objective/Operations Criteria	Current Climate and Sea Level	ELT Climate and Sea Level	LLT Climate and Sea Level
Water Supply Operations			
SWP Contractors	Drought year operation depending on supply		
Level 4 Water Supply for Wildlife Refuges	Long-term operation depending on supply		
CVP Contractors	Long-term operation depending on supply		
Water Quality Operation			
Delta Water Quality	Non-drought operation depending on supply		
Ecosystem Enhancement Storage Account (EESA) Actions/Operation			
EESA-1: Shasta Coldwater Pool	Drought year operation	Increased in attempt to counter climate change impacts on drier years	
EESA-2: Sacramento River Flows for Temperature Control	Drought year operation	Adjusted specific to ELT conditions	None
EESA-3: Folsom Lake Cold Water Pool	Drought year operation	Continued drought year operation	EESA-3: Folsom Lake Cold Water Pool
EESA-4: Stabilize American River Flows	Not explicitly included in CALSIM II modeling		
EESA-5: Delta Outflow for Delta Smelt Habitat Improvement (Summer/Fall)	Non-drought operation depending on supply	None	None
EESA-6: Lake Oroville Coldwater Pool	Drought year operation	Continued drought year operation	

Sites Reservoir Primary Objective/Operations Criteria	Current Climate and Sea Level	ELT Climate and Sea Level	LLT Climate and Sea Level
EESA-7: Stabilize Sacramento River Fall Flows	Non-drought operation	None	None
EESA-8: Sacramento River Diversion Reduction at Red Bluff and Hamilton City	Covered under intake operations strategy		

25A.4.7 Considerations

The No Project/No Action Alternative CALSIM II model inputs and outputs have been refined and vetted through the State and federal agencies over the last 3 years since the USFWS and NMFS Biological Opinions were published (USFWS, 2008; NMFS, 2009). The Project alternatives CALSIM II model inputs and outputs were refined to achieve the primary objectives subject to performance constraints, as analyzed through the results of a full suite of model and analysis tools.

The climate and sea level scenarios have been implemented in the CALSIM II model as a sensitivity analysis, and the results do not reflect the potential changes in the No Project/No Action Alternative or Project alternatives to adapt to the changes between these scenarios and the current climate and sea level conditions. The ability of the CALSIM II model to simulate these climate and sea level scenarios is limited without additional model refinements and including other information and feedback from the full suite of models mentioned earlier. The figures previously presented (Figures 25A-E, 25A-F, and 25A-G) show the effect of the projected climate change and sea level rise on the number of occurrences in dead pool conditions at Trinity, Shasta, and Folsom reservoirs, respectively. These figures demonstrate the need for additional model refinements under the modified climate and sea level. The figures indicate that including the Project would offset some of the increased dead pool storage conditions.

Additional limitations of the CALSIM II model, in addition to the ones highlighted in this appendix, are documented in Appendix 6B Water Resources System Modeling.

The results of the sensitivity analysis should be considered for information purposes only and not used for detailed evaluation. Any conclusions derived from the sensitivity analysis results should be considered to be qualitative and an indicator of potential changes related to climate change and sea level rise. The results of this analysis should not be used independently for decision-making purposes, but rather as supplemental to the detailed evaluations in the EIR/EIS and FR.

If additional analysis is to be performed on future climate and sea level scenarios for the purpose of detailed evaluation of the alternatives, a multiagency review process that includes DWR and Reclamation operations teams should be considered. In addition, the full suite of models used in the Project detailed evaluation should be used, and reevaluation of the alternatives assumptions should be undertaken to refine the representation of the No Project/No Action Alternative and Project alternatives subject to future climate and sea level conditions.

The Project represents only one potential opportunity for the State of California and the State and federal agencies to respond to the impacts of and adapt to climate change and sea level rise. An overall strategy of response to climate change and sea level rise is needed. The Project should be considered in the context of that strategy.

25A.5 Results and Findings

Using 21 CALSIM II model simulations and a selection of 22 parameters, a compilation of figures and tables has been prepared as a tool for planners, resources specialists, and stakeholders to consider the influence of climate change and sea level rise on the Project and to verify that the EIR/EIS and FR findings are adequate.

Selected model inputs and results for the No Project/No Action Alternative are compiled in Section 25A.7. Selected model results for all alternatives are compiled in Section 25A.8. The format of figures and tables, and guidance for interpretation of results is discussed in this section. Selected results and findings are highlighted and presented.

The tables and figures presented in this appendix are based on the CALSIM II model results for Existing Conditions, the No Project/No Action Alternative, and the No Project/No Action Alternative and Alternatives A, B, and C with each climate and sea level rise condition. The appendix includes tables and figures for the Current, ELT Q5, and LLT Q5 climate and sea level scenario results ("ELT Q5 and LLT Q5" in the figure or table subtitle) and the LLT Q2 and LLT Q4 climate and sea level scenarios results ("LLT Q2 and Q5" in the figure or table subtitle).

Traditionally, water year types, based on the 40-30-30 index defined in SWRCB D-1641 (SWRCB, 2000), are used to evaluate year type specific results. Due to the changes in inflow and water operations between Current, ELT, and LLT climate and sea level scenarios, the use of water year types is avoided for analysis of results because these definitions, for particular years, have changed across scenarios. Averages of ranges of probabilities are a more useful tool in this circumstance. Results are presented in tables and figures for long-term and upper, above median, below median, and lower quartile range averages. The long-term average is the average of model results over the 82-year simulation period of CALSIM II. The upper quartile range average is the average of the largest 25 percent results, for a given parameter, over the 82-year simulation period of CALSIM II. The upper quartile range average is equivalent to the average result for the parameter over the 0 to 25 percent range of probability of exceedance. Similarly, the above median, below median, and lower quartile range averages are equivalent to the average result for the parameter over the 25 to 50 percent, 50 to 75 percent, and 75 to 100 percent ranges of probability of exceedance, respectively. Figure 25A-H shows different quartiles presented in this appendix using an example exceedance plot. The lower quartile range average is similar to the combined average of the "Dry" and "Critically Dry" years based on the 40-30-30 index (upper quartile for X2 position).

25A.5.1 No Project/No Action Alternative Compilation of Results

Selected model inputs and results for the No Project/No Action Alternative are compiled in Section 25A.7. This compilation is helpful to understand the magnitude of potential changes in the No Project/No Action Alternative due to climate change and sea level rise.

Using the five CALSIM II model simulations of the No Project/No Action Alternative, simulated using the Current, ELT Q5, LLT Q5, LLT Q2, and LLT Q4 climate and sea level scenarios, selected model inputs and results for the No Project/No Action Alternative are compiled for six CALSIM II model input parameters and 11 CALSIM II model output parameters.

