Chapter 29
Climate Change

29.1 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 a "statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer)" (World Meteorological Organization 2013). 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 2007a). 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 22, *Air Quality and Greenhouse Gases,* Section 22.1.3.

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 global surface temperatures in turn result in changes to the Earth's climate system, including: the jet stream; El Niño; the Indian monsoon; ocean temperature and acidity; the extent of alpine glaciers, sea ice and polar ice sheets; atmospheric water content; and the extent and health of boreal and tropical forests (Intergovernmental Panel on Climate Change 2007a, b). Some of the above changes will result in specific impacts at the state and local level.

29.1.1 Purpose

This EIR/EIS analyzes three fundamental questions relating to climate change. Two of them are analyzed in other chapters. The third is analyzed in this chapter.

1. What is the impact of the action alternatives on climate change? i.e., how will GHG emissions from construction and operation activities associated with the project alternatives contribute to elevated GHG concentrations in the atmosphere?
2. How will the impacts of the action alternatives on the study area for each resource (the area in which impacts may occur) be affected by climate change? i.e., are future changes in climate likely to exacerbate project impacts?
3. How will the action alternatives affect the resiliency and adaptability of the Plan Area (the area covered by the project) to the effects of climate change?

Question 1 is addressed in Chapter 22, *Air Quality and Greenhouse Gases* (Impacts AQ-15, AQ-16, and AQ-18), through the calculation of GHG emissions inventories and identification of GHG mitigation opportunities associated with the action alternatives.

Question 2 is addressed throughout this document in each of the resource chapters. Under discussion of the No Action Alternative, each resource chapter evaluates how the project would affect the specific resource in question. In each of these analyses, where the effects of the action alternatives are analyzed for 2025 and 2060 conditions, climate change is integrated into the analysis. In these analyses, the action alternatives are evaluated using a projection of future climate that includes changes in temperature, precipitation, humidity, hydrology, and sea level rise. Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*, provides detailed information about the development of the climate change projections. The interrelation between resource topics addressed in this EIS/EIR and potential climate change effects under the No Action Alternative are presented in Table 29-1. An 'X' in the table signifies that there is a clear connection between the resource topic and a climate change effect under the No Action Alternative. Readers seeking additional information about a specific climate change effect on a specific resource should reference the resource specific chapter of this EIR/EIS. The potential climate effects under the No Action Alternative listed in Table 29-1 are based on the California Natural Resource Agency's (CNRA) climate adaptation guidance (California Natural Resources Agency 2009) that was adapted to be specific to the Plan Area.

Question 2 also fulfills the requirements for climate change analysis outlined in the Delta Reform Act of 2009 (California Water Code Sections 85000 *et seq*.). Within the Delta Reform Act, Water Code Section 85320 identifies the contents that the EIR portion of this EIR/EIS must include for the BDCP to be considered for inclusion in the Delta Plan prepared by the Delta Stewardship Council. Section 85320(b)(2)(C) of the Water Code directs that the EIR address "[t]he potential effects of climate change*, possible sea level rise up to 55 inches* [140 centimeters], and possible changes in total precipitation and runoff patterns on the conveyance alternatives and habitat restoration activities considered in the [EIR]." (Italics added.). It should be noted, the California Ocean Protection Council and other scientific bodies have projected that sea level rise will not reach 55 inches (140 centimeters) until approximately the year 2100. Sea level rise projections for 2025 and 2060 were developed based on research available during the analysis design and based on the requirements of Water Code Section 85320, which required that BDCP evaluate a sea level rise of 55 inches (well in excess of the expected sea level described by any major study for 2060).

This information is provided to discuss the benefits of the action alternatives in the face of expected climate change.

This chapter is organized differently from the other resource chapters because analyzing how the action alternatives would improve the Plan Area's resiliency and adaptability to climate change is a fundamentally different analysis than those presented in other resource chapters. Whereas the other chapters are organized to identify effects of the action alternatives and how to mitigate these impacts, this chapter's function is to analyze and disclose how the action alternatives affect the Plan Area's resiliency and adaptability to expected climate change. The study area for this chapter, therefore, is defined as the Plan Area, which is largely formed by the statutory borders of the Delta, along with areas in Suisun Marsh and the Yolo Bypass.

This chapter addresses question 3: How will the action alternatives affect the resiliency and adaptability of the Plan Area to the effects of climate change? In this context, resiliency and adaptability mean the ability of the Plan Area to remain stable or flexibly change, as the effects of climate change increase, in order to continue providing water supply benefits with sufficient water quality and supporting ecosystem conditions that maintain or enhance aquatic and terrestrial plant and animal species.

Table 29-1. Linkages between Resource Areas Addressed in this EIR/EIS and Climate Change

	Potential Climate Change Effect																	
Resource Topic	Increased air temperature	Increased water temperature	Increased soil temperature	Reduced precipitation/runoff volumes	Shift from snowfall to rainfall	Early snowmelt	Changes in evapotranspiration	Increased frequency/severity of flood events	Increased frequency/severity of droughts	Increased frequency of extreme heat events	Sea Level Rise	Increased salinity intrusion	Changes in erosion/sedimentation rates	Decreased species populations and quality of species habitat	Changes in species geographic range/ distribution	Spreading of pests and vector-borne diseases	Increased fire risk	Increased atmospheric CO_2 concentrations and acidification
Water Supply (Ch. 5)	X	X	X	X	X	X	X	X	X	X	X	X	X				X	
Surface Water (Ch. 6)	X	X	X	X	X	X	X	X	X		X	X	X					
Groundwater (Ch. 7)	X	X	X	X	X	X	X	X	X		X	X					X	
Water Quality (Ch. 8)	X	X		X	X	X	X	X	X		X	X	X	X		X	X	X
Geology and Seismicity (Ch. 9)																		
Soils (Ch. 10)	X		X					X	X		X	X	X					X
Fish and Aquatic Resources (Ch. 11)	X	X		X	X	X		X	X	X	X	X	X	X	X		X	X
Terrestrial Biological Resources (Ch. 12)	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Land Use (Ch. 13)	X		X				X	X			X						X	
Agricultural Resources (Ch. 14)	X		X	X			X	X	X	X	X	X					X	X
Recreation (Ch. 15)	X			X		X		X	X	X	X				X		X	
Socioeconomics (Ch. 16)	X		X	X				X	X	X	X			X		X	X	
Aesthetics and Visual Resources (Ch. 17)	X							X	X	X					X		X	
Cultural and Historic Resources (Ch. 18)			X					X	X		X		X				X	X
Transportation (Ch. 19)								X			X							
Public Services and Utilities (Ch. 20)	X							X	X	X	X					X	X	
Energy (Ch. 21)	X	X		X	X			X	X	X								
Air Quality and Greenhouse Gases (Ch. 22)	X	X						X		X	X						X	X
Noise (Ch. 23)																		
Hazards and Hazardous Materials (Ch. 24)	X							X		X	X						X	
Public Health (Ch. 25)	X							X	X	X	X	X				X	X	
Mineral Resources (Ch. 26)	X							X			X		X				X	X
Paleontological Resources (Ch. 27)	X							X	X				X				X	X
Environmental Justice (Ch. 28)	X							X	X	X	X					X	X	

This resiliency and adaptation analysis focuses on the major impacts of climate change in the Plan Area and the clear and measurable ways that the action alternatives will ameliorate these impacts or add flexibility to the system so that the Plan Area 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 action alternatives would be able to completely counteract all of the impacts of climate change; however, as shown below the action alternatives provide important added resilience and adaptability to many of the expected changes. Impacts for which the action alternatives provide no added resiliency or adaptation benefit or for which the benefit is minimal, or not documentable are not discussed in this chapter.

While there is a lot of overlap between the analysis provided here and that provided in the resource effects chapters, the main difference is that this chapter focuses on both negative effects and benefits and that it compares a climate changed future without the action alternatives to a climate changed future with the action alternatives. Resource chapters include comparisons to the No Action/No Project Alternative at 2060 (the NEPA point of comparison), which represents the net impact of the project isolated from the effects of climate change. These chapters also compare the action alternatives to Existing Conditions (the CEQA baseline), which represents the net impact of the project combined with the effects of climate change. The differences between these two comparisons allow readers to determine the incremental effects attributable to climate change as distinct from the impacts of the action alternatives. The resource chapters do not, however, specifically contemplate the extent to which action alternatives would contribute to the resiliency and adaptability of the Plan Area to the effects of climate change. Instead, this analysis is included in this chapter.

29.1.2 Organization

This chapter presents 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, *BDCP California WaterFix FEIR/FEIS 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 Plan Area; 3) an evaluation of the resiliency and adaptability of the Plan Area to the major expected impacts of climate change; and 4) an evaluation of the BDCP alternatives' and non-HCP alternatives' compatibility with applicable plans and policies designed to adapt to climate change or improve resilience to it.

29.1.3 Climate Change Background

A vast amount of scientific research on climate change, both its causes and effects, at all geographic scales has been conducted during the last 50 years. The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Program and the World Meteorological Organization (WMO) 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 2011). IPCC, an organization of more than 800 scientists from around the world, regularly publishes summary documents, which 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 to be the best available science. IPCC documents address change at the global and super-regional scales. Both IPCC studies and California-specific studies (e.g., California Air Resources Board, California Energy Commission, the California Department of Water Resources [DWR], CNRA, and U.S. Department of the Interior, Bureau of Reclamation [Reclamation]) that are based on IPCC data are referenced throughout this chapter.

Scientific measurements have shown that changes in the *global* climate system are already occurring. These include: rising air temperatures; rising ocean temperatures; rising ocean salinity; rising global sea levels; changes in precipitation patterns; and increased intensity and frequency of extreme events such as storms, droughts, and wildfires (Intergovernmental Panel on Climate Change 2007b; California Department of Water Resources 2009).

