Chapter 30

# Climate Change

## 30.1 Introduction

*Climate* is the average weather over many years, measured most often in terms of temperature, precipitation, and wind. For example, the climate of California's Central Valley is a Mediterranean climate, which is hot and dry during the summer and cool and damp in winter, with the majority of precipitation falling as rain in the winter months. Climate is unique to a particular location and changes on timescales of decades to centuries or millennia.

*Climate change* generally refers to "statistically significant variations of the mean state of the climate or of its variability, typically persisting for decades or longer" (Intergovernmental Panel on Climate Change 2001:87). Although the climate can change, and has changed, in the past in response to natural drivers, recent climate change has been more rapid than previous episodes of climate change and has been unequivocally linked to increasing concentrations of greenhouse gases (GHGs) in Earth's lower atmosphere and the rapid timescale on which these gases have accumulated (Intergovernmental Panel on Climate Change 2021[1]:SPM-5, TS-8). The major causes of this rapid loading of GHGs into the atmosphere include the burning of fossil fuels since the beginning of the Industrial Revolution, agricultural practices, increases in livestock grazing, and deforestation. More background information on GHG emissions is provided in Chapter 23, *Air Quality and Greenhouse Gases,* Section 23.1.3, *Global Climate Change*.

Higher concentrations of heat-trapping GHGs in the atmosphere result in increasing global surface temperatures, a phenomenon commonly referred to as *global warming* or *climate change*. Higher atmospheric GHG concentrations and global surface temperatures in turn result in changes to Earth's climate system, including rainfall patterns, extreme weather events, ocean temperature and acidity, the amount of spring snow cover in the Northern Hemisphere, atmospheric water content, and global sea level rise (Intergovernmental Panel on Climate Change 2021:SPM-6, SPM-19, 2-5–7). Some of the above changes will result in specific impacts at the state and local levels.

### 30.1.1 Purpose

The objective for this chapter is to evaluate how observed trends and projected future conditions show the need for the proposed project and how climate change could influence the ability of the project to fulfill its intended purpose. More information on the analysis of project-generated GHGs can be found in Chapter 23, *Air Quality and Greenhouse Gases*. To understand this, this chapter analyzes three fundamental questions relating to climate change:

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[1] To date, the Summary for Policymakers (SPM) is the approved version of IPCC 2021 and remains subject to final copyediting and layout. The Technical Summary (TS), Report chapters, Annexes, and Supplementary Materials are the Final Government Distribution versions and remain subject to revisions following SPM approval, corrigenda, copyediting, and layout. Although these documents still carry the note from the Final Government Distribution "Do Not Cite, Quote or Distribute," they may be freely published subject to the disclaimer above because the report has now been approved and accepted. This chapter of the Draft EIR uses information from the Sixth Assessment Report where appropriate—downscaled information is not yet available from this Assessment, and so this chapter does not include it in the modeling.

1. How is climate change projected to affect the study area?
2. How might the project's impacts on operations and resources in the study area be affected by climate change (i.e., are future changes in climate likely to exacerbate project impacts or operations)?
3. How might the project affect the resiliency of the study area or its resources to climate change?

This chapter is organized differently from the other resource chapters in this Draft Environmental Impact Report (Draft EIR) because analyzing how climate change is projected to affect the study area, how anticipated resource impacts from the project may be affected by climate change, and how project alternatives may improve the study area's resiliency and adaptability to climate change are fundamentally different analyses than those presented in other resource chapters. Whereas other chapters are organized to identify existing conditions as of issuance of the Notice of Preparation (NOP) in 2020, one of the functions of this chapter is to analyze and disclose the future conditions of the study area under climate change. The study area for this chapter includes areas upstream of the Delta region, the Delta region, and State Water Project (SWP)/Central Valley Project (CVP) export service areas. The project alternatives do not affect areas upstream of the Delta region; however, both the SWP and CVP water delivery systems rely on runoff and reservoir releases in areas upstream of the Delta. Both water delivery systems may be affected by changes in Delta salinity levels due to climate change, regardless of the project alternative.

Section 30.2.3, *Climate Change Trends and Associated Impacts on the Study Area*, helps to address Question 1 by noting recent trends, climate change projections to 2100, and expected climate impacts in the study area.

Question 2 is addressed in Section 30.4, *Potential Impacts of Alternatives*. Most resource chapters evaluate how the project would affect the specific resource in question compared to existing conditions at the time of the NOP (January 2020) to evaluate the effects of project alternatives without the confounding effects of future climate change. Resource analyses also compare the No Project Alternative in the future to existing resource conditions, including reasonably foreseeable changes in existing conditions and changes that would be predicted to occur in the foreseeable future (i.e., including climate change) if the project were not approved, as further described in Appendix 3C, *Defining Existing Conditions, No Project Alternative, and Cumulative Impact Conditions*. Resources that consider hydrologic modeling primarily focus on conditions in 2040; assumptions and further detail on the No Project Alternative 2040 scenario are found in Appendix 3C and Appendix 5A, *Modeling Technical Appendix*, Section B, *Hydrology and Systems Operations Modeling*. Appendix 3D, *2070 Analysis*, provides a qualitative discussion of longer-term operational impacts based on trends and conditions for water demand and supply in California. Appendix 30A, *CalSim 3 Results Sensitivity to 2040 Climate Change Projections*, summarizes results under additional 2040 climate scenarios to understand anticipated changes in variables relevant to project operations under a broader range of climate scenarios. The project alternatives are evaluated using a projection of future climate that includes changes in temperature, precipitation, and hydrology and sea level rise.

This chapter also addresses Question 3 in Section 30.5, *Resilience and Adaptation Benefits*. In this context, *resiliency* and *adaptability* mean the ability of the study area and its resources to remain stable or flexibly change as the effects of climate change increase.

The resiliency and adaptation discussion focuses on the major impacts of climate change in the study area and the clear and measurable ways that the project alternatives will ameliorate these impacts or add flexibility to the system so that the SWP can continue providing water supply benefits with sufficient water quality and supporting ecosystem conditions that maintain or enhance aquatic and terrestrial plant and animal species. No single project and, indeed, none of the project alternatives would be able to completely counteract all of the impacts of climate change; however, as discussed in Section 30.5, the project alternatives provide important added resilience and adaptability to many of the expected changes. Impacts for which the project alternatives provide a benefit that is minimal or not documentable are not discussed in this chapter.

Table 30-1 describes the differences between this chapter and the other resource chapters with respect to climate change discussion. The differences between these two comparisons allow readers to determine the incremental effects attributable to climate change as distinct from the impacts of the project alternatives.

**Table 30-1. Comparison of Climate Change Chapter to Other Resource Chapters**

| Topic | Chapter 30: *Climate Change* | Other Resource Chapters |
|---|---|---|
| What is covered | Focuses on effects of climate change; also compares a climate-changed future without the project alternatives to a climate-changed future with the project alternatives. Evaluates how the project will affect the resiliency of the study area or its resources to climate change.<br>References analyses of project operations were performed for the 2040 and 2100 timeframes and draw from Appendix 5A, *Modeling Technical Appendix*, Section B, *Hydrology and Systems Operations Modeling*.<br>References design analysis, performed at 2040 for construction and 2100 for facility design, including intakes and conveyance facilities. | Focus on comparisons of alternatives at the 2020 timeframe to Existing Conditions (i.e., the "environmental setting" as it exists at the time of issuance of the NOP). This comparison excludes any impacts resulting from climate change.<br>Includes a discussion of the No Project Alternative that describes expected future conditions resulting from a continuation of existing policies and programs by federal, state, and local agencies in the absence of the project alternatives that are likely to be in place by 2040, including related climate change impacts in respective analyses.<br>Select resources include appendices providing modeled quantitative comparisons for the No Project Alternative against the project alternatives at the 2040 and 2070 timeframe.<br>A qualitative discussion at the 2100 timeframe (for relevant resources). |
| Limitations | Uses peer-reviewed literature and best-available science to identify likely climate impacts in the study area and evaluate resiliency. | Do not specifically contemplate the extent to which project alternatives would contribute to the resiliency and adaptability of the study area to the effects of climate change. |

NOP = Notice of Preparation.

As noted in CEQA Guidelines Section 15064.4, the lead agency must determine: (1) whether GHGs may be generated by a proposed project and, if so, quantify or estimate the GHG emissions by type and source; and (2) whether the project's incremental contribution to climate change is cumulatively considerable. This is addressed in Chapter 23 with the discussion of Impact AQ-9: *Result in Impacts on Global Climate Change from Construction and O&M*, Mitigation Measure AQ-9: *Develop and Implement a GHG Reduction Plan to Reduce Construction and Net CVP Operational Pumping Emissions to Net Zero*, and ultimately results in no cumulative impacts of the project's GHG emissions on global climate change. See Appendix 23E, *Assessment Form for Consistency with GHG Emissions Reduction Plan,* for the California Department of Water Resources (DWR's) assessment form to document a DWR CEQA project's consistency with the DWR *Greenhouse Gas Emissions Reduction Plan*.

### 30.1.2 Organization

This chapter presents the following: (1) basic background on scientific efforts to evaluate the degree and impacts of future climate changes (a detailed background discussion on climate change is provided in Appendix 5A, *Modeling Technical Appendix*); (2) a discussion of observed climatological changes over the past several decades and expected future changes during the rest of this century globally, in California, and for the study area; (3) an evaluation of how the project's impacts on resources in the study area will be affected by climate change; and (4) an evaluation of the resiliency and adaptability of the study area to the major expected impacts of climate change.

### 30.1.3 Climate Change Background

Scientific measurements have shown that changes in the global climate system are already occurring. These changes include rising global average surface temperatures, rising ocean temperatures, changes in precipitation patterns, changes in ocean salinity, ocean acidification, glacier shrinking, decreased Arctic sea-ice extent, rising global sea levels, and increased intensity and frequency of extreme events such as heat waves and heavy precipitation events (Intergovernmental Panel on Climate Change 2021:1-50–1-51, 2-7; California Department of Water Resources et al. 2020:14–15).