For each parameter, CALSIM II results are presented for the No Project/No Action Alternative at each climate and sea level rise condition. The compilation includes tables and figures showing monthly and annual changes in the parameter between each ELT and LLT when compared to the current climate and sea level scenario.

The results are shown in tables as monthly and annual values, and differences with the current climate and sea level scenario. The results are shown graphically as monthly values using columns to show the Current, ELT Q5, and LLT Q5 climate and sea level scenario results and using dashed lines showing the upper and lower bounds of the LLT Q2 and LLT Q4 climate and sea level scenario results. The figures and tables are shown for long-term and lower and upper quartile range averages.

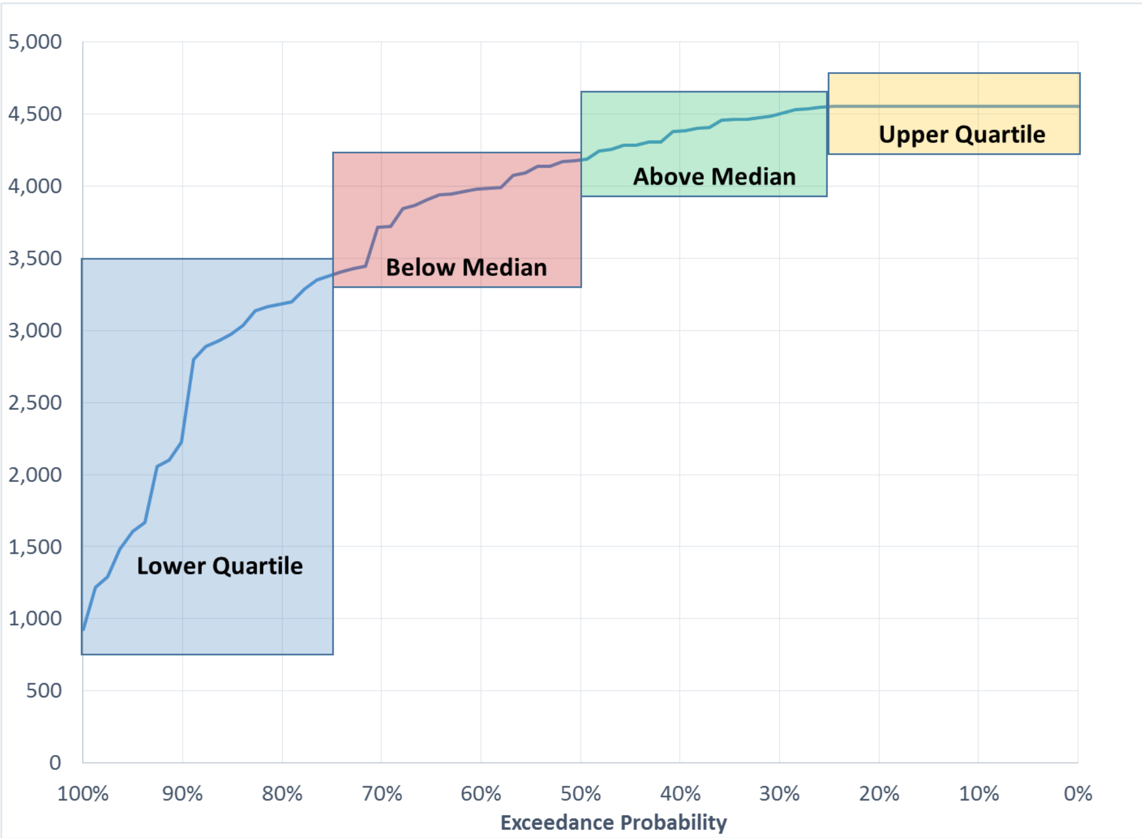

Figure 25A-H Lower Quartile (75% - 100%), Upper Quartile (0% - 25%), Below Median (50% - 75%), and Above Median (25% - 50%) Identified on an Example Exceedance Plot

25A.5.2 No Project/No Action Alternative Findings

Based upon the results of the ensemble approach used to select the climate and sea level scenarios for this analysis, as documented in Section 25A.3 and related references (DWR, 2013a and DWR, 2013b), the following are expected:

- The expected changes over the 50-year period based on the Current, ELT Q5, and LLT Q5 scenarios would be primarily the result of increases in temperature in the climate projections that are part of the inner-quartile (25th to 75th percentile) of the collection of 112 climate projections used, and the sea levels selected at ELT and LLT.

- The potential changes under the LLT Q2 and Q4 scenarios would be primarily the result of uncertainty in total precipitation and the degree of warming in the collection of climate projections used in each ensemble.

A summary of potential changes is provided below based on the relative changes in Current, ELT Q5, and LLT Q5 scenarios, and to some extent the potential changes under the LLT Q2 and Q4 scenarios. The results of VIC simulations for the climate and sea level scenarios selected and the subsequent results of CALSIM II simulations of the No Project/No Action Alternative based on these scenarios were analyzed for these summary findings:

- Increased runoff in late winter/early spring and reduced runoff in late spring and summer
- Increased salinity in the western and central Delta
- Reduced river and Delta inflow due to decreases in runoff, specifically in summer months and Dry and Critically Dry year conditions
- Increased Delta outflow requirements in Dry and Critically Dry year conditions due to increased salinity conditions
- Increased relative use of reservoir storage to maintain flow, temperature, and Delta salinity requirements
- Decreased relative use of reservoir storage to meet demands for agricultural and urban water use
- Decreased reservoir storage conditions in summer and fall and uncertain changes in frequency of annual refilling of existing reservoirs
- Increased variability and overall decreased water allocations for SWP and CVP Delta exports and other diversions
- Increased occurrence of dead pool storage and potential operational interruptions

As previously noted, the sensitivity analysis did not include the full suite of models (Appendix 6B Water Resources System Modeling), including daily operations, temperature, fisheries, and economics. However, the CALSIM II results indicate changes in flows and storage conditions from the Current, ELT Q5, and LLT Q5 scenarios and to some extent the potential changes under LLT Q2 and Q4 scenarios such that the following is expected (but has not been confirmed with detailed modeling):

- Increased water temperatures in reservoirs and rivers
- Reduced riverine habitat for cold water fish due to warmer water temperatures throughout all seasons and lower flows during late spring and summer
- Modified peak and natural pulse flow conditions

The changes in monthly and annual inflows for Shasta Lake, Sacramento River, Trinity Lake, Folsom Lake, and Lake Oroville in the No Project/No Action Alternative between the Current and all ELT and LLT climate and sea level scenarios are shown in Tables 25A-1 through 25A-6 and Figures 25A-1 through 25A-6 in Section 25A.7.