29.2 Environmental Setting/Affected Environment

The Plan Area has a predominantly Mediterranean climate characterized by hot, dry summers and cool, rainy winters. From 1981–2010, average monthly temperatures in Sacramento ranged from 41.0°F (5°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 2012). Average air temperatures in the mountainous regions of the watershed are typically 5–10 degrees 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 it typically melts gradually during the spring and summer. The snowline is often around the elevation of 5,000 feet (1,524 meters) (U.S. Army Corp of Engineers 2002).

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 (Huber-Lee et al. 2003). Precipitation that falls as rain in the project area can run off into the rivers (and eventually into the Delta), infiltrate into the soils (recharging the groundwater system) or evapotranspirate. Factors such as spring temperatures and the nature of precipitation (rain/snow elevations in storms) during the October to April period play an important role in runoff timing.

The primary type of soil in the Plan Area is peat. These soils were developed by the formation of mineral soils near the channels during flood conditions, and by the formation of organic soils on marsh island interiors as 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 30 feet (9 meters) in some areas. In addition to peat, the Delta soils are composed of mineral sediments from rivers (United States Geological Survey 2000).

The Plan Area has historically been affected by periodic extreme precipitation events. The majority of these historical events have likely been caused by an atmospheric phenomenon called an atmospheric river (AR) (Dettinger 2011). ARs are narrow corridors of water vapor transported in the lower atmosphere that traverse long swaths of the Earth's surface (Dettinger and Ralph 2011). These storms can deliver tremendous amounts of precipitation to California in a very 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 Plan Area is provided in Chapter 6, *Surface Water*, and Chapter 22, *Air Quality and Greenhouse Gases*.

Because this chapter discusses how the action alternatives affect the resiliency and adaptability of the Plan Area to the effects of climate change, this section also discusses expected changes to the environmental setting. 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 year 2100 is approximately 40 years after the end of the 2060 time period analyzed in other chapters of this EIR/EIS (reflecting the approximate end date of the 50-year permit term proposed for the BDCP), the year 2100 was chosen in part because of language enacted by the California Legislature in the Sacramento-San Joaquin Delta Reform Act of 2009 (Water Code Sections 85000 *et seq*.) requiring the EIR to address "[t]he potential effects of climate change*, possible sea level rise up to 55 inches* [140 centimeters], and possible changes in total precipitation and runoff patterns on the conveyance alternatives and habitat restoration activities considered in the [EIR]" (Water Code Section 85320. Italics added.). It should be noted, the California Ocean Protection Council and other scientific bodies have projected that sea level rise will not reach 55 inches (140 centimeters) until approximately the year 2100.

This information is provided at the global scale, at the state level, and for the Plan Area. Projections of future climate change are based on the level of GHGs already in the atmosphere, the current rate at which human activity releases GHGs to the atmosphere, and the 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 are typically displayed as a range, with the lower end representing a minimum amount of estimated change based on past and current GHG emissions and the higher end representing a high degree of global economic growth and the absence of large-scale mitigation of GHG emissions.

29.2.1.1 Global Climate Change Effects

Recent Trends

The IPCC has found that, "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (Intergovernmental Panel on Climate Change 2007a). Global annual surface temperatures have increased at a rate of 0.13°C (0.23°F) per decade during the period 1950–2000. This rate is double the rate observed during the period 1900–1950. Further, 11 of the 12 years during the period 1995–2006 rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850) (Intergovernmental Panel on Climate Change 2007a).

Much of the Western United States has experienced warming during the 20th century (roughly 2°F [1.1°C]) and is projected to experience further warming during the 21st century with central estimates varying from roughly 5 to 7°F (2.8°C to 3.8°C), depending on location (Bureau of Reclamation 2011). Historical trends in annual precipitation are less apparent. Future projections suggest that the Northwestern and north-central portions of the United States gradually may become wetter (e.g., Columbia Basin and Missouri River basin) while the Southwestern and south-central portions gradually become drier (e.g., San Joaquin, Truckee, and Rio Grande River basins and the Middle to Lower Colorado River Basin). Areas in between have median projected changes closer to no change, meaning they have roughly equal chances of becoming wetter or drier (e.g., Klamath and Sacramento basins and the Upper Colorado Basin). These summary statements refer to median projected changes in temperature and precipitation, characterized generally across the Western United States. Projections show that there is significant variability and uncertainty about these projected conditions both geographically and with time (Bureau of Reclamation 2011).

Warming trends appear to have led to a shift in cool season precipitation towards more rain and less snow, which has caused increased rainfall-runoff volume during the cool season accompanied by less snowpack accumulation in some Western United States locations (Bureau of Reclamation 2011). Hydrologic analyses-based future climate projections 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 high altitude and high latitude areas, there is a chance that cool season snowpack actually could increase during the 21st century (e.g., Columbia headwaters in Canada, Colorado headwaters in Wyoming), because precipitation increases are projected and appear to offset the snow-reduction effects of warming in these locations (Bureau of Reclamation 2011).

During the same period over which global temperatures have increased, sea levels have risen on average 0.07 inches (0.18 centimeters) per year with sea level rise during the period 1993–2003 rising at a rate of 0.12 inches (0.31 centimeters) per year and increasing overall by about 6.7 inches (17 centimeters) during the twentieth century (Intergovernmental Panel on Climate Change 2007a). Observed trends in sea level rise can be attributed to both thermal expansion of the world's oceans and the melting of ice sheets (polar and alpine). Also during a similar period (1900–2007) measurements have shown increases in global ocean temperature (since 1961); a decline in the extent of mountain glaciers and global snow cover; increased atmospheric water vapor content; loss in mass of the polar ice sheets; decreased extent of Arctic sea ice; increased precipitation in the eastern portions of North and South America, northern Europe and northern and central Asia; drying conditions in the Sahel region of the Sahara Desert in Africa, the Mediterranean and southern Africa; strengthening in mid-latitude westerly winds (since 1960s); more intense and longer drought conditions in the tropics and sub-tropics (since the 1970s); increased frequency of extreme precipitation events over land areas; higher average night time temperatures; decreased frost days and increased frequency and duration of extreme heat events (since 1950s); and increased tropical cyclone activity in the North Atlantic (Intergovernmental Panel on Climate Change 2007a). There may also be additional synergistic impacts of extreme weather events, such as the sea level rise coupled with high tide and extreme storm surges. The above listed changes are in turn resulting in changes to the climate of California as the regional climate is moderated by sea surface temperature, westerly jet stream wind patterns, the El Niño Southern Oscillation (ENSO), and Pacific storm patterns.

Projections to 2100

Climate models indicate that global average surface temperature will increase at a rate of approximately 0.4°F (0.2°C) per decade for the period 2000–2020, and will increase by at least that amount per decade during the period 2020–2080. Based on a number of emissions scenarios, the IPCC projected an average increase in surface temperatures of 3.2 to 7.2°F (1.7 to 4°C) by 2100 compared to 1980 through 1999 levels, with a likely range of 2.0 to 11.5°F (1.1 to 2.2°C) when accounting for the uncertainty in climate science (Intergovernmental Panel on Climate Change 2007a). Approximately half of this warming is the result of past GHG emissions and will occur even if GHG emissions were halted at 2000 levels. Some regions of the globe, particularly high latitudes, will experience much larger changes relative to Existing Conditions. Corresponding global average sea level rise levels during the period 2000–2100 are estimated to be between 7 inches (18 centimeters) and 23 inches (58 centimeters) (Intergovernmental Panel on Climate Change 2007a). However, recent scientific data now strongly suggests that these sea level rise projections are likely too low and that actual sea level rise may be significantly greater than initially estimated (Rahmstorf 2007; National Research Council 2012).[1]

The following additional changes to the global climate system are projected: increased ocean acidity due to increased carbon dioxide uptake by the oceans; reduced global snow cover; increased thaw depth in permafrost regions; decrease in sea ice with potential full disappearance in summer months; increased frequency in heat waves, droughts, and heavy precipitation events; increased intensity of tropical cyclone events; northward movement of extra-tropical storm tracks; increased precipitation at high latitudes and decreased precipitation in tropical and sub-tropical regions; and increased melting of the ice sheets (Intergovernmental Panel on Climate Change 2007a).

29.2.1.2 Climate Change Effects on California

Recent Trends

Scientific measurements and observations indicate that California's climate is already changing in a manner consistent with what would be expected from global climate change. Since 1920, California's average temperature has been increasing, although this change, or any climate change impact, is not uniform across California. Nighttime temperatures are rising across California and at a higher rate than day-time temperatures. Furthermore, daytime and nighttime heat wave events throughout California have increased in intensity, particularly the nighttime component (Moser et al. 2009). During the last century, sea level along the California coast has increased approximately 7 inches (18 centimeters), with higher rates of increase occurring since 1993 (Cayan et al. 2009).

California's water supply system is dependent on snowpack storage in the Sierra Nevada. Temperatures over the Sierra Nevada have increased during the last 100 years, resulting in less snowfall (and more rainfall) and an earlier snowmelt (Moser et al. 2009). The average early spring snowpack in the Sierra Nevada has decreased by about 10 percent during the last century, a loss of 1.5 million acre-feet (MAF) of snowpack storage (California Department of Water Resources 2008). Reductions in water supply can adversely affect hydropower reserves, decreasing hydropower generation in the summer months when peak demand is highest (California Natural Resources Agency 2012).

Data also show evidence for the following additional changes to California climate and conditions during the last 50 years: the warming of Lake Tahoe; decreasing chill hours and increased stresses on California agriculture; shifts and disturbances in managed landscapes; increased frequency of wildfire; changes in Santa Ana winds; increases in photochemical smog production in southern

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[1] California agencies including the Bay Conservation and Development Commission (BCDC) and DWR are using the more recent data of Rahmstorf et al. 2007 in their SLR planning efforts in lieu of the estimates as reported by IPCC in the Fourth Assessment Report. As identified above, California Water Code Section 85320 identifies in order to be considered for inclusion in the Delta Plan, the BDCP must assess "[t]he potential effects of climate change*, possible sea level rise up to 55 inches* [140 centimeters], and possible changes in total precipitation and runoff patterns on the conveyance alternatives and habitat restoration activities."