Studies on climate change impacts conducted by the Intergovernmental Panel on Climate Change (IPCC), the U.S. Global Change Research Program (USGCRP), the Governor's Office of Planning and Research (OPR), the California Energy Commission (CEC), the California Natural Resources Agency (CNRA), agencies in the State of California (e.g., DWR), the DWR Interagency Ecological Program (IEP), and the U.S. Department of the Interior Bureau of Reclamation (Reclamation) are referenced throughout this chapter. Particularly relevant studies to the study area include the Delta Stewardship Council's report, *Delta Adapts: Creating a Climate Resilient Future* (Delta Stewardship Council 2021) and DWR's vulnerability assessment in the *Climate Action Plan Phase III: Climate Change Adaptation Plan* (California Department of Water Resources 2020a).

The IPCC was established by the United Nations Environment Programme and the World Meteorological Organization to provide the world with a clear scientific view of the current state of knowledge regarding climate change and its potential environmental and socioeconomic impacts (Intergovernmental Panel on Climate Change 2012:i). IPCC, an organization of more than 800 scientists from around the world, regularly publishes summary documents that analyze and consolidate all recent peer-reviewed scientific literature, providing a consensus of the state of the science. Thus, IPCC is viewed by governments, policymakers, and scientists as the leading international body on the science of climate change, and its summaries are considered the best-available science. IPCC documents address changes at the global and super-regional scales. The *Sixth Assessment Report of the Intergovernmental Panel on Climate Change: Climate Change 2021: The Physical Science Basis* (AR6 Report) (Intergovernmental Panel on Climate Change 2021) is the most recent synthesis report and the one cited here (along with various special reports).

The USGCRP was established by a U.S. Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act of 1990 (15 USC § 2921 *et seq*.). It consists of 13 U.S. federal agencies that "conduct or use research on global change and its impacts to society." USGCRP's congressional mandate is to develop and coordinate "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." As part of meeting this mandate, USGCRP develops National Climate Assessments that "analyze the impacts of global change in the United States," and each assessment undergoes extensive external peer review to serve as an "authoritative" and "policy neutral" resource (U.S. Global Change Research Program n.d.).

OPR, CEC, and CNRA coordinate development of statewide climate assessments, including *California's Fourth Climate Change Assessment* (Fourth Assessment), published in 2018. The Fourth Assessment presents climate science and impact and adaptation analyses specific to the state, regional, or local levels and includes information and recommendations to inform vulnerability assessments and adaptation strategy development for sectors such as water resources and management in California (California Governor's Office of Planning and Research et al. 2018a). All research contributing to the Fourth Assessment was peer-reviewed.

## 30.2 Affected Environment and Resources

The study area is characterized by hot, dry summers and cool, rainy winters. From 1981–2010, average monthly temperatures in Sacramento ranged from 41.0 degrees Fahrenheit (°F) (5 degrees Celsius [°C]) in December and January to 94.1°F (34.5°C) in July, with average monthly rainfall ranging from a low of 0.02 inches (0.05 centimeters) in July to a high of 3.90 inches (9.9 centimeters) in February (Western Regional Climate Center 2021). Average air temperatures in the mountainous regions of the watershed are typically 5°F to 10°F (3°C to 6°C) lower than the temperature on the valley floor.

Although the snow lines vary by storm event, portions of the Sacramento, San Joaquin, Mokelumne, and Cosumnes River watersheds are above the snow line; consequently, much of their respective runoff into the Delta is from snowmelt. Snow in higher elevations serves as an effective type of natural storage because typically it melts gradually during the spring and summer.

Annual precipitation in the Sacramento River watershed ranges from 80 to 90 inches (as liquid water) (203 to 229 centimeters) of primarily snowfall in the mountainous regions, to 41 inches (104 centimeters) of rain in Redding and 19 inches (48 centimeters) in Sacramento. Average annual precipitation for the entire watershed is approximately 36 inches (91 centimeters). Most precipitation occurs between November and April, with little or no precipitation falling between May and October (Stockholm Environment Institute 2003:6). Precipitation that falls as rain in the study area can run off into the rivers (and eventually into the Delta), infiltrate into the soils (recharging the groundwater system), or evapotranspire. Factors such as spring temperatures and the nature of precipitation (i.e., rain/snow elevations in storms) during the October to April period play an important role in runoff timing.

Sandy and peaty soils are found in the Delta region. These soils were developed by the formation of mineral soils near the channels during flood conditions and organic soils on marsh island interiors because plant residues accumulated faster than they could decompose. Prior to the mid-1800s, the Delta was a vast marsh and floodplain, under which peat soils developed to a thickness of up to

65 feet (20 meters) in the central Delta (Whipple et al. 2012:125). In addition to peat, the Delta soils are composed of mineral sediments from rivers (U.S. Geological Survey 2013:3). More information on this topic can be found in Chapter 11, *Soils*.

The study area historically has been affected by periodic extreme precipitation events. The majority of these historical events have likely been caused by atmospheric phenomena called *atmospheric rivers* (Dettinger 2011:518–519)—narrow corridors of water vapor transported in the lower atmosphere that traverse long swaths of Earth's surface (Ralph and Dettinger 2011:265). These storms can deliver large amounts of precipitation to California in a short period of time. In addition, these storms tend to be warm (originating in the tropics), which results in higher snowlines and larger portions of the watershed contributing to direct runoff. More detailed information on surface water and climate and meteorological conditions in the study area is provided in Chapter 5, *Surface Water*, and Chapter 23, *Air Quality and Greenhouse Gases*.

Because this chapter discusses how the project alternatives affect the resiliency and adaptability of the study area to the effects of climate change, this section also discusses expected changes to the affected environment. The following background sections provide brief descriptions of: (1) recent trends in key climate metrics, such as temperature, precipitation, and sea level; and (2) projections of how the climate will change between now and 2100. Although the project is designed with a 100-year lifespan, an end-of-century time horizon was chosen for discussion of climate change trends in this chapter because it represents the latest time horizon for a range of best-available sea level rise scenarios (California Ocean Protection Council 2017:8).

In the subsections that follow, this information is summarized at the global scale, at the state level, and for the study area. Projections of future climate change are based on: (1) the level of GHGs already in the atmosphere; (2) the current rate at which human activity releases GHGs to the atmosphere; and (3) the projected future rate of GHG emissions, which in turn relies on predictions of future population, global economic growth, future available energy sources, and regulations. Consequently, future projections of climate change typically are displayed as a range, with the lower end representing a lower expectation of the amount of change, and the higher end representing a higher expectation for the degree of change.

## 30.2.1 Global Climate Change Trends

### 30.2.1.1 Recent Trends in Climate

The IPCC has found observed changes to be unprecedented: "Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2,000 years" (Intergovernmental Panel on Climate Change 2021:SPM-9). Atmospheric and ocean warming, reduced snow and ice, and sea level rise have been observed (Intergovernmental Panel on Climate Change 2021:1-50–1-51). Global average surface temperatures from 2011 to 2020 are 1.96°F (1.09°C) higher than those from 1850 to 1900 (Intergovernmental Panel on Climate Change 2021:SPM-5). Furthermore, the period from 1983 to 2012 was very likely[2] the warmest 30-year period in the Northern Hemisphere over the last 800 years (Intergovernmental Panel on Climate Change 2021:2-34).

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[2] The IPCC used the term *very likely* to indicate the assessed likelihood of the outcome or result, based on an evaluation of underlying evidence and agreement. *Very likely* probability indicates 90%–100% likelihood of this outcome or result (Intergovernmental Panel on Climate Change 2021:SPM-4).

Global mean sea levels rose by approximately 7.87 inches (0.2 meters) from 1901 to 2018 and have been rising at a higher rate since the mid-nineteenth century compared to the average rate in the two millennia prior, increasing to an average rate of 0.15 inches (3.7 millimeters) per year during 2006 to 2018 (Intergovernmental Panel on Climate Change 2021:SPM-6). Melting glaciers and ice sheets have been the main contributors to twenty-first century global mean sea level rise, as well as thermal expansion of oceans (Intergovernmental Panel on Climate Change 2021:SPM-14, 7-128).

The AR6 Report identifies observed changes in the climate system, causes of climate change, impacts of climate change, and changes in extreme events. In addition to warming surface temperatures and rising sea levels, the AR6 Report identified the following observed changes in the climate system: ocean warming; changes in precipitation, with trends varying by region; changes in ocean surface salinity; ocean acidification; mass loss in the Greenland and Antarctic ice sheets; global glacier shrinking; decreased extent of spring snow cover in the Northern Hemisphere; increased permafrost temperatures in most regions; and changes in sea-ice extent (e.g., decreased annual mean Arctic sea-ice extent and regional differences in extent of change in Antarctica) (Intergovernmental Panel on Climate Change 2021:SPM-6, SPM-9–SPM-10).

The AR6 Report also describes impacts of changes in climate on natural and human systems, including altering hydrological systems and shifting geographic range, migration patterns, seasonal patterns, abundances, and interaction of species. Some impacts on human systems have also been attributed to climate change, including the negative impacts of climate change on crop yields and fisheries (due to ocean acidification), which have adverse effects on food security (Intergovernmental Panel on Climate Change 2021:1-69–1-70, 5-56).

Furthermore, the AR6 Report states that since 1950, changes in extreme weather and climate events have been observed, including increases in the frequency of warm temperature extremes, extreme high sea levels, and the number of heavy precipitation events (Intergovernmental Panel on Climate Change 2021:SPM-10–SPM-11, SPM-29). Additionally, globally, the number of warm days and nights has increased and heat waves have become more frequent, along with increased intense tropical cyclone activity (Intergovernmental Panel on Climate Change 2021:TS-48–TS-49).