The impacts of climate change on long-term average annual inflows are summarized in Table 25A-C. Between Current, ELT Q5, and LLT Q5 climate scenarios, there would be little change in long-term average annual inflow across these watersheds. However, there is a large degree of uncertainty as shown between the range of values for LLT Q2 and Q4 climate scenarios, with a change of -19 to +21 percent compared to the LLT Q5 climate scenario. This variation is due to the uncertainty regarding the precipitation impacts of climate change, as discussed in Section 25A.3 and related references (DWR, 2013a and DWR, 2013b). These variations in average annual inflow would increase in relative magnitude the wetter the year and would decrease in relative magnitude the drier the year. Upper and lower quartile averages are compiled in Figures 25A-1 through 25A-6 and Tables 25A-1 through 25A-6 of Section 25A.7.

Table 25A-C
Impacts of Climate Change on Long-Term Average Annual Inflows at Shasta Lake, Sacramento River, Trinity Lake, Folsom Lake, and Lake Oroville

Climate Scenario:	Current	ELT Q5	LLT Q5	LLT Q2	LLT Q4
Location	Annual Inflow (TAF)	Change in Annual	Inflow from Current	(TAF and	Percent Change)
Shasta Lake	5,690	+45 (1%)	+98 (2%)	-779 (-14%)	+1021 (18%)
Sacramento River, Keswick Dam to Hamilton City	2,993	+51 (2%)	+40 (1%)	-338 (-11%)	+450 (15%)
Sacramento River, Keswick Dam to Delevan Intake	4,073	+59 (1%)	+46 (1%)	-386 (-9%)	+515 (13%)
Trinity Lake	1,277	+2 (0%)	+23 (2%)	-241 (-19%)	+271 (21%)
Folsom Lake	1,342	-6 (0%)	-41 (-3%)	-253 (-19%)	+168 (13%)
Lake Oroville	3,967	+69 (2%)	+54 (1%)	-551 (-14%)	+616 (16%)

The basins most sensitive to both temperature and precipitation impacts of climate change are the upper watersheds that depend on snowmelt for runoff. The basins that provide the majority of the inflow to SWP and CVP reservoirs are basins with significant runoff from snowmelt. In contrast, the lower elevation tributaries, along the Sacramento River and San Joaquin rivers, have less runoff from snowmelt and, therefore, are not as sensitive to the temperature impacts of climate change that is the cause of changes in snowmelt runoff.

A sample of the impacts of climate change on the timing of inflows, due to changes in snowmelt runoff, is shown in Table 25A-D. The months of February and June were selected to give an indication of the types of changes in patterns that occur between a snowmelt runoff fed location, such as Shasta Lake, when compared to a location (region of reaches) that is not. This table shows the long-term average February and June inflows at Shasta Lake and along the Sacramento River between Keswick Dam to Hamilton City and Keswick Dam to the proposed Delevan Intake and the relative changes that would occur in the pattern of inflows during these two selected months.

Compared to Current conditions, ELT Q5, and LLT Q5 climate scenarios show a dramatic change in inflows at Shasta Lake that are concentrated into late winter/early spring period as indicated by the February values. Similar to the annual average values, there is a large degree of uncertainty, as shown by the range of values for LLT Q2 and Q4 climate scenarios. Similarly, there would be an opposite set of changes in the late spring and summer, as indicated by the June values.

However, the change in inflows along the Sacramento River downstream of Keswick Dam would be much less in magnitude and relative degree when compared to Shasta Lake under the ELT Q5 and LLT Q5 climate scenarios compared to the Current conditions. The remainder of the long-term, wet year (upper quartile), and Dry year (lower quartile) monthly pattern averages are compiled in Figures 25A-1 through 25A-6 and Tables 25A-1 through 25A-6 of Section 25A.7.

Table 25A-D
Impacts of Climate Change on Long-Term Average Selected Monthly Inflows at Shasta Lake and Sacramento River Inflow Patterns

Climate Scenario:		Current	ELT Q5	LLT Q5	LLT Q2	LLT Q4
Location	Month	Monthly Inflow (TAF)	Change in Monthly	Inflow from Current	(TAF and	Percent Change)
Shasta Lake	Feb	803	+69 (9%)	+126 (16%)	-65 (-8%)	+317 (39%)
	Jun	326	-39 (-12%)	-67 (-21%)	-112 (-34%)	-7 (-2%)
Sacramento River, Keswick Dam to Hamilton City	Feb	557	+17 (3%)	+23 (4%)	-60 (-11%)	+106 (19%)
	Jun	113	-1 (-1%)	-5 (-4%)	-21 (-18%)	+14 (13%)
Sacramento River, Keswick Dam to Delevan Intake	Feb	855	+18 (2%)	+25 (3%)	-72 (-8%)	+121 (14%)
	Jun	128	-1 (-1%)	-4 (-3%)	-22 (-17%)	+16 (12%)

As shown in Tables 25A-C and 25A-D, there would be a significant increase in runoff in late winter/early spring and reduced runoff in late spring and summer due to climate change. This change is driven by increase in temperature and decrease in snowmelt runoff in basins with significant snowmelt under current climate conditions.

The change in magnitude and pattern of inflows associated with the 22 tributary watersheds of the Central Valley, in addition to the impacts of sea level rise, would drive many changes in the water resources system as modeled in CALSIM II.

To investigate the potential impact of sea level rise on increased salinity in the western and central Delta, a CALSIM II simulation was prepared with inflows based on the current climate scenario but with a revised ANN based on an assumed sea level rise of 45 cm (18 inches), as was assumed for all LLT scenarios. This simulation is denoted as climate and sea level scenario LLT Q0. The results for the X2 position and Delta outflow for the No Project/No Action Alternative for climate and sea level scenarios LLT Q0 and LLT Q5 are shown in Tables 25A-7 through 25A-8 and Figures 25A-7 through 25A-8 in Section 25A.7. These results show that sea level rise would overwhelmingly drive the increasing salinity shown in the LLT scenarios (and by inference the ELT scenario). Under the LLT Q0 scenario, the No Project/No Action Alternative long-term average results show an upstream shift in X2 position of as much as 1.2 to 3.1 kilometers (km) would occur during the February through June period of compliance for SWRCB D-1641 (SWRCB, 2000). The Dry year (upper quartile for X2 position) average results show an upstream shift in the X2 position of as much as 1.1 to 2.2 km would occur during the February through June period. The associated change in flows associated with this change in X2 position is shown in the Dry year (lower quartile) results for Delta outflow. As indicated by the Dry year (lower quartile) results, average Delta outflow requirements associated with compliance of D-1641 X2 requirements could increase on the order of 200 to 700 cfs and an overall increase in Delta outflow of 7 percent or more than 400 TAF per year during the Dry years (lower quartile) of the CALSIM II simulation period. This is not necessarily the case under the LLT Q2 and Q4 scenarios in which uncertain changes in precipitation could also significantly impact salinity in the western and central Delta differently from what is shown in the LLT Q0 and LLT Q5 scenarios.