California; increased frequency and intensity of heat wave and drought events; changes in ENSO and the impact on California temperatures; and changes in extreme precipitation events and daily average precipitation (California Energy Commission 2011a).[2]

Plants and animals around the globe are already reacting to changes caused by increasing temperatures. In California, species are also reacting to extreme conditions, including heat waves (and increased fire frequency); cold snaps; droughts (and the saltwater intrusion that droughts often cause); floods; and coastal upwelling. Observed changes also include altered timing of animal and plant lifecycles (phenology), disruption of biotic interactions, changes in physiological performance, species range and abundance, increase in invasive species, altered migration patterns of fishes, aquatic-breeding amphibians, birds and mammals, changes in forage base, local extinction of plant and animal populations, and changes in habitat, vegetation structure, and plant and animal communities (California Department of Fish and Game 2010).

Projections to 2100

Average annual surface temperatures for California are projected to increase by between 2 and 5°F (1.1 and 2.8°C) by 2050 and between 4 and 9°F (2.2 and 5.0°C) by 2100, depending on the GHG emissions scenario assumed. Warming will not be uniform temporally or geographically across the state. Climate models project a greater amount of warming during summer months, especially during nighttime, and in the interior regions of California. Chill hours in the Central Valley are expected to decrease, but unprecedented extremes of cold weather are still possible (Gershunov 2011). Changes in temperature and humidity have implications for agriculture in the Central Valley; as the climate warms and dries, crop diversity and production may slow (Jackson et al. 2011). Extreme events will also stress California's energy system (Auffhammer 2011).

Best available data indicate that California, as a whole, will experience changes in precipitation. It is likely that some areas in California will experience higher annual rainfall amounts whereas precipitation in other regions will decrease (Gershunov 2011). Cayan et al. (2009) estimates California, particularly southern California, will be 15–35% drier by 2100. Snowpack volumes are expected to diminish by 25% by 2050 (California Department of Water Resources 2010b).

Frequency and intensity of large storms and precipitation events may be influenced by changes in ARs. In California, nearly all major historic flood events have been associated with the presence of ARs along the Pacific coast. It is estimated that future changes in climate will increase the frequency of years with AR storms, but the number of storms per year is not likely to be affected. More importantly, occasional "much-larger-than-historical-range storm intensities" are projected to occur under most warming scenarios. Changes in the frequency and magnitude of ARs may result in increases in major flood and storm events (Dettinger 2011).

Climate change and increasing temperatures are expected to increase energy demand in California, particularly during the summer months. The California Natural Resources Agency (2012) predicts that higher temperatures in the next decade could increase demand by up to 1 gigawatt. Increased

[2] The State of California under the auspices of the California Energy Commission is conducting comprehensive and detailed research into a range of climate change impacts in California as well as research aimed at developing adaptation strategies to deal with impacts already underway and that can no longer be avoided. The majority of this research is available through the California Climate Change Portal. Available at: <http://www.climatechange.ca.gov/>.

energy demand would require additional generation resources or the purchase of costly peak power from external sources.

Sea level rise along the California Coast is expected to accelerate during the 21st century. A recent study completed by the National Research Council (NRC) looked at both global (e.g., thermal expansion, land ice melting) and local (e.g., tectonic land movement, localized subsidence) factors effecting sea level relative to land surface. Table 29-2 below shows the projection and the range of uncertainty for expected sea level rise at San Francisco and the Delta at 2030, 2050, and 2100.

Table 29-2. Sea Level Rise Projections and Ranges for San Francisco, California 2030, 2050, and 2100

		2030		2050		2100	
		Projection	Range	Projection	Range	Projection	Range
Projected Sea Level Rise at San Francisco	cm	14.4 ± 5.0	4.3–29.7	28.0 ± 9.2	12.3–60.8	91.9 ± 25.5	42.4–166.4
	in	5.7±2	1.7–11.7	11±3.6	4.84–23.9	36.2±10	16.7–65.5

Source: National Research Council 2012.

Sea level rise will continue to threaten coastal lands and infrastructure, increase flooding at the mouths of rivers, place additional stress on levees in the Delta, and will intensify the difficulty of managing the Delta as the heart of the state's water supply system (California Department of Water Resources 2010a).The effects of sea level rise, combined with large waves generated during El Niño events will have the greatest potential for impacts (Griggs 2011).

These changes in temperature, precipitation and sea level may have substantial effects on other resources areas. Potential effects of climate change anticipated in California (and discussed in this document) are listed below (California Natural Resources Agency 2009, 2012).

- Increased average temperatures (air, water, and soil).
- Changes in annual precipitation amounts.
- Change from snowfall (and spring snowmelt) to rainfall.
- Decreased Sierra snowpack (earlier runoff, reduced maximum storage).
- Changes in evapotranspiration.
- Increased frequency and intensity of Pacific storms (flood events).
- Increased severity of droughts.
- Increased frequency and severity of extreme heat events.
- Increased energy demand (particularly during peak summer periods).
- Increased frequency and severity of wildfire events.
- Sea level rise (with increased salt water intrusion in the Delta).
- Changes in species distribution and ranges.
- Decreased number of species.
- Increased number of vector-borne diseases and pests (including impacts to agriculture).

- Altered timing of animal and plant lifecycles (phenology).
- Disruption of biotic interactions.
- Changes in physiological performance, including reproductive success and survival of plants and animals.
- Changes in invasive species.
- Altered migration patterns of fishes, aquatic-breeding amphibians, birds and mammals.
- Changes in food (forage) base.
- Changes in habitat, vegetation structure, and plant and animal communities.

These changes have significant implications for water quality, water supply, flooding, aquatic ecosystems, energy generation, and recreation throughout the state. Several guidance documents have been drafted or have been published to discuss strategies to protect resources from climate change in California such as the 2009 *California Climate Adaptation Strategy* (California Natural Resources Agency 2009).

29.2.1.3 Climate Change Effects on the Plan Area

Recent Trends

Average annual temperatures in the Plan Area have increased approximately 0.9°F (0.53°C) during the period 1920–2003 (see Table 29-3). Local annual precipitation has increased by an average of approximately 1.7 inches (4.3 centimeters) during this same period. As discussed above, sea level in San Francisco Bay has risen approximately 7 inches (18 centimeters) over the last 100 years, affecting high tide events and salinity levels in the Delta. Hydrologic conditions in the Delta are largely determined by precipitation (amount, form, and timing) in the Sierra Nevada, as well as water management upstream (reservoir releases, diversions, operation of weirs, etc.), as opposed to local conditions. The average early spring snowpack in the Sierra Nevada has decreased by about 10% during the last century, a loss of 1.5 MAF of snowpack storage (California Department of Water Resources 2008).

Projections to 2100

As shown in Table 29-3, by 2060, average annual temperatures in the Plan Area are projected to increase by 3°F (1.6°C), relative to current conditions. Average annual precipitation is projected to decrease slightly (approximately 0.16 inch [0.40 centimeter] during this same period).

It is important to note that, while the mean-annual amount of precipitation may only change slightly, the character of precipitation within the Sacramento and San Joaquin River basins is expected to change under warming conditions, resulting in more frequent rainfall events and less frequent snowfall events. Increased warming is expected 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. This conceptually leads to increases in December–March runoff and decreases in April–July runoff.

Table 29-3. Temperature, Precipitation, and Runoff Statistics for the Plan Area

	Historical (1922–1970)	Current (1970–2003)	2025 Conditions	2060 Conditions
Average Temperature, Sacramento Basin	10.6°C	10.9°C	11.6°C	12.7°C
Average Temperature, San Joaquin Basin	11.5°C	12.0°C	12.7°C	13.7 °C
Average Temperature, Delta area	14.8°C	15.6°C	16.0°C	17.0°C
Average Precipitation, Sacramento Basin	86.3 cm	92.9 cm	88.6 cm	88.5 cm
Average Precipitation, San Joaquin Basin	63.1 cm	66.5 cm	63.2 cm	62.0 cm
Average Precipitation, Delta area	33.2 cm	35.9 cm	33.4 cm	32.9 cm
% of Runoff already arrived at Res. April 1 Sac Basin	73%	75%	80%	85%
% of Runoff already arrived at Res. April 1 SJ Basin	44%	45%	49%	55%

°C = degrees Celsius.
cm = centimeters.
Based on climate change scenarios and runoff data modeled for the action alternatives (see Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix)*.

Recent modeling indicates that sea level along the San Francisco Coast is expected to increase by 5 to 24 inches (12 to 61 centimeters) by 2050 and by as much as 17 to 66 inches (42 to 167 centimeters) by 2100 (National Research Council 2012). It is expected that more land in the Plan Area will be subject to inundation by 2100 in comparison to current conditions. Potential changes in inundation zones (tidal regime) will affect the salinity and suitable habitat for species in the Delta.