The IPCC also found that measurements have shown a decline in the extent of mountain glaciers; increased atmospheric water vapor content; increased precipitation in most of North America, the southeastern portion of South America, northwestern Australia, and northern and central Eurasia; drying conditions in most of Africa, the Mediterranean, the Middle East, eastern Australia, central South America, and parts of East Asia and Canada; strengthening in mid-latitude westerly winds; more intense and frequent drought conditions in some regions; and decreased frost days and increased frequency and duration of extreme heat events (since the 1950s) (Intergovernmental Panel on Climate Change 2021:8-34, 12-31, 12-78, 12-96, 12-105, SPM-19).

### 30.2.1.2 Twenty-First Century Climate Change Projections

A variety of projected climate changes may occur during the twenty-first century. Climate models indicate that global average surface temperature will increase by approximately 1.2°F to 1.4°F (0.65°C to 0.75°C) for the period from 2021 to 2040, compared to the period from 1995 to 2014, with similar changes across the five shared socioeconomic pathway (SSP) scenarios used for climate model simulations. The SSP5-8.5 modeling trajectory represents a very high GHG concentration trajectory if no concerted policy efforts are undertaken to reduce GHGs; the SSP2-4.5 modeling scenario represents an intermediate GHG concentration trajectory. GHG concentration trajectories vary depending on socioeconomic assumptions and climate mitigation levels (Intergovernmental Panel on Climate Change 2021:SPM-15, SPM-17–SPM-18).

The SSP scenarios begin to affect the magnitude of projected changes in climate significantly by midcentury, with increasing divergence among scenarios in 2100 and beyond. The IPCC finds that compared to 1850–1900 levels, end-of-century (i.e., 2081–2100) conditions may be notably different, with global surface temperature likely to be higher by approximately 5.0°F (1.8°C) or 8.1°F (4.5°C), depending on the scenario studied (e.g., SSP2-4.5 or SSP5-8.5). Warming will vary by region, more rapid warming will continue to occur in the high-latitude Arctic region compared to the global mean, warming over land will be greater than warming over oceans, and there will be global average warming for all modeling scenarios. Hot temperature extremes are projected to become more frequent and cold extremes less frequent over most land areas on seasonal and daily timescales for all modeling scenarios. Heat waves are projected to increase in frequency and duration, although cold winter extremes will continue to occur on occasion (Intergovernmental Panel on Climate Change 2021:TS-17–TS-18, TS-30, TS-48–49).

Changes in precipitation, ocean temperatures and acidity, Arctic sea ice and near-surface permafrost extent, glacier volume, and sea levels are also likely to occur for all SSP modeling scenarios (Intergovernmental Panel on Climate Change 2021:SPM-28, TS-115). Changes in precipitation may vary by region, with many high-latitude regions, mid-latitude wet regions, and the equatorial Pacific likely to see increased mean precipitation and many subtropical regions likely to see decreased mean precipitation by end of century under all SSP modeling scenarios. Additionally, increased frequency and intensity of extreme precipitation events is likely, depending on regional conditions, such as monsoons and mid-latitude storms (Intergovernmental Panel on Climate Change 2021:SPM-25).

Ocean warming and global ocean acidification will continue over the century for all SSP scenarios. Surface ocean pH is projected to decrease for all SSP scenarios. Arctic sea ice is projected to decrease, as is extent of permafrost and mountain and polar glaciers across scenarios (Intergovernmental Panel on Climate Change 2021:SPM-28).

Global average sea levels are projected to continue to rise through the twenty-first century and at a faster rate compared to historical rates. Compared to 1995 to 2014, end-of-century global mean sea level rise is likely[3] to be 1.4 to 2.5 feet (0.44 to 0.76 meters) under the intermediate SSP2-4.5 modeling scenario and 2.07 to 3.3 feet (0.63 to 1.01 meters) under the SSP5-8.5 scenario, although there will be variation by region. By 2100, sea levels will very likely[4] rise in more than approximately 95% of the ocean area, and almost 70% of the global coastline is projected to see a change in sea level "within ±20% of the global mean increase" (Intergovernmental Panel on Climate Change 2021:SPM-28, SPM-33).

The IPCC projected additional changes to the global climate system, including reduced global snow cover; increased thaw depth in permafrost regions; decrease in sea ice with potential full

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[3] The Intergovernmental Panel on Climate Change used the term *likely* to indicate the assessed likelihood of the outcome or result, based on an evaluation of underlying evidence and agreement. *Likely* probability indicates 66-100% likelihood of this outcome or result (Intergovernmental Panel on Climate Change 2021:SPM-4).

[4] The Intergovernmental Panel on Climate Change used the term *very likely* to indicate the assessed likelihood of the outcome or result, based on an evaluation of underlying evidence and agreement. *Very likely* probability indicates 90%–100% likelihood of this outcome or result (Intergovernmental Panel on Climate Change 2021:SPM-4).

disappearance in summer months; increased frequency of heat waves, droughts, and heavy precipitation events; increased intensity of tropical cyclone events; and northward movement of extra-tropical storm tracks (Intergovernmental Panel on Climate Change 2021:TS-38, TS-43, TS-49, TS-98).

## 30.2.2 Climate Change Trends in California

This section reviews the current understanding of potential climate change in California as established by recent scientific and peer-reviewed publications, including the *California's Fourth Climate Change Assessment* and the *Fourth National Climate Assessment*. These assessments use projections from downscaled Coupled Model Intercomparison Project Phase 5 (CMIP5) Global Climate Models using Representative Concentration Pathway (RCP) GHG trajectories, rather than the SSPs described above. Downscaled projections for California using CMIP6 Global Climate Models and SSPs are in development and will be used in future state and federal climate assessments. California has experienced warming during the twentieth century, and annual maximum temperatures are projected to increase by 5.6°F (3.1°C) for RCP 4.5 and 8.8°F (4.9°C) for RCP 8.5 throughout the state by 2100 (California Governor's Office of Planning and Research et al. 2018a:23). Overall precipitation is projected to continue to be variable, and annual precipitation may increase broadly in the north and decrease in the southernmost regions of California (California Governor's Office of Planning and Research et al. 2018a:25). These wetter conditions in the northern regions are expected to be more notable under the RCP 8.5 GHG concentration trajectory compared to the RCP 4.5 trajectory, particularly in the central California coast, due to the increased heavy precipitation extremes (Scripps Institution of Oceanography 2018:22). Some basins overall—and some areas within basins—are projected to become wetter, some are projected to become drier, and some have approximately equal chances of becoming drier or wetter (California Governor's Office of Planning and Research et al. 2018a:25; Bureau of Reclamation 2021:335–349). Projected changes in precipitation are less consistent across climate models and characterized by greater uncertainty compared to projected changes in temperature. Although changes in annual precipitation are projected to be small in many regions throughout California, extreme heavy precipitation events and dry spells are projected to increase significantly throughout the state (California Governor's Office of Planning and Research et al. 2018a:22, 26).

Warming trends appear to have led to a shift in cool season precipitation toward more rain and less snow, which has caused increased rainfall-runoff volume during the cool season accompanied by less snowpack and spring snow water accumulation in some Western United States locations (Scripps Institution of Oceanography 2018:51, California Governor's Office of Planning and Research et al. 2018a:26). Hydrologic analyses-based future climate projections, using RCPs 4.5 and 8.5 and a yearly timeframe, suggest that warming and associated loss of snowpack will persist over much of the Western United States. However, there are some geographic contrasts. Snowpack losses are projected to be greatest where the baseline climate is closer to freezing thresholds (e.g., lower-lying valley areas and lower-altitude mountain ranges). It also appears that, in some high elevation regions, there is a chance that snowpack actually could increase during the twenty-first century because winter precipitation increases are projected (Bureau of Reclamation 2021:ES-iii). This increase in snowpack in some areas may occur during rain–snow storms due to an increase in mixed precipitation types and increased precipitation (California Energy Commission 2018a:40).

One of the technical reports in California's Fourth Climate Change Assessment is *Mean and Extreme Climate Change Impacts on the State Water Project* (California Department of Water Resources

2018a). This report used the CalSim 3.0 water resources planning model to assess risks of midcentury impacts of shifting hydrology, warming temperatures, and rising sea levels on the SWP. It also presents key findings on impacts to the SWP system by midcentury under both the RCP 8.5 and RCP 4.5 modeling scenarios.

The technical report *Climate Change Risk Faced by the California Central Valley Water Resource System* is also included in the Fourth Assessment and was prepared by DWR (2018b). This report assesses water supply vulnerability to midcentury climate impacts of changing temperatures and precipitation, using a stress-test strategy and Global Climate Model-based probability estimates, under RCPs 4.5 and 8.5. It uses the 1,100-year record of Sacramento and San Joaquin River flows, assessing extreme droughts and floods and variability. The report presents key findings on changing temperatures and precipitation levels that could affect system performance, finding likely declines in system performance of supply, storage, and Delta outflow with increasing temperatures (California Department of Water Resources 2018b:iii).

#### 30.2.2.1 Recent Trends in Climate

Over the last 100+ years, temperatures have been warming and sea levels have been rising. Long-term observations have not shown significant trends of California being wetter or drier overall, but rather recent trends have observed general increases in annual, winter, and spring precipitation variability that indicate an increasing frequency of precipitation extremes—heavy precipitation and drought (He and Gautam 2016:11, 17). Over the last 60+ years, snowpack has been declining, there have been some downward trends (mostly not significant) in marine layer clouds, and there have been no significant trends in frequency and intensity of Santa Ana winds (California Governor’s Office of Planning and Research et al. 2018a:22). Over the last 30+ years, acres burned by wildfire have been increasing, for which both biophysical factors (e.g., temperature, moisture, wind, vegetation) and rapid population growth near wildland areas are attributed as causes (California Governor’s Office of Planning and Research et al. 2018a:22).