Given the (1) impact of temperature and change in magnitude and pattern of inflows and (2) impact of sea level rise on western and central Delta salinity, along with (3) no changes in regulatory requirements for minimum instream flows and Delta salinity standards (stationary assumption discussed in Section 25A.4), the result of this interaction in CALSIM II would be decreased summer and Dry year (lower quartile) flows in the Sacramento and San Joaquin Rivers and increased summer and Dry year (lower quartile) outflow requirements for the Delta.

The changes in monthly and annual flows for the Sacramento River downstream of Keswick Dam, Sacramento River downstream of Hood, and San Joaquin River at Vernalis, in the No Project/No Action Alternative between the Current and ELT Q5 and all LLT climate and sea level scenarios, are shown in Tables 25A-9 through 25A-11 and Figures 25A-9 through 25A-11 in Section 25A.7.

The changes in monthly and annual outflows from the Delta and X2 position in the No Project/No Action Alternative between the Current and ELT Q5 and all LLT climate and sea level scenarios are shown in Tables 25A-12 through 25A-13 and Figures 25A-12 through 25A-13 in Section 25A.7.

River flows would be reduced in late spring and summer months between Current, ELT Q5, and LLT Q5 climate scenarios. The pattern of the reduction follows the pattern seen in the reduction of reservoir and tributary inflows to the river. On the Sacramento River, long-term average flows would decrease 3 percent throughout summer months up to 10 percent in late summer months of Dry years (lower quartile). On the San Joaquin River, long-term average flows would decrease in the range of 10 to 15 percent in summer months, primarily in wetter years (upper quartile) with reductions of 4 percent typically in summer months of Dry years (lower quartile).

River flows would vary dramatically under the LLT Q2 and Q4 climate scenarios. The LLT Q2 scenario results show an average reduction of flow of 13 to 14 percent on the Sacramento River and a reduction of 22 percent on the San Joaquin River inflow into the Delta, when compared to the Current scenario. The LLT Q4 scenario results show an average increase of flow of approximately 10 percent on the Sacramento River and an increase of 16 percent on the San Joaquin River inflow into the Delta.

Relative to the Current conditions scenario, long-term average Delta outflow during summer months would vary from minor change in the ELT Q5 scenario to an increase in the LLT Q5 scenario. However, month-to-month changes are highly variable. For example, April and May outflows would be reduced approximately 15 percent under the LLT Q5 scenario; however, October would be increased by 40 percent. This highly variable response is symptomatic of sea level rise and its impacts on salinity control throughout the western and central Delta and requirements to maintain compliance with D-1641 standards and manage changes in Delta export conditions.

Long-term average annual Delta outflow shows that a reduction would occur of 15 percent under LLT Q2 and an increase of 24 percent under LLT Q4 climate scenarios. However, throughout the range of all ELT and LLT scenarios, the change in the Dry year (lower quartile) average impacts varies from a reduction of 3 percent under the LLT Q2 to an increase of 18 percent under the LLT Q4 scenario with the LLT Q5 showing that an increase of 6 percent would occur. The changes in X2 position are an inverse response to the changes in Delta outflow. Even though the range of impact to the X2 position would vary according to Delta outflow conditions, the X2 position moves further eastward (more positive) under ALL climate and sea level scenarios, when compared to the Current scenario. The X2 position is almost always impacted adversely (more positive) in every statistic for every scenario (e.g., monthly, long-term average, and/or upper and lower quartile). The only exception is in the fall months of the LLT Q4 scenario.

The expected change in X2 position is both due to a shift in inflows earlier in the spring and subsequent increase in outflow due to larger unregulated flows, as well as SWP and CVP storage withdrawals to comply with X2 criteria, based on the SWRCB D-1641 (SWRCB, 2000), as well as the Action 4, Fall X2 action, of the USFWS Biological Opinion (USFWS, 2008).

The result would be a reduced amount of water available in storage to manage environmental, water quality, and water supply objectives, as well as a greater dependency on storage withdrawals to manage late spring and summer time Delta water quality requirements.

The changes in storage conditions for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake in the No Project/No Action Alternative between the Current and all ELT and LLT climate and sea level scenarios are shown in Tables 25A-14 through 25A-18 and Figures 25A-14 through 25A-18 in Section 25A.7.

The changes in monthly and annual exports from the Delta through Banks and Jones pumping plants in the No Project/No Action Alternative between the Current and all ELT and LLT climate and sea level scenarios are shown in Table 25A-19 and Figure 25A-19 in Section 25A.7.

Long-term average total September carryover in all SWP and CVP reservoirs would decrease by 8 percent in the ELT Q5 scenario and would decrease by 18 percent in the LLT Q5 scenario relative to the Current conditions scenario. The Dry year (lower quartile) average carryover in SWP and CVP reservoirs would decrease by 13 percent in the ELT Q5 scenario and would decrease by 26 percent in the LLT Q5 scenario. Under the LLT Q2 and Q4 climate scenarios, long-term average September carryover in SWP and CVP reservoirs would decrease by 34 percent in the LLT Q2 scenario and would decrease by 4 percent in the LLT Q4 scenario, when compared to the Current scenario. As shown in the detailed results, storage under LLT Q4 would be higher in most other months. The slight reduction in September under LLT Q4 may be an artifact of how the operations are tuned in CALSIM II to achieve carryover storage targets that are common under current conditions. The increased inflows are translated into increased releases from storage to capture and store at the Project, to provide additional flow to meet

Delta salinity requirements, to provide deliveries, and to meet the ecosystem enhancement actions, in addition to potentially increased spills under LLT Q4.

Under all future climate scenarios, there would be an increase in uncertainty as to how frequently reservoirs would be able to refill and remain full through the spring flood period. The expected substantial systemwide losses in flows in late spring and early summer indicated by projected changes in inflows to the reservoirs as well as flows in the rivers and Delta outflow would cause storage to be depleted more frequently and earlier in the summer season. Loss of flexibility in reservoir operations would limit the capability to manage storage and flow for all water uses, with a significant impact on the ability to manage temperature- and flow-based habitat for coldwater fisheries downstream of the reservoirs.