Water Temperatures

Reservoir operations may change temperatures below reservoirs, but will not affect temperatures in the Delta. Increased water temperatures may have adverse effects on fish spawning (reduced egg survival) and may reduce the habitat zone (reduced abundance) of fish that are sensitive to higher temperatures (i.e., delta smelt). The projected effects of climate change on habitat and egg mortality for the early long-term (2025) and late long-term (2060) timeframes were evaluated using three water temperature models (BOR Temperature model, Sacramento River water quality model and Delta temperature model). Specific modeling procedures and assumptions are further described in Appendix 29C, *Climate Change and the Effects of Reservoir Operations on Water Temperatures in the Study Area.*

Precipitation and Runoff

The projected effects of climate change on precipitation in the Central Valley were estimated using general circulation model (GCM) results that were processed with a watershed hydrology model, Variable Infiltration Capacity (VIC), to provide monthly runoff estimates for the CALSIM II planning model. Two projections were developed with separate inflow sequences representing the early long-term (2025) climate assumptions that included 5.9 inches (15 centimeters) of sea level rise, more variable precipitation, and warmer temperatures, and late long-term (2060) climate assumptions that included 17.7 inches (45 centimeters) of sea level rise, more variable precipitation than in the early long-term, and warmer temperatures than in the early long-term. These potential climate conditions were used to simulate the reservoir operations and Delta operations (export pumping) for each action alternative. The differences in these anticipated changes in the runoff sequences are fully described in Appendix 29B, *Climate Change Effects on Hydrology in the Plan Area Used for CALSIM Modeling Analysis*.

Sea Level Rise

The likely effects of anticipated sea level rise on the Plan Area were evaluated based on detailed modeling simulations. When considering potential sea level rise impacts, special consideration must be given to the following three interrelated elements.

- **Inundation**: Changes in sea level have the potential to inundate previously dry areas. The extent of inundation in the Delta is sensitive to the magnitude of sea level rise. As discussed below, Figure 29-1 depicts the changes in inundation at high tide assuming a 55-inch (140-centimeter) sea level rise.
- **Salinity Gradient**: The location of the gradient between saline, brackish, and freshwater in the San Francisco estuary will be affected by sea level rise. As sea levels rise, the salinity gradient will shift further upriver. The position of the daily average salinity gradient in the estuary is called "X2", which is the distance in kilometers upstream of the Golden Gate Bridge of the 2 parts per thousand (ppt) isohaline, (1995 Bay-Delta Water Quality Control Plan [WQCP]). The X2 position is highly variable due to daily tidal movement. Outflow objectives identified in the WQCP manage the X2 position to control salinity intrusion into the Delta. The daily average X2 position provides a good index of the upstream extent of saltwater intrusion as a consequence of sea level rise. Maintaining the existing X2 position under future sea level rise scenarios will likely require increased outflows from the Delta.
- **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.

Best available information suggests a range of potential sea level rise from 17 to 66 inches (42 to 167 centimeters) by 2100 (National Research Council 2012). Given the inherent variability in anticipated future scenarios, a broad range of potential sea level changes (from 6 to 55 inches) was analyzed. The projections from the NRC study were not used directly in the project analysis for two reasons. 1) the study was published in June 2012, well after the modeling analysis for the project had been designed and performed, and 2) the projection years are not directly aligned with the 2025 and 2060 analysis periods used for the project. Sea level rise projections for 2025 and 2060 were developed based on research available during the analysis design and based on the requirements of Water Code Section 85320, which required that the project evaluate a sea level rise of 55 inches (well in excess of the expected sea level described by any major study for 2060). The sea level rise projections used in the project analysis at 2025 and 2060 are consistent with the findings of the NRC and fall within the range of expected sea level rise that could be extrapolated from the NRC analyses at each analysis time period. The inclusion of additional analysis for 55 inches (140 centimeters) of sea level rise provides a conservative analysis of potential sea level rise late in the 21st century.

As discussed in Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*, several models were used to assess and quantify the effects of sea level rise on the action alternatives. Figure 29-2 identifies the three primary models used in the analysis, as well as how these models interact to predict tidal variations and other corresponding sea level rise effects in the Plan Area.

Climate and sea level change are global phenomena that can have unique impacts on local systems. As shown in Figure 29-2, the UnTRIM Bay-Delta Model (MacWilliams et al., 2009), a three dimensional hydrodynamics and water quality model, was used to simulate localized impacts on hydrodynamics and salinity transport in the Delta for a range of selected sea-level scenarios (6 to 55 inches [15 to 140 centimeters]). The results from the UnTRIM model were used to corroborate (adjust coefficients to match) the RMA Bay-Delta Model (RMA 2005) and Delta Simulation Model (DSM2) to correctly simulate tidal marsh restoration effects with and without sea level rise. Finally, the DWR/Reclamation CALSIM II planning model was adjusted to match the salinity effects from sea level rise to simulate Central Valley Project (CVP) and State Water Project (SWP) operation over the range of projected hydrologic conditions. Higher Delta outflows were calculated to be required to meet the existing salinity objectives. Please refer to Appendix 29A, *Effects of Sea-Level Rise on Delta Tidal Flows and Salinity*, for additional information on modeling procedures and assumptions.

Potential changes in inundation at high tide as a consequence of 55 inches (140 centimeters) of sea level rise are shown in Figure 29-1. Figure 29-1 is based on tidal elevation data developed as part of the Delta Risk Management Strategy, Phase 1 (Phase 1 datasets) (California Department of Water Resources). The Phase 1 datasets are projections of floodplain depths as a function of sea level rise scenarios (including 55 inches [140 centimeters]). Areas shaded in light yellow are at or below the high tide elevation based on the current sea level. Areas shaded in orange are additional areas at or below high tide elevation when a 55-inch (140-centimeter) rise in sea level is considered. Note that the yellow and orange areas are not necessarily inundated due to control structures such as levees. Figure 29-1 provides insight as to which additional areas in the Delta may need to introduce or augment control structures to avoid inundation should mean sea level rise increase by 55 inches (140 centimeters).

As shown in Figure 29-1, several communities with elevations greater than 17 feet (e.g., Fairfield, Manteca, Tracy, and Brentwood) (5.2 meters) will likely not be directly affected by a 55-inch (140-centimeter) sea level rise. However, some of the Delta islands and other low lying areas may incur additional inundation risk if 55 inches of sea level rise were to occur, especially if levees or other control structures were to fail.

29.3 Resiliency and Adaptation Analysis

As described in Chapter 2, *Project Objectives and Purpose and Need*, the action alternatives seek to make physical improvements to the SWP/CVP system which will serve to provide resiliency and adaptability to rising sea levels and other reasonably foreseeable consequences of climate change. The analysis below seeks to describe the manner in which the alternatives would achieve the stated objective of increasing resiliency and adaptability to climate change over the No Action/No Project Alternative. Project components that could affect the resilience and adaptability of the Plan Area to climate changes consist of water diversion and conveyance facilities combined with differing operational scenarios (collectively Conservation Measure [CM]1), measures focused on the protection, restoration, and enhancement of natural communities (CM2—CM11), and measures related to reducing other stressors (CM12—CM21). These conservation measures and the components they comprise are described in detail in Chapter 3, *Description of Alternatives*. Depending on the alternative, the water facility components would create a new conveyance mechanism and operational guidelines to divert water from the north Delta to existing SWP and CVP export facilities in the south Delta to achieve the planning goals outlined in the project.[3]

To the extent possible, detailed project specific analysis done for the project is reported to provide evidence of the expected changes in resiliency and adaptability. Where no detailed project specific analysis was available, references and or qualitative descriptions are included that provide evidence that the described effect would provide a resiliency or adaptation benefit.

The discussion on the resiliency and adaptability of the Plan Area to the major expected impacts of climate change is broken into a discussion first about the BDCP alternatives (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9) and then the non-HCP alternatives (Alternatives 4A, 2D, and 5A). The analyses are bifurcated to allow for differences in the NEPA point of comparison—No Action Alternative LLT (with sea level rise and climate change that would occur at around Year 2060) for the BDCP alternatives, versus a No Action Alternative ELT (with sea level rise and climate change that would occur at around Year 2025) for the non-HCP Alternatives; as well as other modeling assumption differences between the BDCP alternatives and the non-HCP alternatives.

29.3.1 BDCP Alternatives

29.3.1.1 Resiliency and Adaptability to Sea Level Rise and Hydrology Changes

Water Supply Reliability and Aquatic Species in the Delta

Impacts

Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies,* describes the existing and future risks to the Plan Area and specifically to the Delta as a result of climate changes described above. The appendix highlights how increased sea level and changes in upstream hydrology will affect the Plan Area. For the project analyses, potential sea level increases of 6 inches (15 centimeters) in 2025 and 18 inches (46 centimeters) in 2060 were evaluated as was a sea level rise of 55 inches (which is not projected to occur until 2099, but is evaluated consistent with the requirements of Water Code Section 85320). Expected changes in precipitation and hydrology were also evaluated including earlier runoff as a result of warmer temperatures causing more precipitation to fall as rain instead of snow and the remaining snow melting earlier. Additional information about the analysis methodology and modeling assumptions can be found in Appendices 29A, *Effects of Sea-Level Rise on Delta Tidal Flows and Salinity,* and 29B, *Climate Change Effects on Hydrology in the Study Area Used for CALSIM Modeling Analysis*.

Modeling results for the 2060 period indicate a shift in runoff from snowmelt months (April–June) to snow/rainfall months (January–March) of about 5–10% for the Sacramento River Basin and of about 5–7% for the San Joaquin River Basin. The total runoff was increased (over historical conditions) slightly (2%) for the Sacramento River Basin and decreased (6–10%) for the San Joaquin River Basin. While these change metrics represent long-term averages, modeling results for

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[3] As described in Chapter 1, *Introduction*, Section 1.1, the Final EIR/EIS includes the 2013 Draft EIR/EIS, BDCP, 2015 RDEIR/SDEIS, and all associated appendices with these documents; as well as revisions to these documents as contained in this Final EIR/EIS.

the 2060 period also indicate that droughts will increase in severity and duration—resulting in periods of critical dryness.