California experiences significant precipitation variability across seasons, between annual, monthly, and daily precipitation totals, and in multi-year dry and wet cycles; notably, extreme precipitation events significantly affect annual variability. This climate is exemplified by recent, unusually wet years (e.g., 2005, 2011, 2017) and droughts (e.g., 2012–2016). Winter storms caused by atmospheric river events and capable of creating widespread, severe flooding—modeled by the USGS ARkStorm scenario (U.S. Geological Survey 2021a) and often referred to as *ARkStorms*—can create heavy precipitation when they encounter mountain ranges along the coast; they are a cause of historical floods and heavy precipitation events and can also contribute to snowpack when occurring in the colder months. Many of California’s water resources depend on snowpack from atmospheric rivers each year (California Governor’s Office of Planning and Research et al. 2018a:24–26).

#### 30.2.2.2 Twenty-First Century Climate Change Projections for California

In brief, projected trends of climate impacts anticipate future temperature warming, sea level rise, snowpack decline, and increasing intensity of heavy precipitation events, frequency of drought, and acres burned by wildfire. The direction of future change in annual precipitation, frequency and intensity of Santa Ana winds, and marine layer clouds is unknown (California Governor’s Office of Planning and Research et al. 2018a:22).

Trends and associated impacts will vary by region, and it will become increasingly critical for water managers to use climate science and projections to plan as historical hydrological information stops serving as a "trustworthy guide" (California Department of Water Resources et al. 2020:14–15).

As described in the 2020 California Water Resilience Portfolio (California Department of Water Resources et al. 2020:14–15), these trends may affect California water resources in various ways, including those listed below.

- Increased risk of intense storms and flooding and rising sea levels and storm surges, making coastal communities vulnerable to coastal flooding and seawater intrusion. Water resources in the San Francisco Bay Area and Sacramento–San Joaquin Delta may be adversely affected, for example, by increased salinity.
- Decreased snowpack in areas such as the Cascade and Sierra Nevada ranges may lead to increased "flashy winter runoff and flood risks" and lower spring and summer stream flow (California Department of Water Resources et al. 2020:14–15). Additionally, more intense drought particularly may affect areas dependent on surface water flows and may affect water resources (e.g., degrading water quality in estuaries). Updated water infrastructure and management—for example, to capture water in high-flow periods to mitigate impacts in dry periods—will be key to managing increased variability of water bursts and prolonged periods of dry conditions.
- Increased wildfire risk in fire-prone areas heightens the risk of catastrophic fire impacts to water supply and quality.
- Decreased water quality in estuaries during droughts.
- Increased saltwater intrusion in the San Francisco Bay Area and the Sacramento–San Joaquin Delta as sea level rises.

Compared to 1960–2005 observations, annual average maximum daily temperatures across California are projected to increase by between 4.4°F and 5.8°F (2.4°C and 3.2°C) by 2050 and between 5.6°F and 8.8°F (3.1°C and 4.9°C) by 2100, depending on the GHG concentration trajectory assumed (California Governor's Office of Planning and Research et al. 2018a:22–23). Warming will not be uniform across the state (California Department of Water Resources et al. 2020:14–15).

Broadly, California is expected to experience a longer dry season and increased numbers of dry days and dry years and more frequent heavy precipitation and flood events, although future total precipitation projections remain uncertain (California Governor's Office of Planning and Research et al. 2018a:19). The modeling for this study relies on an ensemble of climate projection scenarios to account for a range of climate change outcomes; however, it does not explicitly resolve or investigate precipitation extremes. Precipitation projections in California show regional variation, with models indicating Northern California may become wetter and Southern California may become drier, although, compared to annual precipitation variability, these trends are relatively small. Atmospheric rivers are projected to become stronger and carry more moisture in a warmer climate, which may lead to increased extreme precipitation. Additionally, the likelihood of a "prolonged 'mega-drought'" occurring in the twenty-first century in the Southwestern United States is increasing, as is the likelihood of a "mega-flood" occurring in California (California Governor's Office of Planning and Research et al. 2018a:24–27). Global changes, such as a decrease in Arctic sea ice, may affect future precipitation in California, as well; further research is needed to understand this potential link (California Governor's Office of Planning and Research et al. 2018a:24–27).

Snowpack in the Nevada and California mountains that serves as a natural reservoir and key source of surface and groundwater may decline substantially under future climate conditions, in part because warmer temperatures may lead to a smaller percentage of precipitation falling as snow and a greater percentage of precipitation falling as rain (California Governor's Office of Planning and Research et al. 2018a:26–28).

Warmer air temperatures may increase soil moisture loss and lead to drier soils, affecting both drought events and seasonal dryness; seasonal impacts will vary (e.g., earlier soil drying in the spring may lead to prolonged summer dryness).

Wildfire risks in California are already increasing due to changes in climate (e.g., warmer air temperatures) and other factors (e.g., changes in land use, such as development along the wildland–urban interface). Scientists are still working to determine how winds that often play a significant role in amplifying fire weather conditions in California—such as the Santa Ana, Sundowner, and Diablo winds—may respond to climate change. The complexity of wildfire drivers also leads to a range in results of future projections, from "modest changes" to "relatively large increases in wildfire regimes" compared to historical conditions; projections by the California Energy Commission (2018b:19, 21), which do not incorporate potential changes in wind regimes, project a significant increase in large fire events by end of century under the RCP 8.5 modeling scenario (California Governor's Office of Planning and Research et al. 2018a:28–30).

It is "virtually certain" that substantial sea level rise will occur by the end of the century, although the rate and degree of increase remain uncertain (e.g., at the San Francisco Bay, the 50th percentile change in projected sea level rise by 2100 under the RCP 8.5 modeling scenario is 2.5 feet, but it is 1.6 feet under the RCP 2.6 modeling scenario) (California Natural Resources Agency and Ocean Protection Council 2018:57). Erosion caused by flooding from coastal wave events and sea level rise may affect large areas and lead to substantial property damage. The U.S. Geological Survey's (USGS's) Coastal Storm Modeling System (CoSMoS) model simulations along the Southern California coastline estimated widespread beach erosion by end of century, assuming "limited human intervention" and sea level rise scenarios from 3 to 6.6 feet (0.9 to 2 meters) (California Governor's Office of Planning and Research et al. 2018a:31–33).

## 30.2.3 Climate Change Trends and Associated Impacts on the Study Area

### 30.2.3.1 Climate Change Trends in the Study Area

Looking comparatively at existing conditions (2020) and projected 2040 conditions, scenarios were chosen to assess impacts of the project alternatives, considering expected impacts of climate change and sea level rise and changes in land use, population, and water demand (Appendix 5A, *Modeling Technical Appendix*). Global model projections generated under RCPs 4.5 and 8.5 are used. These were selected because of their relevance to DWR's programs and planning and as representative of broader climate projections. Historical events and future climate projections with this basis support precipitation and temperature data used for the 2040 scenario. The most feasible models were chosen for historical data and projected outcomes based on changing factors, including temperature and precipitation changing hydrologic conditions, sea level rise, water temperature and quality, and salmonid populations.

As shown in Table 30-2, average daily maximum temperatures, temperature extremes, flood risks, and wildfire risks are all expected to increase in the study area by 2100 or earlier.

It is important to note that the character of precipitation within the Sacramento and San Joaquin River Basins is projected to change under warming conditions, resulting in more frequent rainfall events and less frequent snowfall events (He et al. 2019:11). Increased warming is projected to diminish the accumulation of snow during the cool season (i.e., late autumn through early spring) and the availability of snowmelt to sustain runoff during the warm season (i.e., late spring through early autumn). Warming may lead to more rainfall runoff during the cool season, rather than snowpack accumulation. Consequently, this change in runoff pattern leads to increases in December–March runoff and decreases in April–July runoff.

Recent modeling indicates that sea level at the San Francisco (Golden Gate) tide gage may increase by as much as 1.8 feet (0.55 meters; H++ scenario, which is an extreme modeling scenario resulting from loss of the West Antarctic ice sheet) by 2040 and 10.2 feet (3.11 meters; H++ scenario) by 2100 (California Natural Resources Agency and Ocean Protection Council 2018:18). It is expected that more land in the study area will be subject to inundation by 2100, in comparison to current conditions. Potential changes in inundation zones (i.e., tidal regime) may affect the salinity and suitable habitat for species in the Delta.

Table 30-2 reflects climate projections (for all variables except sea level rise) provided in regional reports developed as part of the Fourth Assessment by OPR, CEC, and CNRA: Sacramento Valley (2018b:18–20), San Francisco Bay Area (2018c:14, 17, 31, 61), San Joaquin Valley (2018d:7–8), Central Coast (2018e:7, 13–17, 25, 31, 39), Los Angeles (2018f:6, 10–14, 18, 54, 61), San Diego (2018g:10, 19, 21, 27–29, 39, 74), Sierra Nevada (2018h:5, 15, 18, 28, 46), and Inland Deserts (2018i:14, 18, 21, 23, 29). The Delta Stewardship Council's *Delta Adapts: Creating a Climate Resilient Future* (2021:3-13, 5-8) is used to supplement some information. Sea level rise projections referenced are those developed for the 2018 update to the *State of California Sea-Level Rise Guidance*; data is provided for representative tide gages in each region (California Natural Resources Agency and Ocean Protection Council 2018:18, 63, 72, 78). Regions for which sea level rise data is not provided are indicated with a "–" symbol.