Long-term average Delta export at Banks and Jones pumping plants would decrease by 3 percent in the ELT Q5 scenario and would decrease by 9 percent in the LLT Q5 scenario relative to the Current conditions scenario. The dry year (lower quartile) average Delta export would decrease by 5 percent in the ELT Q5 scenario and would decrease by 15 percent in the LLT Q5 scenario. Under the LLT Q2 and Q4 climate scenarios, long-term average Delta exports would decrease by 21 percent in the LLT Q2 scenario and by 0 percent in the LLT Q4 scenario when compared to the Current scenario. Late spring and summer are when exports would be impacted the most.

Due to the impact of climate change and sea level rise, the decreasing performance and increasing uncertainty of storage and Delta export conditions would impact SWP and CVP water supply allocations and water deliveries in similar magnitude as the impact on Delta exports.

As mentioned in Section 25A.4, even under Current scenario conditions, there are times when dead pool conditions exist and Delta exports would not be able to sustain minimal health and safety Delta export pumping conditions. With the impacts on storage and Delta flows and exports shown above, there would be an increased frequency of dead pool conditions and Delta export pumping below health and safety pumping conditions under all ELT and LLT climate and sea level scenarios. These conditions would lead to more frequent water delivery interruptions, regulatory compliance issues for ecosystems, and water quality protections.

25A.5.3 Sites Reservoir Alternatives Compilation of Results

Selected model results for all alternatives are compiled in Section 25A.8. This compilation is helpful to understand the magnitude of potential changes in the Project alternatives due to climate change and sea level rise.

Using all 21 CALSIM II model simulations simulated using the Current, ELT Q5, LLT Q5, LLT Q2, and LLT Q4 climate and sea level scenarios, selected model results for all alternatives are compiled for 22 CALSIM II model output parameters.

For each parameter, CALSIM II results are presented for Existing Conditions, the No Project/No Action Alternative, and the No Project/No Action Alternative and Alternatives A, B, C, and D with each climate and sea level rise condition. The compilation includes tables and figures showing annual, seasonal, and selected monthly changes in the parameter, and between each Project alternative and the No Project/No Action Alternative, at climate and sea level scenarios.

The results are shown in tables as seasonal, annual, and selected monthly values; differences with the Current climate and sea level scenario; and differences with the No Project/No Action Alternative for

Current, ELT Q5, and LLT Q5 climate and sea level scenarios. The tables are shown for long-term and upper, above median, below median, and lower quartile range averages. The results are shown graphically as seasonal, annual, and selected monthly values ranked and charted against probability of exceedance. The figures show the whole range of probability.

The tables and figures for each parameter, as well as seasonal, annual, and selected monthly statistics, are grouped to present the Current, ELT Q5, and LLT Q5 climate and sea level scenario results first and the LLT Q2 and LLT Q4 climate and sea level scenario results second.

25A.5.4 Sites Reservoir Alternatives Findings

A few key findings are summarized below, based on the comparison of the CALSIM II results for the Project alternatives with the No Project/No Action Alternative evaluated across Current, ELT Q5, and all LLT climate and sea level scenarios:

- The ability to divert water into Project storage would be the same or increased slightly due to changes in the timing of snowmelt runoff and the continued opportunity to use the intakes under a wide range of climate scenarios.
- The Project alternatives could provide a similar array of potential benefits under a wide range of climate and sea level scenarios, including the primary objectives of (1) increasing survival of anadromous fish populations, (2) improving water supply reliability for agricultural, urban, and environmental uses, and (3) improving drinking and environmental water quality in the Delta.
- The Project alternatives could be operated to potentially mitigate some of the effects of climate change and sea level rise, specifically related to climate change impacts on storage operations and associated increase in vulnerability of the water resources system to operational interruption.

The sensitivity analysis did not include the full suite of models (Appendix 6B Water Resources System Modeling), including daily operations, temperature, fisheries, and economics modeling. However, the CALSIM II results indicate changes in flows and storage conditions between the Project alternatives and the No Project/No Action Alternative throughout the Current, ELT Q5, and all LLT scenarios, such that the following is expected (but has not been confirmed with detailed modeling):

- The environmental impacts of the Project alternatives relative to the No Project/No Action Alternative under climate change and sea level rise are likely to be similar or less than the impacts determined under the current climate and sea level scenario used in the detailed evaluation in the EIR/EIS.
- The relative value of ecosystem enhancement and other similar “non-economic” values of the Project alternatives, evaluated in the FR, are likely to increase relative to the No Project/No Action Alternative given that the performance of ecosystem and water quality-related storage and flow conditions in the No Project/No Action Alternative would decrease with climate change and sea level rise.
- The relative economic value of the Project alternatives, evaluated in the FR, is likely to increase relative to the No Project/No Action Alternative given that the performance of water supply reliability for agricultural, urban, and environmental uses of the No Project/No Action Alternative would decrease with climate change and sea level rise.

The indicators of changes in flows and storage conditions and how they relate to the findings of the EIR/EIS and FR are discussed in this section.

The annual and seasonal flows to fill Sites Reservoir (Funks Reservoir to Sites Reservoir flows) from the Sacramento River intakes for all Project alternatives, for ELT and LLT climate and sea level scenarios, are shown in Figures 25A-20-1 through 25A-21-8 exceedance probability charts.

Under ELT Q5 and LLT Q5 climate and sea level scenarios for all Project alternatives, long-term annual average flows to fill Sites Reservoir would increase relative to the Current conditions. Annual flows to fill Sites Reservoir would generally increase in LLT Q2 and LLT Q4 scenarios as well. Results for Alternatives A, C, and D show that larger relative increases and fewer potential reductions would occur than for Alternative B. The results for the upper, above median, below median, and lower quartile show changes that would be consistent with the long-term averages. The results for seasonal flows show changes would be consistent with the changes in annual averages, with the exception of the July through September season, which shows that a reduction in flows in the upper quartile would occur.

The increase of flows to fill Sites Reservoir for all Project alternatives under all climate and sea level scenarios demonstrates the expected resilience of the Project alternatives in capturing excess flows and storage of these flows for later use for the primary objectives of (1) increasing survival of anadromous fish populations, (2) improving water supply reliability for agricultural, urban, and environmental uses, and (3) improving drinking and environmental water quality in the Delta. This finding is consistent with and supported by the finding of increased runoff in late winter/early spring due to increased temperatures on the timing of snowmelt runoff in the ELT and LLT scenarios. It also appears that the opportunity to use the intakes to fill Sites Reservoir (sustain the number of days each year for which intakes divert flows) is not significantly impaired by the uncertainty in precipitation in the LLT Q2 and LLT Q4 scenarios. The use of the CALSIM II and USRDOM models to analyze daily flow variability is documented in Appendix 6B Water Resources System Modeling.