All of these climate changes may result in less water flowing into the Delta between March and October. At the same time, higher sea levels, in the absence of intervention, will increase the penetration of salinity into the Delta. This increased Delta salinity would have a myriad of impacts on in-Delta and Delta export water users whose water quality would be diminished. Aquatic species such as Delta smelt would also be affected by these changes as their habitats would shrink or move to less productive areas as discussed in Chapter 11, *Fish and Aquatic Resources,* Section 11.3.4.1. Interventions that could be taken to counteract additional salinity intrusion would likely include the release of additional water from upstream storage reservoirs. These actions would have corresponding tradeoffs as less water would be left in the reservoirs for other actions. Reduced water available for agricultural, municipal, and industrial water supplies would reduce reliability and have economic costs. Reduced water available for instream and other ecological uses would result in negative effects on upstream aquatic species including cold water pool resources, critical for salmonid rearing.

All of the hydrologic changes discussed above will make water management more challenging and more constrained in the future and are expected to result in more years of critical dryness. DWR's modeling of future conditions suggests that with current management and operations, level of demand, and current climate, major CVP and SWP reservoirs could reach dead storage levels (the level below which water cannot be released) and that the likelihood of these critical conditions will increase substantially as the climate warms. In these instances, there would be critical water shortages leading to potentially extreme impacts to agriculture, municipal, industrial, and ecological water uses.

Resilience/Adaptation

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, and 5 would provide substantial resiliency and adaptation benefits over the No Action/No Project alternative for dealing with the combined effect of increases in sea level rise and changes in upstream hydrology. Implementation of any of these nine alternatives would result in an increase in Delta exports and total SWP and CVP water deliveries over the No Action Alternative (Table 29-4). These alternatives have dual conveyance facilities, allowing water to be moved through the Delta when conditions permit and allowing water to be diverted from the Sacramento River in the northern Delta when conditions do not permit through Delta conveyance. Diversions at the proposed NDDs [north Delta diversions] would be allowed if Sacramento River inflows are adequate to protect downstream species habitat and water quality conditions. The location of the north Delta diversion facility is further inland making it less vulnerable to salinity intrusion. Even with substantial sea level rise and critically dry upstream conditions, salinity could be repelled from this location. By establishing an alternative diversion point for Delta exports, a great deal of Delta management flexibility is added. Currently, management of the Delta is constrained by requirements to maintain X2 at specific locations during certain times of the year to ensure water diversions have low salinity and to ensure that critical fish populations stay outside of the entrapment zone. Alternatives 1A–2C, 3, 4, and 5 would allow the Delta to be managed in a number of different ways, including maintaining salinity as it is currently managed or allowing salinity to fluctuate more freely in the Delta as it did prior to the development of upstream reservoirs. This added flexibility would allow managers more options for adaptively managing the Delta so that conditions can be optimized to provide the greatest benefits across all Delta water uses and habitat conditions. As shown in Table 29-4, Alternatives 6A through 8 would slightly decrease Delta exports and total SWP and CVP water deliveries over the No Action Alternative. Accordingly, these alternatives may not add resiliency to existing water supplies. However, similar to Alternatives 1A–2C, 3, 4, and 5, Alternatives 7 and 8 would have dual conveyance facilities, which could improve management flexibility. The location of the north Delta diversion facility proposed under these alternatives, as well as under Alternative 6, would also be further inland, making it less vulnerable to salinity intrusion.

Table 29-4. Delta Exports and CVP/SWP Deliveries

Alternative	No Action/ No Project	1	2	3	4	5	6	7	8	9
Delta Exports	**4,441**	**5,456**	**5,068**	**5,371**	**4,945**	**4,786**	**3,758**	**3,754**	**3,098**	**4,377**
Change in Exports		**1,015**	**627**	**930**	**504**	**345**	**(683)**	**(687)**	**(1,343)**	**(64)**
Total CVP/SWP deliveries	6,553	7,371	7,060	7,321	6,995	6,868	5,902	5,942	5,273	6,496
Change in CVP/SWP deliveries (Alt-NAA)		818	507	767	442	315	(652)	(612)	(1,281)	(57)

For the analysis of the action alternatives, operation of the CVP and SWP systems are modeled using current regulatory conditions and a set of operational strategies. While this provides a good reference point for evaluating the potential operational benefits and impacts of the action alternatives, additional infrastructure constructed and ecological restoration implemented as elements of the alternatives could also open up additional operational possibilities that could be explored through the adaptive management process, thus allowing other operational alternatives that could provide potentially larger benefits to Delta resources. There is currently a high level of uncertainty about how different Delta conditions, including salinity, tidal habitat, Delta outflow, water temperature, Delta water quality, and level of Delta exports would affect critical aquatic species, which of these variables has the greatest effect on these species, and what the best combination of management practices would be. Climate change responses add more uncertainty to these variables and tighten the constraints within which the Delta can be managed. Alternatives 1A–2C, 3, 4, and 5 would also increase resilience and adaptability to this uncertainty by providing additional management flexibility for in-Delta conditions.

In addition to added water management flexibility created by CM1, CM2–CM21 provide for actions that will improve habitat and reduce the effects of other stressors on the Delta ecosystem. By improving and expanding available habitat, the action alternatives increase resilience and adaptability to the climate changes described above by increasing the amount of alternative habitat that is available during periods of high stress such as very high or low freshwater inflow or very high salinity intrusion. By reducing other stressors on the Delta ecosystem, the action alternatives will improve the health of the ecosystem and of individual species populations making them stronger and more resilient to the potential variability and extremes caused by climate change. Below are some of the key ways in which CM2–CM11 improve resiliency and adaptability of aquatic resources in the Delta to climate change.

- Restoration of wetlands, floodplains, and riparian habitats will restore ecosystem services, including flow regulation, nutrient cycling, and sediment processes that enhance the functioning of aquatic habitats (Mitsch and Gosselink 2000).

- Increased wetland plant biomass, including belowground production, helps to promote accretion and the ability of the marsh to keep pace with sea level rise (Callaway et al. 2011; Parker et al. 2011).
- A wider and more extensive marsh plain in tidal wetlands and a wider floodplain in river systems increase protection of upland habitat from flooding and storm surges, which are projected to get worse with climate change (Cayan et al. 2008).
- Improved floodplain connections to rivers will restore the ability of floodplains to absorb flood flows and provide a reservoir of water to help aquatic species withstand droughts.
- Seasonally inundated floodplains provide more resilience from invasive species by increasing numbers and health of native species and excluding invasive species (Moyle et al. 2007).
- Restoration supports species diversity by providing a mosaic of habitats that can be used by different species that have evolved to use specific habitats.
- Wetland restoration will include networks of channels within marshes that are used by fish for foraging, refuge, and movement into and out of the marsh. Currently, such channels are rare (Parker et al. 2011).

Terrestrial Habitat and Species

Impacts

Sea level rise and hydrologic changes will also have potentially detrimental effects on important terrestrial habitat and species in the Delta. In addition to sea level changes, changes in average precipitation, and runoff timing (discussed above), there is one additional hydrologic effect of climate change that could result in impacts to terrestrial species in the Plan Area: increased incidence and magnitude of extreme precipitation events. This additional impact has not been included in the quantitative modeling analysis done for the project because there remains high levels of uncertainty about the scale of the effects and because project hydrologic and operations modeling was not conducted at a time step conducive to evaluating short duration extreme precipitation events.[4] Other analyses done for other purposes suggest that extreme precipitation events may become more frequent and larger in the future (Climate Action Team 2010; Dettinger 2011). While the effects of more extreme precipitation events are not included in the quantitative analysis, the effects on terrestrial species and potential for the action alternatives to improve or reduce resilience and adaptability to increased frequency and magnitude of extreme precipitation events are described here.

The remnant marshes of the Delta are habitat for several species listed under the Federal and State Endangered Species Acts such as California black rail and Mason's lilaeopsis. The Plan Area lies in a central portion of the Pacific Flyway and continues to provide vital migratory, wintering, and

[4] The hydrologic modeling done for the project was done on a monthly time step, as is typical for analysis of water management projects in California where flood protection is not a primary objective. However, extreme precipitation events often unfold over much shorter periods of time (usually 2–7 days). At a monthly time step, important details about how streamflows move through the system can be masked. Because flood protection is not a primary objective of the project, analysis at a more detailed time step in order to evaluate these effects in detail is not necessary. Nonetheless, qualitatively, high flow events becoming more frequent or larger in the future could increase the vulnerability of terrestrial species in the Plan Area under the No Action/No Project Alternative and under the action alternatives.

breeding habitat for migratory birds, especially in designated wildlife management areas (e.g., Suisun Marsh and Yolo Bypass), where habitat management is optimized for managed species, including waterfowl, shorebirds, and wading birds. Although waterfowl have been reduced in numbers, the Delta still provides habitat for 26 species of wintering waterfowl (Bay Institute 1998). The Pacific Flyway is also particularly important for shorebirds and neotropical migratory birds. Although fragmented, limited riparian habitat remains in the Delta. Remnant patches of tall riparian trees (e.g., Fremont cottonwood, western sycamore, Gooding's black willow) occur, but the reproduction of these species is greatly impaired by lack of active floodplain habitat and hydrologic modifications. Grasslands with vernal pools support high levels of endemic biodiversity in the Central Valley (Witham et al. 1998). This habitat type occurs in the northeast and southwest areas of the Delta.

Higher sea levels will inundate existing low lying terrestrial habitats described above, potentially destroying marshy and tidal habit and increasing species mortality or changes in distributions (California Department of Fish and Game 2010). Current Delta land use patterns, which devote most of the land to agricultural uses, provide habitat value for some species, but provide limited opportunities for migration of low lying terrestrial habitat as sea level rises. Terrestrial habit in the Delta is also likely to face higher risk of inundation or desiccation due to more extreme fluctuations in precipitation.