1 **Table 30-2. Climate Change Projections for the Study Area [a]**

| Study Area Region | Average Daily Max. Temperature [b] | Temperature Extremes [c] | Precipitation | Sea Level Rise [d] | Flood Risk | Wildfire Risk | Other Impacts |
|---|---|---|---|---|---|---|---|
| Sacramento Valley Region | Likely [e] to increase by 10°F (5.6°C)*† | Average number of extreme heat days (above 104°F [40°C]) increases from 4 to 40 per year in midtown Sacramento*† | Dry and wet extremes increase | Sea level rise in the San Francisco Bay Area will increase flood potential and salinity of Sacramento–San Joaquin Delta waters | More flood potential in Delta | Heightened risk of catastrophic wildfire | Streamflow shifts from spring to winter, more runoff, and less groundwater recharge |
| San Francisco Bay Area Region | Likely to increase by 7.2°F (4.0°C)*† | Average number of extreme heat days (over 85°F [29.4°C]) to potentially increase by 90*† | Dry and wet extremes increase | San Francisco tide gage: 1.8 feet (0.5 meters) to 10.2 feet (3.1 meters) | More flood potential | Frequent and sometimes large wildfire | Winter storms more intense; a once-in-20-year storm will become a one-in-7-year or more frequent storm |
| San Joaquin Valley Region | Likely to increase by 10°F (5.6°C)*† | Average number of extreme heat days (above 101.6°F [38.7°C]) increases from 4 to 46 per year*† | Dry and wet extremes increase | – | More flood potential in Delta | Longer fire season, increase in wildfire frequency, expansion in fire-prone areas | Salinity intrudes deeper into Delta; stream flows shift from spring to winter; more runoff and less groundwater recharge |
| Central Coast Region | Likely to increase by 7.5°F (4.2°C)*† | Average number of extreme heat days (above 87.5°F–90.1°F [30.8°C–32.3°C], depending on the county) increases from 4.3 to 20–50 per year*†[f] | Dry and wet extremes increase | Port San Luis tide gage: 1.6 feet (0.5 meters) to 9.9 feet (3.0 meters) | More flood potential, particularly coastal flooding | Frequent and sometimes large wildfires continue, with heightened post-fire impacts | Sediment from wildfires intrudes flows |
| Los Angeles Region | Likely to increase by 8.4°F (4.7°C)*† | Average number of extreme heat days (over 90°F [32.2°C]) increases from less than 15 to up to 90 at Los Angeles International Airport*† | Dry and wet extremes increase | Los Angeles tide gage: 1.7 feet (0.5 meters) to 9.9 feet (3.1 meters) | More flood potential, particularly coastal flooding | Increase in wildfire frequency, expansion in fire-prone areas | More stormwater runoff and less groundwater recharge, possible changes in Santa Ana winds |

| Study Area Region | Average Daily Max. Temperature [b] | Temperature Extremes [c] | Precipitation | Sea Level Rise [d] | Flood Risk | Wildfire Risk | Other Impacts |
|---|---|---|---|---|---|---|---|
| San Diego Region | Likely to increase by 7°F–9°F (3.6°C–5°C) *† | Average hottest day per year increase by 10°F (5.5°C)*† | Dry and wet extremes increase | San Diego tide gage: 1.8 feet (0.5 meters) to 10.2 feet (3.1 meters) | More flood potential | Increase in wildfire frequency, expansion in fire-prone areas | Changes in Santa Ana winds, sediment from wildfires intrudes flows |
| Sierra Nevada Region | Average temperature likely to increase by 6°F–10°F (3.3-5.6°C)*† | – | Dry and wet extremes increase | – | More flood potential | Increase in wildfire frequency and size, expansion in fire-prone areas | Higher rain-to-snow ratio, earlier snowmelt, less snowpack |
| Inland Deserts Region | Likely to increase by 14°F (7.8°C)*† | Average number of extreme heat days (over 112°F [44.4°C]) goes from 10 to more than 80 per year*† | Dry and wet extremes increase | – | More flood potential, particularly flash floods | Increase in wildfire frequency | More runoff, diminished inflows into and increased salinity of Salton Sea |

Sources: California Governor's Office of Planning and Research et al. 2018b:18–20; 2018c:14, 17, 31, 61; 2018d:7–8; 2018e:7, 13–17, 25, 31, 39; 2018f:6, 10–14, 18, 54, 61; 2018g:10, 19, 21, 27–29, 39, 74; 2018h:5, 15, 18, 28, 46; 2018i:14, 18, 21, 23, 29; Delta Stewardship Council 2021:3-13, 5-8; California Natural Resources Agency and Ocean Protection Council 2018:18, 63, 72, 78.

°C = degrees Celsius; °F = degrees Fahrenheit.

[a] * Indicates "under RCP8.5"; † indicates "by 2100." Temperature data shown in the table are probabilistic projections developed for RCP scenario 8.5 assuming an end-of-century (i.e., 2100) timeline (see second and third columns from left). Sea level rise changes shown (see fifth column from left) are projections developed for the H++ scenario, which does not have an associated likelihood of occurrence.

[b] Information available in the Fourth Assessment region reports varies by region; average daily maximum temperature is provided for all regions except the Sierra Nevada region, which has the average projected change in temperature (i.e., not average daily maximum).

[c] Information available in the Fourth Assessment region reports varies by region; average number of extreme heat days is provided for all regions except San Diego, which has average hottest day instead.

[d] Sea level rise projections referenced are those developed for the *State of California Sea-Level Rise Guidance: 2018 Update* (California Natural Resources Agency and Ocean Protection Council 2018). Projections provided are for the H++ scenario, a single scenario for extreme sea level rise, not a probabilistic projection; it does not have an associated likelihood of occurrence but is recommended for consideration in significant, long-term decisions (California Natural Resources Agency and Ocean Protection Council 2018:12). For example, sea level rise at the San Diego tide gage for the H++ scenario is 1.8 feet in 2040 and 10.2 feet in 2100, shown as 1.8 feet (0.5 meters) to 10.2 feet (3.1 meters) in the table above.

[e] The IPCC used this term to indicate the assessed likelihood of the outcome or result, based on an evaluation of underlying evidence and agreement. "Likely" probability indicates 66%–100% likelihood of this outcome or result (Intergovernmental Panel on Climate Change 2021:SPM-4).

[f] This range covers the average number of days with maximum temperatures above the threshold for five counties (i.e., Santa Cruz, San Benito, Monterey, San Luis Obispo, and Santa Barbara); for values at each location, see *California's Fourth Climate Change Assessment: Central Coast Region Report* (California Governor's Office of Planning and Research et al. 2018e:15).

### 30.2.3.2 Climate Change Impacts in the Study Area

Water temperatures, precipitation, and runoff, sea level rise, flooding, and drought climate change impacts are explored in more detail in the subsections that follow because they are common climate impacts within the study area among the resource topics covered in this Draft EIR.

#### Water Temperatures

Increased water temperatures affect aquatic organisms and habitats biologically, physically, and chemically. These impacts may be seen in changing maximum dissolved oxygen saturation levels (i.e., the highest amount of oxygen water can dissolve) and primary productivity, nutrient and chemical cycling, and organism metabolism, growth, and reproductive and mortality rates (IEP MAST 2015:32). Reduced dissolved oxygen levels may have adverse effects on fish spawning in the form of reduced egg survival and may reduce the habitat zone (i.e., reduce abundance) of fish that are sensitive to higher temperatures, such as delta smelt (*Hypomesus transpacificus*). Salmonid egg survival and population productivity also may be affected by higher temperature levels, which can limit sufficient oxygen levels, increase disease prevalence, and interfere with synchrony of natural systems like migration (National Oceanic and Atmospheric Administration 2018:4, 25, 31, 37).

Higher water temperatures can affect fish habitat, and there are some existing management strategies to maintain the desired water temperature; however, projected critically dry years resulting from climate change would make it more difficult to meet water temperature requirements for suitable aquatic habitat for sensitive species. Water temperatures in the lower American River are influenced primarily by the timing, magnitude, and temperature of water releases from Folsom and Nimbus Dams and are currently managed according to the Water Temperature Objectives established in the 2006 Flow Management Standard (Bureau of Reclamation et al. 2006:2–7). Reclamation manages flows to meet a 65°F (18.3°C) water temperature objective in the lower American River for steelhead incubation and rearing during the late spring and summer; however, critically dry years and low reservoir storages could make flow and temperature management more difficult under future climate conditions.

#### Precipitation and Runoff

The geographic variation and unpredictability in precipitation that California receives make it challenging to manage the available runoff that can be diverted or captured in storage to meet urban and agricultural water needs. In California, winter precipitation and spring snowmelt are captured in surface water reservoirs to provide flood protection and water supply. In general, peak runoff times are projected to be earlier for watersheds in the study area according to climate projections. The peak is projected to shift 1 month earlier from March to February by the late twenty-first century for the Sacramento Four Rivers (i.e., the Sacramento River and its tributaries [the Feather, Yuba, and American Rivers]) under both 4.5 and 8.5 RCP modeling scenarios. Sacramento Valley watersheds are expected to peak earlier (except for Sacramento River above Bend Bridge), by midcentury (He et al. 2019:9). The San Joaquin Four Rivers (i.e., the San Joaquin River and its tributaries [the Stanislaus, Tuolumne, and Merced Rivers]) and San Joaquin Valley watersheds are projected to remain unchanged in May in both future periods under both 4.5 and 8.5 RCP modeling scenarios; however, the Stanislaus River is projected to have an earlier peak during late century under the RCP 8.5 modeling scenario (He et al. 2019:11).