The end-of-May and end-of September storage in Sites Reservoir for all Project alternatives, for ELT and LLT climate and sea level scenarios, is shown in Figures 25A-22-1 through 25A-22-4.

For all Project alternatives, long-term average end-of-May and end-of-September storage in Sites Reservoir would decrease under ELT Q5 and under LLT Q5 climate and sea level scenarios relative to Current climate and sea level conditions. End-of-May and end-of-September storage in Sites Reservoir would be substantially lower in LLT Q2. LLT Q4 results would be similar to the Current scenario. Results for Alternative B would be relatively lower under ELT Q5, LLT Q5, and LLT Q2 scenarios when compared to the Current scenario results in contrast to Alternatives C and D (also alternatives with 1.81-MAF storage capacity), which perform relatively better. The results for the upper, above median, below median, and lower quartile show changes consistent with the long-term averages.

In Project alternatives, Sites Reservoir storage conditions would decrease consistent with the changes seen in existing SWP and CVP storage across ELT and LLT climate and sea level scenarios. This reduction in storage is observed in the No Project/No Action Alternative and all Project alternatives scenarios across ELT and LLT climate and sea level scenarios. The rate of decline in storage conditions would be slowed by the addition of Sites Reservoir to the water resources system. The increase of flows to fill Sites Reservoir for all Project alternatives under all climate and sea level scenarios, coupled with the decrease in Sites Reservoir storage conditions relative to the Current scenario, indicates that Sites

Reservoir would be filling and releasing higher rates of flow and potentially producing greater levels of benefits as climate change and sea level rise worsens.

The end-of-May and end-of-September storage in the total Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir, for all Project alternatives, for ELT and LLT climate and sea level scenarios, is shown in Tables 25A-20-1 and 25A-20-2 in Section 25A.8. Figures 25A-23-1 through 25A-23-4 show the same results in exceedance probability charts. The individual results for Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir are shown in Tables 25A-21-1 and 25A-21-2, Tables 25A-22-1 and 25A-22-2, Tables 25A-27-1 and 25A-27-2, Tables 25A-29-1 and 25A-29-2, and Tables 25A-20-1 and 25A-20-2, in Section 25A.8. Each set of tables has an associated set of exceedance probability charts that follow (Figures 25A-24, 25A-22, 25A-33, 25A-35, and 25A-23).

For all Project alternatives, long-term average end-of-May and end-of-September storage in Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir would decrease in the ELT Q5 and LLT Q5 scenarios relative to the Current climate and sea level scenario. End-of-May and end-of-September storage would be substantially lower in LLT Q2. LLT Q4 results would be similar to the Current scenario. The results for the upper, above median, below median, and lower quartile show changes that would be consistent with the long-term averages. These changes are similar to what would be seen for each other individual CVP and SWP reservoir in the water resources system.

These changes would be similar; however, not as large as the changes seen in the No Project/No Action Alternative. The distinct difference in these changes in total storage between the Project alternatives and the No Project/No Action Alternative is that the No Project/No Action Alternative results show an expected substantial loss in systemwide storage due to climate change and sea level rise. The Project alternatives show that improved storage conditions would occur over the No Project/No Action Alternative. As climate change and sea level effects increase, the improvement in storage over the No Project/No Action Alternative (without climate change and sea level rise) is lowered. The results of the ELT Q5 and LLT Q5 scenarios show that the Project alternatives could mitigate the loss in storage associated with the No Project/No Action Alternative ELT Q5 scenario and, depending on the alternative, much of the loss in storage associated with the No Project/No Action Alternative LLT Q5 scenario. The Project alternatives could not mitigate for the loss in storage in No Project/No Action Alternative LLT Q2 scenario; other adaptation measures would be needed in addition to increased storage capacity to manage the impact of climate change and sea level rise on system storage.

The performance of the Project alternatives to accomplish the primary objectives depends primarily on the ability of the alternative to store and manage additional flows not otherwise captured in the No Project/No Action Alternative.

For the primary objective of increasing survival of anadromous fish populations, the highest priority is to maintain improved storage conditions through the Dry years (lower quartile) and summer months (July through September season). The improvement in storage conditions during these periods would retain cooler water (coldwater pool improvement) and more water (releases) for maintaining temperature conditions in the river reaches downstream of these reservoirs. As indicated by the improvement in beginning, end-of-May, storage and the ending, end-of-September, storage, there would be a potential improvement in temperature conditions downstream of Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake due to the Project alternatives, when compared to the No Project/No Action Alternative, for all the same climate and sea level scenario. This was found to be consistent with the Current scenario evaluated in the FR and in the detailed evaluation of the EIR/EIS. Consistent with the intent of the Project alternatives operations, the most substantial relative improvement in storage would be at Shasta Lake.

Anadromous fish populations depend on both temperature and flow dependent habitat conditions. For completeness, the seasonal average flows downstream of the existing reservoirs, for Sacramento River downstream of Keswick Reservoir (downstream of Shasta Lake), Feather River downstream of Thermalito (downstream of Lake Oroville), and American River downstream of Watt Avenue (downstream of Folsom Lake) are shown in Tables 25A-23-1 and 25A-23-2, Tables 25A-28-1 and 25A-28-2, and Tables 25A-30-1 and 25A-30-2, respectively (in Section 25A.8). Each set of tables has an associated set of exceedance probability charts that follow (Figures 25A-26, 25A-34, and 25A-36).

The improvement in storage conditions during the Dry years (lower quartile) and summer months (July through September season) for cooler water (coldwater pool improvement) and more water, is translated into temperature- and flow-dependent habitat improvements through increases in releases during Dry years (lower quartile) and summer months (July through September season) from the reservoirs. For all Project alternatives, Dry year (lower quartile) and summer (July through September) flows, Shasta Lake, and Lake Oroville would be increased in ELT Q5 and all LLT scenarios as in the Current scenarios. The results for the below median and summer flows generally also show that these improvements would occur. The results of the storage and flow trends for Dry year (lower quartile) and summer (July through September) flows indicate that Project alternatives would continue to perform strongly for the primary objective of increasing survival of anadromous fish populations as climate change and sea level rise occurs.