Resilience/Adaptation

The BDCP alternatives include measures to restore between 43,000 and 94,000 acres of new seasonally inundated floodplain, tidal wetland, valley/foothill riparian, grassland, vernal pool complex, and nontidal marsh habitat. Additionally, approximately 69,000 acres of natural communities would be protected and 20 or 40 miles of channel margin habitat would be enhanced. While the locations and specific characteristics of each of these restoration, enhancement, and protection activities are not yet fully known, the comprehensive analysis, selection, and implementation of these actions will allow resource managers to plan for habitat migration and transformation, providing greater resilience and adaptability to changing future conditions. Protection and restoration of a variety of natural communities will increase the patch size and connectivity of these habitats. Increasing patch size could increase population sizes of native species, which provides more resilience against a changing climate. Increasing connectivity allows more genetic exchange among populations and movement to more suitable habitats as environmental conditions change. The expansion of habitat will also provide greater resilience and adaptability ensuring that alternate habitats exist if habitats in some locations are destroyed or degraded by expected or unforeseen climate changes or catastrophic events. BDCP measures that restore and protect habitat will also assist in protecting and restoring upland refuges for terrestrial species affected by changes in tidal influence thereby increasing resiliency. These upland refuges may also provide added resiliency and adaptability to more extreme precipitation events such as droughts and floods. The additional habitat will likely provide more possibilities for alternative habitat locations that are less impacted during temporary inundation or desiccation periods. Restoration activities can also provide opportunities to contribute to climate change mitigation by increasing the carbon sequestration potential of these habitats.

29.3.2 Non-HCP/NCCP Alternatives (Alternatives 4A, 2D, and 5A)

29.3.2.1 No Action Alternative Early Long-Term

Climate change would be anticipated to change the conditions under which alternatives would be implemented. The impact analysis associated with each resource includes an evaluation of how the alternatives would affect the specific resource in question. In each of these analyses, where the effects of the alternatives are analyzed at the ELT (at 2025) and the LLT (at 2060), climate change is integrated into the analysis. In these analyses, the alternatives are evaluated using a projection of future climate that includes changes in temperature, precipitation, humidity, hydrology, and sea level rise. Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*, provides detailed information about the development of the climate change projections. Effects related to climate change would be anticipated to be smaller in magnitude in the ELT timeframe than in the late long-term.

29.3.2.2 Alternative 4A—Dual Conveyance with Modified Pipeline/Tunnel and Intakes 2, 3, and 5 (9,000 cfs; Operational Scenario H)

This section is organized differently from the other sections above because analyzing how Alternative 4A would affect the Delta's resiliency and adaptability to climate change is a fundamentally different analysis than those presented in other resource analyses. Whereas the other sections are organized to identify effects of Alternative 4A and how to mitigate any significant impacts, this section's function is to analyze and disclose how Alternative 4A would affect the Delta's resiliency and adaptability to expected climate change. While climate change is already ongoing and would occur under the ELT timeframe, effects of Alternative 4A on the resiliency and adaptability would be greater under LLT conditions as climate change effects are expected to be more pronounced.[5] Nevertheless, an assessment of conditions under the ELT timeframe is provided below.

As described Section 29.3.1, the impact analyses evaluated potential sea level increases of 6 inches (15 centimeters) in 2025, which is relevant to the early long-term timeframe considered for the purposes of Alternative 4A. Expected changes in precipitation and hydrology were also evaluated including earlier runoff as a result of warmer temperatures causing more precipitation to fall as rain instead of snow and the remaining snow melting earlier. These hydrologic changes will make water management more challenging and more constrained in the future and are expected to result in more years of critical dryness. DWR's modeling of future conditions suggests that with current management and operations, level of demand, and current climate, major CVP and SWP reservoirs could reach dead storage levels (the level below which water cannot be released) and that the likelihood of these critical conditions will increase substantially as the climate warms. In these instances, there would be critical water shortages leading to potentially extreme impacts on agriculture, municipal, industrial, and ecological water uses.

[5] The ELT timeframe is modeled at 2025. The LLT timeframe is modeled at 2060.

Alternative 4A would provide resiliency and adaptation benefits over the No Action/No Project alternative for dealing with the combined effect of increases in sea level rise and changes in upstream hydrology. As shown in Table 5-12 of Chapter 5, *Water Supply*, implementation of this alternative would result in Delta exports that either remain similar or increase in wetter years and decrease in drier years under Alternative 4A (ELT) as compared to exports under No Action Alternative (ELT) depending on the capability to divert water at the north Delta intakes during winter and spring months. Alternative 4A includes dual conveyance facilities, allowing water to be moved through the Delta when conditions permit and allowing water to be diverted from the Sacramento River in the northern Delta when conditions do not permit through Delta conveyance. Diversions at the proposed north Delta diversions would be allowed if Sacramento River inflows are adequate to protect downstream species habitat and water quality conditions. The location of the north Delta diversion facility is further inland making it less vulnerable to salinity intrusion. Even with substantial sea level rise and critically dry upstream conditions, salinity could be repelled from this location. By establishing an alternative diversion point for Delta exports, a great deal of Delta management flexibility is added. Currently, management of the Delta is constrained by requirements to maintain X2 at specific locations during certain times of the year to ensure water diversions have low salinity and to ensure that critical fish populations stay outside of the entrapment zone. Alternative 4A would allow the Delta to be managed in a number of different ways, including maintaining salinity as it is currently managed or allowing salinity to fluctuate more freely in the Delta as it did prior to the development of upstream reservoirs. This added flexibility would allow managers more options for adaptively managing the Delta so that conditions can be optimized to provide benefits across all Delta water uses and habitat conditions. Alternative 4A would also provide more reliable water supplies, which will provide additional resilience and adaptability to increases in water demand as a result of higher temperatures and increased evapotranspiration and evaporation.

In addition to added water management flexibility created by proposed water conveyance facilities, Alternative 4A includes Environmental Commitments 3, 4, 12, 15, and 16 that provide for actions that will improve habitat in certain areas and reduce the effects of stressors, though to a substantially smaller geographic extent than proposed under Alternative 4. By enhancing, restoring, and protecting habitat, Alternative 4A would increase resilience and adaptability to the climate changes described above by increasing the amount of habitat that is available during periods of high stress such as very high or low freshwater inflow or very high salinity intrusion. By creating a wider variety of water management options and restoring habitat, Alternative 4A can also help buffer potential negative effects of increased water temperatures thereby adding resiliency to increased water temperatures. More detail on existing temperature conditions in watersheds within the Delta and water temperature effects on aquatic habitat as well as biological and biochemical processes, and how managed flows influence water temperatures can be found in Chapter 11, *Fish and Aquatic Resources*.

Similarly, in consideration of terrestrial species, protection and restoration of a variety of natural communities will increase the patch size and connectivity of habitats. Increasing patch size could tend to increase population sizes of native species, which provides more resilience against a changing climate. Increasing connectivity allows more genetic exchange among populations and movement to more suitable habitats as environmental conditions change.

As described for Alternative 4, Alternative 4A would not be anticipated to add resiliency to existing levees; levee fragility would remain high and increase with time as in the No Action/No Project Alternative. However, Alternative 4A would provide additional adaptability to catastrophic failure of

Delta levees. By providing an alternate conveyance route around the Delta, this alternative provides a mechanism to continue making water deliveries to SWP/CVP contractors and local and in-Delta water users with conveyance interties even if the Delta were temporarily disrupted by a catastrophic levee failure.

Construction and operation of the proposed water conveyance facilities and implementation of Environmental Commitments under Alternative 4A would not affect the ability of agencies to implement plans and proactive measures associated with climate change resiliency. Accordingly, the project would be compatible with these federal and state plans to address climate change.

29.3.2.3 Alternative 2D—Dual Conveyance with Modified Pipeline/Tunnel and Intakes 1, 2, 3, 4, and 5 (15,000 cfs; Operational Scenario B)

This section is organized differently from the other sections above because analyzing how Alternative 2D would affect the Delta's resiliency and adaptability to climate change is a fundamentally different analysis than those presented in other resource analyses. Whereas the other sections are organized to identify effects of Alternative 2D and how to mitigate any significant impacts, this section's function is to analyze and disclose how Alternative 2D would affect the Delta's resiliency and adaptability to expected climate change. While climate change is already ongoing and would occur under the ELT timeframe, effects of Alternative 2D on the resiliency and adaptability would be greater under LLT conditions as climate change effects are expected to be more pronounced.[6] Nevertheless, an assessment of conditions under the ELT timeframe is provided below.

Alternative 2D would provide resiliency and adaptation benefits over the No Action/No Project alternative for dealing with the combined effect of increases in sea level rise and changes in upstream hydrology. The benefits would be similar to those anticipated under Alternative 4A and are primarily derived from the alternative's dual conveyance structure and location of the north Delta facility, which allow for more flexible water movement and protection from potential salinity intrusion. Alternative 2D would also provide more reliable water supplies and increased flexibility to adaptively manage the Delta so that conditions can be optimized across all Delta water uses and habitat conditions.

In addition to added water management flexibility, Alternative 2D includes several Environmental Commitments that will improve habitat in certain areas and reduce the effects of stressors. Provided benefits would be similar to those anticipated under Alternative 4A and include expanded habitat options during periods of high or low freshwater inflow, increased habitat connectivity, and potential buffers against rising water temperatures. Alternative 2D would also provide additional adaptability to catastrophic failure of Delta levees.

As described for Alternative 4A, Alternative 2D would not be anticipated to add resiliency to existing levees; levee fragility would remain high and increase with time as in the No Action/No Project Alternative. Similarly, construction and operation of the proposed water conveyance facilities and implementation of Environmental Commitments under Alternative 2D would not affect the ability of agencies to implement plans and proactive measures associated with climate change resiliency.

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[6] The ELT timeframe is modeled at 2025. The LLT timeframe is modeled at 2060.

Accordingly, the project would be compatible with these federal and state plans to address climate change.