Snowmelt is an important part of water systems in the study area. Due to elevation differences, Sacramento Valley watersheds generally have higher temperatures and are less affected by snow compared to San Joaquin Valley watersheds. Specifically, more runoff is from snowmelt for San Joaquin Valley watersheds (He et al. 2019:13). As mentioned in Chapter 6, *Water Supply*, snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June. With inadequate runoff and pattern changes of snowmelt runoff resulting from climate change, CalSim 3 model results show (although infrequently) simulated occurrences of extremely low storage conditions at SWP and CVP reservoirs during critical drought periods when storage is at *dead pool* levels (i.e., when the water level is so low that it cannot drain by gravity through the dam's outlets). Instances may also occur in the simulation results in which flow conditions fall short of minimum flow criteria, salinity conditions may exceed salinity standards, diversion conditions fall short of allocated diversion amounts, and operating agreements are not met (as described in Chapter 6). High temperatures and lower precipitation levels would result in a rapid drop of carryover storage and performance levels for Folsom, Oroville, and Trinity Reservoirs; however, Shasta Reservoir could be slightly more resilient due to its greater inflow of rain, rather than snowmelt (California Department of Water Resources 2018b:21–22). As noted in Appendix 5A, *Modeling Technical Appendix*, modeling results are limited and include an inherent degree of uncertainty, likely within 5%. During real-life operations, operators would use real-time adjustments in operation to satisfy regulatory, legal, and contractual requirements given the current conditions and hydrologic constraints.

## Sea Level Rise

The potential effects of anticipated sea level rise on the study area were evaluated based on detailed modeling simulations as described in Appendix 5A, *Modeling Technical Appendix*. When considering potential sea level rise impacts, special consideration must be given to the following three interrelated elements.

- **Inundation.** Changes in sea levels and Delta inflows have the potential to cause more temporary or permanent inundation (e.g., permanent inundation due to higher sea levels, temporary inundation due to higher inflows associated with higher sea levels and increased precipitation variability) (Delta Stewardship Council 2021:5-52–5-55).
- **Salinity Gradient.** The location of the gradient between saline, brackish, and fresh water in the San Francisco Bay and Delta will be affected by sea level rise. As sea levels rise, the salinity gradient will shift farther upriver. The position of the daily average salinity gradient in the San Francisco Estuary is called "X2," which is the distance in kilometers upstream of the Golden Gate Bridge of the 2 parts per thousand (ppt) isohaline based on the 1995 Bay–Delta Water Quality Control Plan (Bay–Delta WQCP) (State Water Resources Control Board 1995). The X2 position is highly variable due to daily tidal movement. Outflow objectives identified in the Bay–Delta WQCP manage the X2 position to control salinity intrusion into the Delta. The daily average X2 position provides an index of the upstream extent of saltwater intrusion as a consequence of sea level rise. Under State Water Resources Control Board (State Water Board) Water Right Decision 1641 (D-1641), SWP and CVP operators are responsible for maintaining the X2 location, as specified in the 1995 Water Quality Control Plan (State Water Resources Control Board 1995).
- **Tidal Variations.** Changes in sea level will influence natural tidal variations along the California coast and within the San Francisco Bay and Delta. Edge species that rely on existing variations between wet and dry conditions may become permanently inundated or otherwise experience inhospitable environmental changes. Sea level rise and heightened coastal storms have a

combined effect on storm surges, particularly for coastal regions (California Governor's Office of Planning and Research et al. 2018a:54).

## Inland Flooding

Historical patterns of precipitation have been used by the U.S. Army Corps of Engineers (USACE) and DWR to develop reservoir storage criteria to reduce flood potential in watersheds. Assumptions for snowfall and rainfall patterns have been made for the project to reflect climate change that is anticipated to increase surface water runoff from rainfall in the winter and early spring and decrease runoff from snowmelt in the late spring and early summer, as described in Chapter 5, *Surface Water*, and Chapter 6, *Water Supply.*

Flooding occurring from increased precipitation, sea level rise, and more intense storm events threatens California's critical infrastructure and populations. The increasing proportion of precipitation falling as rain, rather than snow, throughout California regions will exacerbate winter floods (California Department of Water Resources 2018b:3). Major sea ports on the West Coast are already flooding because of sea level rise and storms, and this trend will continue. For example, an area of 0.89 square miles (2.28 square kilometers) within the Port of San Francisco is expected to be flooded in the two decades before the end of the century (California Governor's Office of Planning and Research et al. 2018a:54). The San Francisco Bay Area is already experiencing flooding, in part due to atmospheric rivers, which are expected to increase with rising temperatures (California Governor's Office of Planning and Research et al. 2018c:87). Sea level rise will increase the potential for flooding in the Delta, particularly during high-tide events (California Governor's Office of Planning and Research et al. 2018b:33). North of Delta reservoirs will not have the capacity to hold runoff from early snow melting and increased precipitation and instead will be released as flood water and become Delta outflow (California Department of Water Resources 2018a:40–41). Throughout the Sacramento Valley region, growing storm intensity will create conditions that increase the likelihood of and shorten the timeline before inland mega-floods—such as one like the 1862 "Great Flood" (California Governor's Office of Planning and Research et al. 2018b:19, 34). The San Joaquin Valley region also is projected to experience a higher frequency of mega-flooding (California Governor's Office of Planning and Research et al. 2018d:6).

## Drought

The study area experiences periodic droughts. The Sacramento and San Joaquin 8 Rivers Index, the Sacramento 4 Rivers Index, and the San Joaquin 4 Rivers Index were included in a study evaluating drought using streamflow-based indices, looking for "deficits" (i.e., any negative difference between the annual flow and the long-term mean annual flow) from 1906 to 2012, which included six significant deficit spells: 1928 (an 8-year deficit), 1944 (a 7-year deficit), 1976 (a 2-year deficit), 1987 (a 6-year deficit), 2007 (a 4-year deficit), and 2012 (a 4-year deficit) (Bureau of Reclamation 2014:25, 28). The majority of these six drought periods had runoff levels that were classified as "dry" or "critical" under the Sacramento and San Joaquin Valley Water Year Indices, which had important agricultural consequences given the level of agricultural production in the Central Valley (California Department of Water Resources 2018a:12; U.S. Geological Survey 2021b). On April 21, 2021, Governor Newsom announced a state of emergency due to acute water supply shortages in northern and central areas of California; as of July 2021, the state of emergency includes 50 counties (California Governor's Office 2021). The duration of the dry spell is unknown, but it is highly likely to persist until the next rainy season in October (National Weather Service 2021). By 2050, extreme

Delta drought conditions are projected to occur five to seven times more frequently (Delta Stewardship Council 2021:5-62). During midcentury droughts, Delta exports are projected to reduce to half of the quantity compared to historical droughts exports (California Department of Water Resources 2018a:41). Over the next several decades, dry years will become drier (California Governor's Office of Planning and Research et al. 2018a:19). Meanwhile, in the southwest regions, the likelihood of a long-lasting "mega-drought" is becoming greater (California Governor's Office of Planning and Research et al. 2018a:24).

### 30.2.4 Application of California Climate Projections to Alternatives Analysis

Over the last 14 years, the Delta Conveyance Project and its predecessor projects that have proposed new north Delta intakes were extensively studied using a range of projected climate change futures under CMIP3 and CMIP5, including extreme scenarios. In addition, DWR and the Delta Stewardship Council conducted comprehensive climate change studies to understand the potential impacts on the overall SWP and CVP system; these studies considered increased interannual variability and potential increased drought frequency. Based on these extensive analyses, climate change is expected to significantly affect the overall SWP and CVP operations, upstream tributaries, and the Delta. The degree of effects on the SWP and CVP would vary, based on the assumed climate change projection for any future time horizon. However, irrespective of the effects on the overall SWP and CVP operations, key climate change effects that need to be addressed for proposed new intakes in the north Delta include shifts in timing and quantity of flows, increasingly variable hydrology, increased water levels, and potentially greater salinity intrusion. This CEQA analysis appropriately considered these climate change effects and disclosed how the proposed intakes would perform under the projected future changes.

Future temperature, precipitation, and sea level rise conditions were simulated for the project alternatives using CalSim 3 for use in the project's integrated operational analysis. These simulations were used to understand the impact of climate change on a range of project operations, including for water supply (e.g., storage, deliveries, project operations) and water quality (e.g., salinity changes). As noted in Appendix 5A, *Modeling Technical Appendix,* Section F, *Modeling Technical Appendix – Sea Level Rise and Delta Water Quality Modeling*, the simulations were used to understand salinity changes and to analyze the response of water quality in seven sea level rise scenarios ranging in severity of sea level rise assumptions, including a base condition with no sea level rise, compared to recent historical conditions.

For this analysis, the CalSim 3 model was run with inputs based on year 2040 (climate period 2026–2055) anticipated conditions, as described in Appendix 5A. Ten CMIP5 global climate models and two GHG concentration scenarios (RCP 4.5 and RCP 8.5) were used to develop 20 climate model projections. These projections were then downscaled using the Localized Constructed Analogs method to develop the 2040 (2026–2055) central tendency climate change scenario, based on temperature and precipitation projections from the 20-model ensemble. Generally consistent with the Bay Delta Conservation Plan/California WaterFix Analysis, Water Storage Investment Program Application, Sustainable Groundwater Management Act, Reinitiation of Consultation on the Long-Term Operations of SWP and CVP (ROC on LTO), and the SWP Incidental Take Permit (ITP), a quantile mapping approach was used to adjust historical daily temperature and precipitation time series based on the climate projections.

Under the climate change scenario for the 2040 Climate Change Technical Advisory Group (CCTAG) future conditions, compared to the reference period (1981–2010), average temperature is projected to increase by at least 1.6°C (2.88°F) in all major watersheds in the Sacramento and San Joaquin River Basins. The highest temperature increases in the Sacramento River Basin are projected to occur in the Sacramento River (1.8°C, or 3.24°F) and Feather River (1.9°C, or 3.42°F) watersheds. All major San Joaquin River Basin watersheds are expected to increase by 1.8°C (3.24°F).

Overall, all major watersheds are projected to be wetter, with average precipitation increases from 2.7% to 4.8%. Sacramento River Basin is projected to experience a higher increase in long-term average precipitation than the San Joaquin River Basin.