The annual total exports at Banks and Jones pumping plants, for all Project alternatives, for ELT and LLT climate and sea level scenarios, are shown in Tables 25A-34-1 and 25A-34-2 in Section 25A.8. Figures 25A-40-1 through 25A-40-2 show the same results in exceedance probability charts. The exports at Banks Pumping Plant are shown in Tables 25A-35-1 and 25A-35-2 and Figures 25A-41-1 and 25A-41-2.

Under ELT Q5 and LLT Q5 climate and sea level scenarios for all Project alternatives, long-term average annual total exports at Banks and Jones pumping plants would increase from the corresponding No Project/No Action Alternative consistent with Current conditions. There would be variations in these changes across climate scenarios as the changing conditions for Delta exports would vary. This variation was described in the No Project/No Action Alternative. The Project alternatives operations would dynamically adapt to the changing regulation, allocations, and the opportunity to export flow through the pumping plants. The values vary more in the LLT Q2 and LLT Q4 results. Across all climate and sea level scenarios below median and Dry year (lower quartile) averages show expected strong exports throughout, due to the Project alternatives, with the absolute and relative magnitude of improvement increasing as the effect of climate change and sea level rise increases.

Under the No Project/No Action Alternative, LLT Q5 and LLT Q2 scenarios in particular, the impact of climate change and sea level rise would appear to reduce Delta exports to a degree that there is likely an increase in available conveyance capacity for exporting additional flows from the Project alternative or other supplies.

The expected relative increase in annual total exports under below median and Dry year (lower quartile) average conditions is a strong driver of the economic impact of the primary objective of improving water supply reliability for urban uses. The economic value of a given increment of water for urban use would increase as the “without Project supply condition” would deteriorate with climate change and sea level rise. The results of the sensitivity analysis indicate that the increment of water provided by the Project alternatives could increase even as overall system supply would decrease. The primary objective of water supply reliability also includes agricultural and environmental uses (such as wildlife refuge supplies). The economic value of each of these supplies would be increased by storing and exporting these supplies through the Delta and making them available to the south-of-the-Delta water resources system.

The results of the absolute and relative trends when compared to the No Project/No Action Alternative for below median and Dry year (lower quartile) pumping at Banks and Jones pumping plants indicate that Project alternatives would continue to perform strongly for the primary objective of increasing water supply reliability, and indicate increased economic value of the exports as climate change and sea level rise occurs.

The seasonal average X2 position and Old River at Rock Slough salinity conditions are shown in Tables 25A-36-1 and 25A-36-2 and Table 25A-37-1 and 25A-37-2in Section 25A.8. Figures 25A-42-1 through 25A-43-8 show the same results in exceedance probability charts.

Under ELT Q5 and all LLT climate and sea level scenarios for all Project alternatives, the X2 position and Old River at Rock Slough salinity conditions would be improved during the April through December seasons relative to No Project/No Action Alternative, consistent with Current conditions. An improvement is indicated by a reduction in the X2 position (distance from the Golden Gate Bridge in km) or a reduction in electrical conductivity (EC). The No Project/No Action Alternative results showed that the degree of impact to the X2 position would vary according to Delta outflow conditions, and the X2 position would move further eastward (more positive) under ALL climate and sea level scenarios, when compared to the Current scenario. This would also be the case for Old River at Rock Slough salinity (EC).

The improvement shown in the ELT and LLT scenarios between Project alternatives and the No Project/No Action Alternative at a specific climate and sea level condition is due to the operation of the Project for supplemental Delta outflows for improving water quality conditions for urban intakes and environmental benefit in the Delta. These releases would occur in the summer (July through September) and fall (October through December) seasons. The effectiveness of improving Delta water quality conditions with supplemental releases from the Project would decrease with sea level rise. Under ELT Q5 and LLT Q4 scenarios, the releases would be less effective than under the Current scenario; and under LLT Q5 and LLT Q2, the effectiveness of releases would further diminish. For this reason, the EESA Action 5, Delta outflow for Delta Smelt Habitat Improvement, was removed from the sensitivity analysis (EESA Action 5 is described in Chapter 3 Description of the Sites Reservoir Project Alternatives and Appendix 6A Modeling of Alternatives).

The results of the X2 position and Old River at Rock Slough salinity results indicate that in summer and fall seasons (July through December) there would be a potential benefit of operating the Project alternatives for the primary objective of improving drinking and environmental water quality in the Delta.

Additional results of the sensitivity analysis, not discussed in this section, are included in Section 25A.8. Results for the Project elements are available, including Tehama-Colusa Canal Intake at Red Bluff (Figures 25A-27-1 and 25A-27-2), GCID Canal Intake at Hamilton City (Tables 25A-24-1 and 25A-24-2 and Figures 25A-28-1 through 25A-28-8), and Delevan Intake and Pipeline diversion operation and discharge operation (Funks Reservoir to Delevan Pipeline) (Figures 25A-30-1 and 25A-30-2, and Figures 25A-31-1 and 25A-31-2, respectively). Additional model results of flows in the Sacramento River are also available, including Sacramento River downstream of Hamilton City, downstream of the proposed

Delevan Intake and Pipeline, and downstream of Hood, in the Yolo Bypass and Sacramento-San Joaquin River Delta outflow (Tables 25A-25-1 and 25A-25-2, Tables 25A-26-1 and 25A-26-2, Tables 25A-31-1 and 25A-31-2, Tables 25A-32-1 and 25A-32-2, and Tables 25A-33-1 and 25A-33-2, respectively). Each set of tables has an associated set of exceedance probability charts that follow (Figures 25A-29, 25A-32, 25A-37, 25A-38, and 25A-39).

Table 25A-A identifies the occurrence of dead pool conditions in major CVP and SWP reservoirs under the No Project/No Action Alternative under current climate and sea level conditions. The frequency of dead pool conditions would increase under all ELT and LLT climate and sea level scenarios. Exceedance probability charts can be used to observe the changes in dead pool conditions. In the CALSIM II model, dead pool conditions are assumed at 240 TAF for Trinity Lake, 550 TAF for Shasta Lake, and 90 TAF for Folsom Lake. These are extreme operational limits and are well below the range of reasonable reservoir operations. A more reasonable “low storage” condition for evaluating operational limits would be two to three times greater than these values.

Exceedance probability charts showing Trinity Lake, Shasta Lake, and Folsom Lake are shown in Figures 25A-24-1 through 25A-24-4, Figures 25A-25-1 through 25A-25-4, and Figures 25A-35-1 through 25A-35-4, respectively (in Section 25A.8).

Under all climate and sea level conditions including the Current, there would be improvements in operations of these reservoirs under Project alternatives when compared to the No Project/No Action Alternative under the same climate and sea level conditions. It is assumed that reductions in these extreme operations (operating at dead pool conditions) would improve operations in compliance with minimum flow criteria, Delta salinities meeting standards, diversions meeting allocated volumes and water rights priorities, and operating agreements being maintained.