29.3.2.4 Alternative 5A—Dual Conveyance with Modified Pipeline/Tunnel and Intake 2 (3,000 cfs; Operational Scenario C)

This section is organized differently from the other sections above because analyzing how Alternative 5A would affect the Delta's resiliency and adaptability to climate change is a fundamentally different analysis than those presented in other resource analyses. Whereas the other sections are organized to identify effects of Alternative 5A and how to mitigate any significant impacts, this section's function is to analyze and disclose how Alternative 5A would affect the Delta's resiliency and adaptability to expected climate change. While climate change is already ongoing and would occur under the ELT timeframe, effects of Alternative 5A on the resiliency and adaptability would be greater under LLT conditions as climate change effects are expected to be more pronounced.[7] Nevertheless, an assessment of conditions under the ELT timeframe is provided below.

Alternative 5A would provide resiliency and adaptation benefits over the No Action/No Project alternative for dealing with the combined effect of increases in sea level rise and changes in upstream hydrology. The benefits would be similar to those anticipated under Alternative 4A and are primarily derived from the alternative's dual conveyance structure and location of the north Delta facility, which allow for more flexible water movement and protection from potential salinity intrusion. Alternative 5A would also provide more reliable water supplies and increased flexibility to adaptively manage the Delta so that conditions can be optimized across all Delta water uses and habitat conditions.

In addition to added water management flexibility, Alternative 5A includes several Environmental Commitments that will improve habitat in certain areas and reduce the effects of stressors. Provided benefits would be similar to those anticipated under Alternative 4A and include expanded habitat options during periods of high or low freshwater inflow, increased habitat connectivity, and potential buffers against rising water temperatures. Alternative 5A would also provide additional adaptability to catastrophic failure of Delta levees.

As described for Alternative 4A, Alternative 5A would not be anticipated to add resiliency to existing levees; levee fragility would remain high and increase with time as in the No Action/No Project Alternative. Similarly, construction and operation of the proposed water conveyance facilities and implementation of Environmental Commitments under Alternative 5A would not affect the ability of agencies to implement plans and proactive measures associated with climate change resiliency. Accordingly, the project would be compatible with these federal and state plans to address climate change.

29.3.2.5 Delta Levee Stability and Reliability

Impacts

Whether increased sea levels are counteracted by increased outflows for salinity purposes or not, water levels in the Delta will rise as sea levels rise, placing additional stress on fragile Delta levees.

[7] The ELT timeframe is modeled at 2025. The LLT timeframe is modeled at 2060.

In addition, increased likelihood and magnitude of extreme precipitation events, as described above, could also increase the vulnerability of Delta levees. This impact is described in greater detail in Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies*. These levees not only protect farmland but maintain hydrodynamic conditions in the Delta. Western Delta levees serve a critical function of restricting the flow of saline water into the interior Delta, central Delta levees serve to direct freshwater inflows toward the south Delta pumping plants (reducing the amount of salinity that mixes with fresh water inflows). The additional stresses placed on these levees will increase the likelihood of levee failures, most notably from seepage and potentially result in catastrophic levee collapse. Depending on the location of the levee failure and hydrologic conditions at the time of the failure, a levee collapse could change the hydrodynamic balance in the Delta and lead to substantial salinity intrusion. Because the Delta serves as the conveyance system for SWP, CVP and local system exports and as the water source for in-Delta water users, a catastrophic levee collapse leading to salinity intrusion could interrupt water supplies to all of these water users for weeks or months while the levees are repaired and the salinity is flushed from the system. A catastrophic salinity intrusion could also have significant impacts on aquatic species as their habitat would also be affected.

Resilience/Adaptation

The action alternatives, with the exception of Alternative 9, would not add resiliency to existing levees; levee fragility would remain high and increase with time as in the No Action/No Project Alternative. However, Alternatives 1A–8 would provide additional adaptability to catastrophic failure of Delta levees. By providing an alternate conveyance route around the Delta, Alternatives 1A–8 provide a mechanism to continue making water deliveries to SWP/CVP contractors and local and in-Delta water users with conveyance interties even if the Delta were temporarily disrupted by a catastrophic levee failure. Alternative 9 adds additional resiliency to the Delta by strengthening and reinforcing levees critical to the through-Delta conveyance route, however, this alternative does not increase the adaptive capacity of the system.

29.3.3 Resiliency and Adaptability to Increased Temperature

29.3.3.1 Water Demand

Impacts

Increased air temperatures associated with climate change will lead to increased evapotranspiration that will increase the water demand for crops and vegetation (Anderson, et al, 2008). While additional factors such as increased CO_2, humidity, cloudiness, etc. will also influence water demand, agricultural water demand is expected to increase as a result of climate change (Climate Action Team 2010). Increased evaporation may also reduce water supplies in open water supply and conveyance facilities, such as canals and reservoirs.

Resilience/Adaptation

As shown in Table 29-5 below, modeling analysis of the action alternatives indicates that Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, and 5 improve water supply reliability (i.e., increase the long-term average of Delta exports), and will therefore, provide more reliable water supplies which will provide additional resilience and adaptability to increases in water demand as a result of higher temperatures and increased evapotranspiration and evaporation. Alternatives 6A, 6B, 6C, 7, 8, and 9 actually result in reduced water supply reliability and therefore provide reduced resilience and adaptability to the impacts of climate change.

Table 29-5. Long-Term Average Exports

Alternative	Total Delta Exports (thousand acre-feet)
No Action/No Project	4,441
Alternatives 1A, 1B, 1C	5,456
Alternatives 2A, 2B, 2C	5,068
Alternative 3	5,371
Alternative 4	–
Scenario H1	5,255
Scenario H2	4,710
Scenario H3	4,945
Scenario H4	4,414
Alternative 5	4,786
Alternatives 6A, 6B, 6C	3,758
Alternative 7	3,754
Alternative 8	3,098
Alternative 9	4,377
No Action ELT	4,728
Alternative 4A	4,917
Alternative 2D	5,381
Alternative 5A	5,166

29.3.3.2 Water Temperatures

Impacts

Warmer water temperatures are expected to decrease suitable summer habitat of delta smelt, a federally listed endangered species, because waters in the lower Delta may be too saline and lack food, and fresh water in the upper Delta may be too warm (California Department of Water Resources 2009). Warming of streams and rivers also facilitates colonization by invasive species that will compete for native species' habitat (Kaushal et al. 2010).

Resilience/Adaptation

By creating a wider variety of water management options and restoring habitat on a large scale, the project can help buffer potential negative effects of increased water temperatures thereby adding resiliency to increased water temperatures. More detail on existing temperature conditions in watersheds within the Plan Area and water temperature effects on aquatic habitat as well as biological and biochemical processes, and how managed flows influence water temperatures can be found in Chapter 11, *Fish and Aquatic Resources*. Additional information about the analysis methodology and modeling assumptions used in the analysis can be found in Appendix 29C, *Climate Change and the Effects of Reservoir Operations on Water Temperatures in the Study Area*.

29.4 Compatibility with Applicable Plans and Policies

This section provides an overview of federal and statewide efforts to prepare for and adapt to climate change. Regulations associated with the mitigation of GHG emissions (e.g., AB-32) are discussed in Chapter 22, *Air Quality and Greenhouse Gases*, Section 22.2, and are not repeated here.

Constructing the proposed water conveyance facilities (CM1) and implementing CM2–CM21 or any of the restoration activities could potentially result in incompatibilities with these plans and policies related to climate change. A number of plans and policies establish plans or guidance for resource protection, adaptation, and enhancement activities related to resources in the study area. This overview of plan and policy compatibility evaluates whether the action alternatives would be compatible or incompatible with such enactments. This analysis is not required by NEPA or CEQA, but is instead performed here to provide full disclosure regarding the potential impacts the proposed project could have on the Plan Area in the future. Note that as discussed in Chapter 13, *Land Use,* Section 13.2.3, state and federal agencies are not generally subject to local land use regulations; incompatibilities with plans and policies are not, by themselves, physical consequences to the environment.

29.4.1 Applicable Plans and Policies

29.4.1.1 Federal

Council on Environmental Quality

CEQ's Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions (2010)

On February 19, 2010, the Council on Environmental Quality (CEQ) issued draft NEPA guidance on the consideration of the effects of climate change and GHG emissions. This guidance advises federal agencies that they should consider opportunities to reduce GHG emissions caused by federal actions, adapt their actions to climate change effects throughout the NEPA process, and address these issues in their agency NEPA procedures. Where applicable, the scope of the NEPA analysis should cover the GHG emissions effects of a proposed action and alternative actions, as well as the relationship of climate change effects on a proposed action or alternatives. The CEQ guidance is still considered draft as of the writing of this document and is not an official CEQ policy document (Council on Environmental Quality 2010).

National Oceanic and Atmospheric Administration

Global Sea Level Rise Scenarios for the United States National Climate Assessment (2012)

This report was produced in response to a request from the U.S. National Climate Assessment Development and Advisory Committee. It provides a synthesis of the scientific literature on global sea level rise, and a set of four scenarios of future global sea level rise. The report includes input from national experts in climate science, physical coastal processes, and coastal management.

U.S. Environmental Protection Agency

Climate Ready Estuaries Program (ongoing)

U.S. Environmental Protection Agency's (EPA's) Climate Ready Estuaries program has four primary objectives related to climate change adaptation: 1) assess climate change vulnerabilities, 2) develop and implement adaptation strategies, 3) engage and educate stakeholders, and 4) share the lessons learned with other coastal managers. The program provides information and tools for managers to develop adaptation plans for estuaries and coastal communities. Resources published by the Climate Ready Estuaries program can provide guidance for adaptively managing estuaries in the Plan Area.

U.S. Forest Service

Re-Framing Forest and Resource Management Strategies for a Climate Change Context (2008)

This report provides a high-level, preliminary framework for developing forest and natural resource management strategies in response to climate change in western mountainous environments. The report summarizes an approach for developing adaptation and mitigation strategies using a "5-R strategy:" increase resistance, promote resilience, enable response, encourage realignment, and implement practices to reduce the human influence on climate. Strategies outlined in the document could provide potential approaches for responding to climate change impacts on forests in the Plan Area.