Watershed total runoff is projected to increase in all major basins except for the San Joaquin River Basin, where runoff is projected to decrease by 1%. Generally, in reviewing basins from north to south, relative change to runoff is projected to decrease, as evapotranspiration losses overcome precipitation increases. As compared to historical runoff, increased precipitation under 2040 CCTAG is projected to lead to a higher peak in SAC-4 peak runoff. The 2040 CCTAG SJR-4 peak runoff volume and timing are projected to remain similar to historical runoff. In both basins, runoff is projected to increase in winter and decrease in spring or summer. Increased winter temperatures are projected to lead to a higher portion of precipitation that directly results in runoff, as opposed to snowpack. Similarly, with decreased snowpack, runoff during the summer, when the majority of runoff is snowmelt, is projected to decrease.

The project's primary operational analysis also used the extreme risk aversion scenario (H++) at the San Francisco tide gage for 2040 (1.8 feet) at the point when the project would become operational (Appendix 5A, Section B, *Hydrology and Systems Operations Modeling*). Through the project's facility design analysis, intakes and conveyance facilities are being designed to maintain functionality under the H++ scenario at 2100 or 10.2 feet; construction design was assessed under the H++ scenario at 2040 or 1.8 feet (0.55 meters; California Department of Water Resources 2020b:2). Potential effects of projected sea level rise on water quality were assessed using the Bay-Delta Semi-implicit Cross-scale Hydroscience Integrated System Model. An upper boundary for sea level projections analysis is based on anticipated conditions in 2100; the range of sea level rise projections, which are applied in the design of the intake locations, for year 2100 are 6.9 to 10.2 feet (2.10 to 3.11 meters), corresponding to Medium High (0.5% probability) and H++ risk aversion scenarios, respectively. The H++ scenario represents an extreme risk aversion scenario that assumes rapid ice mass loss from the West Antarctic ice sheet and accelerated global sea level rise (California Ocean Protection Council 2017:24). In its *State of California Sea-Level Rise Guidance 2018 Update,* the California Ocean Protection Council recommends the H++ scenario for use on projects that could affect critical infrastructure or critical natural systems (California Natural Resources Agency and Ocean Protection Council 2018:24). Although no current guidance exists for the use of specific climate scenarios under CEQA, per California Ocean Protection Council guidance, the H++ scenario is relevant to high-stakes, long-term decisions and for projects with a lifespan beyond 2050 that have a low risk tolerance. This extreme scenario was included given the potential for nonlinear acceleration of sea level rise driven by positive feedbacks of ice-sheet dynamics during the second half of the century. The probability of the H++ scenario occurring is unknown. See Appendix 5A for further detail.

Two additional climate scenarios were generated for the 2026–2055 climate period, which include a 2040 Central Tendency (CT) climate scenario with 0.5 foot of sea level rise and a 2040 Median climate scenario with 1.8 feet of sea level rise. These additional scenarios help to depict the possible hydrological outputs under a broader range of climate effects. The 2040 CT climate scenario depends on CCTAG projection models most appropriate for California water resources evaluation and planning. The 2040 Median climate scenario was generated from the 10 general circulation model–RCP models that are closest to the median of the 64 climate projections in terms of the annual temperature, annual streamflow and variability in streamflow. In the 2040 Median climate scenario, decreases in summer streamflow are more prominent. More information on these scenarios and the differences between them is provided in Appendix 30A, *CalSim 3 Results Sensitivity to 2040 Climate Change Projections.*

# 30.3 Applicable Laws, Regulations, and Programs

The applicable laws, regulations, and programs considered in the evaluation of climate change are indicated in this section or the impact analysis, as appropriate. Applicable laws, regulations and programs associated with state and federal agencies that have a review or potential approval responsibility have also been considered in the development CEQA impact thresholds or are otherwise considered in the assessment of environmental impacts. A listing of some of the agencies and their respective potential review and approval responsibilities, in addition to those under CEQA, is provided in Chapter 1, *Introduction*, Table 1-1. A listing of some of the federal agencies and their respective potential review, approval, and other responsibilities, in addition to those under NEPA, is provided in Chapter 1, Table 1-2.

The Council on Environmental Quality (2016) has prepared draft guidance on how federal agencies should consider the effects of climate change in their evaluation proposals: *Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews*. Consistent with the draft guidance, this chapter evaluates the relationship of climate change effects to the proposed project and alternatives. The project is therefore compatible with the Council on Environmental Quality guidance on climate change. Furthermore, DWR requires that all projects that go through the CEQA/EIR process document and complete additional information and analysis of climate change in all EIRs in which DWR acts as the lead agency. This chapter evaluates the impacts of climate change on the project and adaptation benefits provided by the project in accordance with the guidance provided in DWR's *Climate Action Plan Phase 2: Climate Change Analysis Guidance* (2018c).

# 30.4 Potential Impacts of Alternatives

## 30.4.1 Impacts of the No Project Alternative with Climate Change

Based on climate trends on the study area, as described in Section 30.2.3.1, *Climate Change Trends in the Study Area*, reduced runoff volume and changes in evapotranspiration in the warm season (April–July) due to climate change may decrease the amount of water in channels and associated infrastructure. However, increases in rain-on-snow events, earlier snowmelt, and increased frequency and severity of flood events that are expected during the cool season (December–March) may exacerbate challenges related to channel and reservoir capacity limits or risks associated with runoff or flood flows. Higher water levels under sea level rise and changes in erosion and sedimentation may compound these effects.

The Delta currently faces significant risks from levee failure, partially due to factors that contribute to flooding within the Delta, as described in Chapter 10, *Geology and Seismicity*. Additionally, the Delta faces long-term progressive risks of levee failures and diminishing operational efficiency and supply reliability from sea level rise and changes in Delta inflow hydrology driven by climate change (Delta Stewardship Council 2021:2-9, 5-46, 5-55–5-59). Continuation of existing management and operation of the Delta will increasingly expose Delta water users and those that depend on water exported from the Delta to risks of water supply interruption and diminishing water supply reliability over time.

Delta levees are critical for maintaining flow through the Delta and protecting marsh habitat (Delta Stewardship Council 2021:2-1). The Delta levee system is vulnerable to sea level rise, increased runoff from the Sierra Nevada, and associated flooding (Delta Stewardship Council 2021:2-9, 3-9; California Department of Water Resources 2017:2-4). Higher sea levels will also push ocean waters into fresher waters in the Delta and increase flood potential in areas around the Delta (California Governor’s Office of Planning and Research et al. 2018b:20).

Sea level rise–driven saltwater intrusion in the Delta may have a variety of effects on soil, groundwater, or infrastructure, particularly affecting water quality for diversions and Delta tidal wetland habitat. Rising groundwater levels and sea levels in the San Francisco Bay Area are associated with increased subsurface salinity; some of this groundwater is used as drinking water (California Governor’s Office of Planning and Research et al. 2018c:45). Climate change and sea level rise will continue to make it increasingly difficult for the projects to meet water quality, outflow, and other regulations, such as State Water Board D-1641 agricultural water quality and controlling standards, given that water storage volumes may be reduced, thus impeding releases.

Under the No Project Alternative, warmer water temperatures are also expected to decrease suitable summer habitat of delta smelt, a federally listed threatened species and state-listed endangered species, because waters in the lower Delta may be too saline and lack enough food for the species, whereas fresh water in the upper Delta may be too warm (National Research Council 2012:167–168). Warming of streams and rivers also facilitates colonization by invasive species that may compete with native species for habitat (Garcia et al. 2018:10993). Growth of nonnative, invasive aquatic plants, such as the water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed (*Egeria densa*), has reduced habitat quality and value for many native fishes and raises concerns about the plants’ ability to clog waterways (as described in further detail in Chapter 12, *Fish and Aquatic Resources*). Given that these plants can clog diversion points and contribute to water quality issues, growth of invasive macrophytes presents maintenance and operational problems for water users. Growth of these invasive plants generally is facilitated by warmer temperatures and inhibited by colder conditions (U.S. Fish and Wildlife Service 2018:6–11), and climate change is projected to increase temperatures around the Delta. Interventions that could be taken to mitigate vulnerability of fish and wildlife to climate effects could include habitat restoration and water flow management to provide greater access to habitat (Delta Stewardship Council 2021:5-50). These actions would have corresponding tradeoffs because less water would remain in the reservoirs for other uses. Reduced instream water availability would result in difficulty meeting regulatory standards, given negative effects on upstream aquatic species, including coldwater pool resources, that are critical for salmonid rearing. Reduced water availability also could affect reliability for agricultural, municipal, and industrial water supplies and result in associated loss in productivity or other economic costs.

Average annual SWP deliveries would decrease under the No Project Alternative for the long-term average of water years, dry water years, and critical water years due to increasing regulatory and environmental needs and changes to precipitation and temperature, which affect rates of runoff, surface water evaporation, and potential evapotranspiration. Long-term average annual deliveries and dry and critical water years deliveries would decrease 7% and 10%, respectively, as described in further detail in Chapter 6, *Water Supply,* Table 6-2.

It can be assumed that, in the absence of the Delta Conveyance Project, participating water agencies would seek to bolster water reliability through other projects. However, other water reliability projects are related to making local supplies more reliable and not related to restoring and protecting SWP supplies. Additionally, under the No Project Alternative, projects that are part of EcoRestore[5] would continue to be implemented. The Delta Adapts adaptation plan will also include the implementation of strategies to address the effects of climate change in the Delta and provide local governments with information to incorporate climate change into future Delta actions and investments. Collectively, these projects support adaptation to climate change and have the potential to mitigate some of the effects of climate change on water reliability discussed here, including sea level rise, flooding, and precipitation variability.