25A.6 References

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25A.7 Compilation of Selected Model Input and No Project/No Action Alternative Results

Selected model inputs and results for the No Project/No Action Alternative are compiled in this section. This compilation is helpful to understand the magnitude of potential changes in the No Project/No Action Alternative due to climate change and sea level rise.

Selected CALSIM II model inputs are presented for various inflows at Shasta Lake, collections of tributaries along the Sacramento River between Keswick Dam and the proposed intakes for Sites Reservoir, and inflows at other existing CVP and SWP reservoirs. The tables and figures of the selected inputs are cataloged in Table 25A-D.

Selected CALSIM II model results are presented for the Delta X2 position and Delta outflow operations for CALSIM II simulation assuming inflows based on the Current climate scenario (Q0) but with a revised ANN based on an assumed sea level rise of 45 cm (18 inches), as was assumed for all LLT scenarios. The tables and figures of the selected inputs are cataloged in Table 25A-E.

For the No Project/No Action Alternative for all climate and sea level scenarios, selected CALSIM II model results are presented for various Sacramento River, San Joaquin River, and Delta locations, as well as existing CVP and SWP reservoirs storage and CVP and SWP Delta export operations. The tables and figures of the selected inputs are cataloged in Table 25A-F.

Refer to Section 25A.5 for more description of these tables and figures, the results, and limitations of the Project climate change and sea level rise sensitivity analysis.

Table 25A-D
Catalog of Selected Model Inputs Showing the Impact of ELT Q5, LLT Q5, LLT Q2 and LLT Q4 Climate Change and Sea Level Rise Scenarios on Pattern and Timing of Inflow Volumes

Location	Parameter		
	Type (units)	**Tables**	**Figures**
Shasta Lake Inflows	Flow Volume (TAF)	Table 25A-1	Figure 25A-1
Sacramento River Inflows, Keswick Dam to Hamilton City	Flow Volume (TAF)	Table 25A-2	Figure 25A-2
Sacramento River Inflows, Keswick Dam to Delevan Intake	Flow Volume (TAF)	Table 25A-3	Figure 25A-3
Trinity Lake Inflows	Flow Volume (TAF)	Table 25A-4	Figure 25A-4
Folsom Lake Inflows	Flow (CFS)	Table 25A-5	Figure 25A-5
Lake Oroville Inflows	Flow Volume (TAF)	Table 25A-6	Figure 25A-6

Table 25A-E
Catalog of Selected No Project/No Action Alternative Model Results Showing the Impact of LLT Q0 and LLT Q5 Climate Change and Sea Level Rise Scenarios on Pattern and Timing of X2 Position and Delta Outflow Operations

Location	Parameter		
	Type (units)	Tables	Figures
X2 (SQ-01)	Position (KM)	Table 25A-7	Figure 25A-7
Sacramento/San Joaquin River Delta (SW-33)	Outflow (CFS)	Table 25A-8	Figure 25A-8

Table 25A-F
Catalog of Selected No Project/No Action Alternative Model Results Showing the Impact of ELT Q5, LLT Q5, LLT Q2, and LLT Q4 Climate Change and Sea Level Rise Scenarios on Pattern and Timing of Flow and Storage Operations

Location	Parameter		
	Type (units)	Tables	Figures
Sacramento River below Keswick Reservoir (SW-10)	Flow (CFS)	Table 25A-9	Figure 25A-9
Sacramento River below Hood (SW-30)	Flow (CFS)	Table 25A-10	Figure 25A-10
San Joaquin River at Vernalis	Flow (CFS)	Table 25A-11	Figure 25A-11
Sacramento/San Joaquin River Delta (SW-33)	Outflow (CFS)	Table 25A-12	Figure 25A-12
X2 (SQ-01)	Position (KM)	Table 25A-13	Figure 25A-13
Trinity Lake (SW-01)	Storage (TAF)	Table 25A-14	Figure 25A-14
Shasta Lake (SW-07)	Storage (TAF)	Table 25A-15	Figure 25A-15
Lake Oroville (SW-18)	Storage (TAF)	Table 25A-16	Figure 25A-16
Folsom Lake (SW-24)	Storage (TAF)	Table 25A-17	Figure 25A-17
Total Trinity Lake (SW-01), Shasta Lake (SW 07), Lake Oroville (SW-18), Folsom Lake (SW-24)	Storage (TAF)	Table 25A-18	Figure 25A-18
Total Banks Pumping Plant (SWP and CVP) and Jones Pumping Plant (CVP) (SW-36)	Diversion (CFS and TAF/Yr)	Table 25A-19	Figure 25A-19

25A.8 Compilation of No Project/No Action Alternative and Alternatives A, B, C, and D Results

Selected model inputs and results for all alternatives are compiled in this section. This compilation is helpful to understand the magnitude of potential changes in the Project alternatives due to climate change and sea level rise.

For all alternatives for all climate and sea level scenarios, selected CALSIM II model results are presented for various Sacramento River, Feather River, and American River locations, proposed Sites Reservoir and intake operations, and Delta locations, as well as existing CVP and SWP reservoirs storage and CVP and SWP Delta export operations. The tables and figures of the selected inputs are cataloged in Table 25A-G.

Refer to Section 25A.5 for more description of these tables and figures, the results, and the limitations of the Project climate change and sea level rise sensitivity analysis.

CALSIM II results for each parameter are presented in one of three formats: (1) as selected monthly values, (2) as seasonal averaged values (averaged for October to December, January to March, April to July, and June to September), or (3) as annual total values (converted to volume units and summed October to September). Each format includes multiple sheets of both tables and figures.

Depending on the formats used for a parameter, the number of presentations will change. The tables and figures for each parameter, and seasonal, annual, and selected monthly statistic are grouped to present the Current, ELT Q5, and LLT Q5 climate and sea level scenario results first, and the LLT Q2 and LLT Q4 climate and sea level scenario results second.

Table 25A-G
Catalog of Selected No Project/No Action Alternative and Alternatives A, B, C, and D Model Results Showing the Impact of ELT Q5, LLT Q5, LLT Q2, and LLT Q4 Climate Change and Sea Level Rise Scenarios on Pattern and Timing of Flow and Storage Operations

Location	Parameter		
	Type (units)	Tables	Figures
Funks Reservoir to Sites Reservoir (OP-04)	Diversion (TAF)		Figure 25A-20
	Diversion (CFS)		Figure 25A-21
Sites Reservoir (OP-09)	Storage (TAF)		Figure 25A-22
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