## 30.4.2 Impacts of the Project Alternatives with Climate Change

The project is designed to operate within future hydrological conditions resulting from climate change, thereby accounting for those effects of climate change on project alternatives. The project design considers changing water surface elevations—water surface elevations where the project would increase in comparison to the No Project Alternative. However, under analysis of the project alternatives at 2040 and 2072, DWR determined that changing water elevations do not affect project operations (see Appendix 7A, *Flood Protection 2040/2072 Analysis*, for further detail). Although a variety of changes in climate described above, including changes in temperature, hydrology, and wildfire risk, may affect the Delta region, the future climate modeling developed for this assessment focuses on projected sea level rise and hydrologic changes (e.g., temperature and precipitation-driven shifts in surface water, groundwater, runoff) because they present the most pressing threats to project operations and design (See Appendix 5A, Section B, *Hydrology and Systems Operations Modeling*, for further detail).

The proposed intake areas will experience sea level rise and be designed to operate at water surface elevations that include climate change and sea level rise effects at year 2100 (California Department of Water Resources 2020b:3). However, intakes in the north Delta were found to *not* be vulnerable to future salinity intrusion conditions evaluated under the H++ scenario at year 2100 (10.2 feet or 3.11 meters) (Appendix 5A, *Modeling Technical Appendix,* Section F, *Climate Change Modeling*); the mixing processes between saltwater and fresh water that may be exacerbated under sea level rise do not appear to progress above the confluence of Sacramento River, Cache Slough, and Steamboat Slough, 14 to 16 miles downstream from the proposed new intake locations. Changing flooding trends, increasing water temperature, and seasonally reduced precipitation and drought (unrelated to the effects of the project alternatives) could result in decreased species populations and quality of species habitat in the study area. In response to decreased species populations and habitat, additional restoration actions could be implemented to support populations of native species

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[5] EcoRestore is a multi-agency initiative started in 2015 to improve or create at least 30,000 acres of critical habitat for native fish and wildlife species in California's Central Valley.

populations. Appendix 5A and Appendix 6A, *Water Supply 2040 Analysis*, provide the detailed results from the climate change sensitivity analysis.

The project alternatives potentially would have negative impacts on critical fish habitat and special-status species. These include construction and operation–related effects. Construction-related impacts include noise from pile driving and temporary and permanent loss of habitat from the aquatic portions of the construction footprint, for example. Operational impacts include factors such as less Sacramento River flow downstream of the proposed north Delta intakes, resulting in changed north Delta hydrodynamics that may reduce through-Delta survival of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) due to a potential decrease in the inundation of riparian and wetland bench habitat, depending on the alternative, season, and location (further described in Chapter 12, *Fish and Aquatic Resources*). As noted in Section 30.2, *Affected Environment and Resources,* and Chapter 12, climate change also presents challenges to fish, fish habitat, and food availability, resulting in the potential for the project impacts on species to compound with those driven by climate change. Because riverine habitat is anticipated to continue to be stressed and vulnerable under climate change (California Department of Water Resources et al. 2020:12), operations that affect flows to tidal and channel habitat could have both exacerbating and mitigating effects, given changes to flow and wetted areas from climate change, depending on timing and volume of those flows. However, the impact of operations and maintenance of the project alternatives would be less than significant with the restoration of tidal and channel habitat. Compensatory mitigation considers impacts of sea level rise on species' habitat (Appendix 3F, *Compensatory Mitigation Plan for Special-Status Species and Aquatic Resources*).

As described in Chapter 7, *Flood Protection*, and Appendix 7A, *Flood Protection 2040/2072 Analysis,* the project would involve no change in flood management operations in the SWP/CVP system, based on the 2-D steady-state Sacramento River system Hydrologic Engineering Center River Analysis System (HEC-RAS) analysis, which incorporates climate change (as described above); reservoirs upstream of the Delta would continue to operate to their permitted flood rule curves, and river flows would not change significantly with respect to channel capacity. Permanent project features would be designed to accommodate the 200-year flood event with climate change induced hydrology and sea level rise for year 2100 (i.e., 10.2 feet at the San Francisco Bay gage). The impact of the project on water surface elevation upstream or downstream of north Delta intakes under 2072 conditions would be similar to 2022 conditions, and the project would not affect the level of flood protection afforded by the federal levees near the intakes in the study area. Therefore, project alternatives would not result in an increase in flood risk (i.e., levee overtopping) or reduce flexibility for flood management in the Delta when compared to existing conditions.

In order to represent the broad range of potential future climate and sea level rise conditions, Alternative 5 and No Project Alternative were analyzed under three different representations of climate change and sea level rise projections at 2040 (the 2026–2055 climate period). The first is the 2040 Central Tendency (CT) climate scenario with 1.8 feet of sea level rise, which is the same scenario analyzed in the 2040 appendices to the EIR, for example, Appendix 5B, *Surface Water 2040 Analysis*. Two additional 2040 climate change and sea level rise scenarios were also used for comparison. These are a 2040 CT climate scenario with 0.5 foot of sea level rise and a 2040 Median climate scenario with 1.8 feet of sea level rise.

Analysis of these three 2040 scenarios for the No Project Alternative showed at least some climate sensitivity of CVP and SWP reservoir storages, river flows, Delta exports, salinity, and X2 position.

Storage is generally higher in the 2040 CT with 0.5-foot sea level rise scenario and lower in the 2040 Median with 1.8-foot sea level rise scenario compared to the 2040 CT with 1.8-foot sea level rise scenario. River flows and Delta outflow also varied between the two 2040 CT scenarios and the 2040 Median scenario, with flows often lower in the 2040 Median scenario, except in May-July on the American River where flows are higher. These flows were not affected by sea level rise. Compared to the 2040 CT with 1.8-feet sea level rise scenario, exports are higher in the 2040 CT with 0.5-foot sea level rise scenario and lower in the 2040 Median with 1.8-feet sea level rise scenario. X2 position during winter and spring and salinity during summer and fall also vary according to the climate scenario, with the 2040 Median with 1.8-feet sea level rise scenario having the most eastward X2 positions and highest salinities, and the 2040 CT with 0.5-foot sea level rise scenario having the most westward X2 positions and lowest salinities.

Climate change sensitivity was generally similar in Alternative 5 as in the No Project Alternative for the factors described above. Differences between Alternative 5 and the No Project Alternative were also generally similar in the three climate scenarios. Compared to the No Project Alternative, in all three climate scenarios, Alternative 5 has (1) either equivalent or slightly increased reservoir storages in drier conditions, especially in September, (2) decreases in flows on the Sacramento River at Hood and Delta outflow in the winter and early spring, (3) an approximately 1 km eastward shift of X2 from December–March, and (4) slightly higher salinities during the September–January period. Exports increase similarly under Alternative 5 in all three climate scenarios, but NDD annual exports are slightly higher in the 2040 CT with 0.5-foot sea level rise scenario (mostly in the wettest years) and are lower in the 2040 Median with 1.8-feet sea level rise scenario, compared to the 2040 CT with 1.8-feet sea level rise scenario.

Generally, these sensitivities to climate change are consistent with prior review of climate projections for related variables, and the project is designed to account for the range of results. More information about the sensitivity analysis for Alternative 5 can be found in Appendix 30A, *CalSim 3 Results Sensitivity to 2040 Climate Change Projections.*

### 30.4.3 Resilience and Adaptation Benefits

Under Assembly Bill 2800, state agencies must take climate change into account in planning, design, construction, operation, and maintenance (Pub. Resources Code § 71155). The project is being built with consideration of climate change by designing to modeled conditions and thus is expected to have a low level of risk for direct climate change effects such as sea level rise. For example, the project design analysis considers the extreme risk aversion sea level rise scenario of 10.2 feet at 2100 to prevent seawater intrusion at the intakes. However, compounding effects of climate change, including increasing stress on supply to meet demand under warmer temperatures, or increasing need for water releases to maintain water quality requirements, may affect the long-term reliability of Delta exports (Delta Stewardship Council 2021:5-55–5-58). For information on climate models and scenarios used, see Section 30.2.4, *Application of California Climate Projections to Alternatives Analysis,* and Appendix 5A, *Modeling Technical Appendix*.

This project supports statewide adaptation needs articulated in the *Water Resiliency Portfolio 2020* (California Department of Water Resources et al. 2020) to diversify local supplies and prepare for hotter conditions and more intense floods and droughts by increasing the average annual SWP deliveries for the long-term average, dry, and critical water years (Chapter 6, *Water Supply*).

The project may make California’s water system more resilient to changes in snowmelt and runoff patterns by helping to capture and move excess flows from locations in the state where runoff is projected to increase (e.g., some locations in the Sacramento and San Joaquin Valleys) to locations that may otherwise face reduced water availability and reduced carryover storage to supply water during dry months (California Department of Water Resources 2018c:17–19; Appendix 5A). DWR considers capture and conveyance in the Delta as important potential adaptations to mitigate these system losses in its *Climate Action Plan Phase III: Climate Change Adaptation Plan* (California Department of Water Resources 2020a:29).

Project alternatives would increase resiliency in managing combined effects of sea level rise and changes in upstream hydrology, including changes to runoff patterns from earlier snowmelt and precipitation (see Section 30.2.3, *Climate Change Trends and Associated Impacts on the Study Area*). The alternatives provide an alternative diversion point in the north Delta for Delta exports, adding management flexibility and increases in SWP deliveries during long-term average, dry, and critical water years (see Chapter 6, *Water Supply*). This increased flexibility would allow managers in the SWP/CVP system more options for adaptively managing resources to optimize benefits across water uses and provide more reliable water supplies that would benefit areas receiving deliveries (see Chapter 6, *Water Supply*).

Furthermore, the project alternatives are expected to provide the future benefit of allowing continued water deliveries and operational flexibility, should catastrophic failure from seismic activity or other disasters temporarily disrupt routing or quality of surface water supplies (see Chapter 3, *Description of the Proposed Project and Alternatives*).