Climate Change Considerations in Project-Level NEPA Analysis (2009)

This guidance document provides initial Forest Service guidance on how to consider climate change in project-level NEPA analysis and documentation. This guidance document addresses how Forest Service management may influence climate change mainly through incremental changes to global pools of GHGs. This guidance will be revised as more scientific literature is published, climate change management experience is gained, and government policies are established.[8]

U.S. Department of Agriculture

2010–2015 Strategic Plan (2010)

The 2010–2015 Strategic Plan outlines future initiatives the U.S. Department of Agriculture will undertake to achieve its overall mission. Four strategic goals are outlined, of which one is to ensure that national forests and private working lands are made more resilient to climate change. Performance measures and strategies for meeting this objective are summarized in the Strategic Plan, and may be applicable to land management in the delta.

U.S. Department of the Interior

National Fish, Wildlife and Plants Climate Adaptation Strategy (ongoing)

The U.S. Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration, and the New York Division of Fish, Wildlife, & Marine Resources are developing a unified approach to maintaining the key terrestrial, freshwater and marine ecosystems needed to sustain fish, wildlife and plant resources and the services they provide in the face of accelerating climate change. This strategy will provide a unified approach—reflecting shared principles and science-based practices—

[8] Source: http://www.fs.fed.us/emc/nepa/climate_change/includes/cc_nepa_guidance.pdf.

for reducing the negative impacts of climate change on fish, wildlife, plants, and the natural systems upon which they depend.

WaterSMART (Sustain and Manage America's Resources for Tomorrow) (ongoing)

The WaterSMART program was established in February 2010 following passage of the SECURE Water Act, which authorizes federal water and science agencies to work together with state and local water managers to plan for climate change and the other threats to our water supplies. WaterSMART provides a framework for federal leadership and assistance on efficient water use, integration of water and energy policies, and coordination of water conservation activities. As the Department's main water management agency, Reclamation plays a key role in implementing the WaterSMART program. Improving water management and supplies through the project is a priority goal for the WaterSMART program. (Bureau of Reclamation 2013)

U.S. Fish and Wildlife Service

Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change (2010)

This report establishes a 5-year framework to analyze fish and wildlife conservation strategies associated with climate change. Adaption, which USFWS defines as "planned, science-based management actions," forms the core of the Strategic Plan. The primary purpose of the Strategic Plan is to identify adaptive responses to climate change through the strategic conservation of terrestrial, freshwater, and marine habitats. USFWS will implement the Strategic Plan during the next five years. To the extent that USFWS actions target ecosystems in the Delta, climate change resiliency in the Plan Area may be improved.

National Fish, Wildlife, and Plants Climate Adaptation Strategy (2013)

The overarching goal of the National Fish, Wildlife, and Plants Climate Adaptation Strategy is to "inspire, enable, and increase meaningful action that helps safeguard the nation's natural resources in a changing climate." The strategy describes current and expected impacts of climate change on major ecosystems in the United States, and describes steps that can be taken to reduce these impacts. The actions proposed by the strategy address the following seven goals: 1) conserve and connect habitat, 2) manage species and habitats, 3) enhance management capacity, 4) support adaptive management, 5) increase knowledge and information, 6) increase awareness and motive action, and 7) reduce non-climate stressors.

U.S. Army Corps of Engineers

Climate Change Adaptation Plan and Report (2011)

The purpose of this report is to develop practical and cost effective measures to reduce the vulnerability of national water conveyance infrastructure to climate change. Strategies for adaptive planning, design, construction, and maintenance are identified. The document also provides a framework for performing a vulnerability assessment.

29.4.1.2 State

Relevant State Executive Order and California Water Code Section

Executive Order S-13-08

This Executive Order requests that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate an independent sea level rise science and policy committee made up of state, national and international experts. It requires that all state agencies that are planning construction projects in areas vulnerable to future sea level rise shall consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. The order does not specify sea level rise scenarios, but it is worth noting that sea level rise projections for California of 16 inches (41 centimeters) by 2050 and 55 inches (140 centimeters) by 2100 have been considered and/or used by multiple state agencies in impacts analyses and policy development. The executive order also tasks the California Natural Resource Agency to coordinate the development of a statewide climate change adaptation strategy which resulted in the 2009 *California Climate Adaptation Strategy*.

California Water Code Section 85320 (b)(2)(C)

As noted earlier, Water Code Section 85320 (b)(2)(C) requires that, to be a part of the Delta Plan, the EIR must analyze the potential effects of climate change, possible sea level rise up to 55 inches (140 centimeters) (the high end of the projected range in sea level rise), and possible changes in total precipitation and runoff patterns on the conveyance alternatives and habitat restoration activities considered in the Plan Area.

California Department of Water Resources

Managing an Uncertain Future; Climate Adaptation Strategies for Water (2008)

This report summarizes adaptation strategies that can be used by state and local water managers to improve the resiliency of the California water resources. The strategies are organized at the regional and state level and focus on investment planning and decision-making. The report was developed by DWR as part of the process of updating the California Water Plan, and was the basis for the water section of the 2009 *California Climate Adaptation Strategy*.

California Water Plan Update (2009)

Chapter 4 of Volume 2 of the California Water Plan (California Department of Water Resources 2010c) focuses on the Delta. In this chapter, DWR highlights the need for adaptation strategies to improve the flexibility of water conveyance and storage. Improving water management will enable operators to store large volumes of water during periods of high flow for use during periods of low flow when water supply allocations are more competitive. In addition, streams and channels enlarged for conveyance and flood passage may incorporate riparian habitat improvements that are designed for varying hydrology and water management operations. Delta conveyance improvements incorporate flexibility that allows for increased water supply reliability of Delta supplies in light of climate change.

Central Valley Flood Protection Plan (2012)

Due to recent legislation, DWR is currently implementing the Central Valley Flood Management Program (CVFMP), which involves the preparation of a Central Valley Flood Protection Plan (CVFPP). The CVFPP outlines an approach for addressing climate change considerations for flood management in the Central Valley (California Department of Water Resources 2011). The following are relevant documents developed as part of the 2012 CVFMP that present climate change adaptation strategies for flood management.

- *2012 Central Valley Flood Protection Plan, Climate Change Scope Definition Work Group Summary Report.*
- *2012 Central Valley Flood Protection Plan, Climate Change Threshold Analysis Work Plan—Draft Technical Memorandum.*

Future management measures developed as part of the 2012 CVFMP and associated documents will have direct effects on the hydrology of the Bay-Delta system within the Plan Area.

California Department of Fish and Wildlife

Unity, Integration, and Action: CDFW's Vision for Confronting Climate Change in California (2011)

The California Department of Fish and Wildlife's (CDFW's) framework for addressing climate change adaptation seeks to protect California's natural resources without compromising the economy. The framework embodies CDFW's commitment to minimizing negative effects of climate change on the state ecosystems through the development of adaptation measures that provide clear benefits to terrestrial and marine ecosystems. CDFW is acutely aware of the uncertainties associated with emerging climate science and is taking an approach that will allow CDFW to be both proactive and adaptive through the use of a variety of planning tools and strategic initiatives. Specifically, their adaptive management framework will allow for the continual improvement and adjustment of management practices based on new information.

California Department of Food and Agriculture

California Agricultural Vision: Strategies for Sustainability (2010)

California Agricultural Vision (Ag Vision) was created by the California Department of Food and Agriculture (CDFA) and the State Board to address challenges associated with sustainable agriculture. The State Board has endorsed several actions to assure agricultural adaptation to climate change. In particular, research is currently being conducted to determine the most likely impacts of climate change on agriculture, and to propose strategies to help agriculture adapt to and benefit from these changes. Strategies developed as part of Ag Vision's research may benefit agriculture in the delta.

California Department of Public Health

Climate Change and Public Health: Building Healthy Communities and a Healthy Planet (ongoing)

California Department of Public Health (DPH) has developed a four-part webinar series to educate health professionals on how climate change will impact health across California, especially within vulnerable communities. The webinar provides tools to communicate the need for action at the local level. The webinars also share how cities and counties throughout California are planning for climate change and how health and equity can be integrated into those efforts. Assistance provided by DPH may help buffer delta communities from changes in climate.

California Natural Resources Agency

California Climate Change Adaptation Strategy (2009) and Safeguarding California Plan (2014)

In cooperation and partnership with multiple state agencies, the 2009 *California Climate Adaptation Strategy* summarizes the best known science on climate change and provides recommendations on how to manage against those threats. The report provides an update on the expected climate risks to California, prioritizes solutions to addressing these risks, and develops an implementation plan for minimizing risks. The adaptation strategy will reduce California's vulnerability to known and projected climate change impacts. The California Natural Resources Agency updated the 2009 *California Climate Adaptation Strategy* with release of the 2014 Safeguarding California Plan. The plan augments previously identified adaption strategies in light of advances in climate science and risk management options

California Department of Forestry and Fire Projection

CAL FIRE Report on Adaption Strategies for Forestry (2008)

This report reviews many of the observed and forecasted impacts to California forests and rangelands as a result of climate change. The document proposes a framework for developing adaptation strategies. More specifically, the report identifies an initial strategy for integrating adaptation into future forest management. Strategies outlined in the document could provide potential approaches for responding to climate change impacts on forests in the Plan Area.

CALFED Bay-Delta Program

Independent Science Board Memorandum (2007)

CALFED Independent Science Board (ISB) is a multidisciplinary panel that provides guidance on climate change and water issues. The CALFED ISB recently prepared a memo recommending appropriate sea level rise projections for ongoing delta planning. In addition, the CALFED Science Program has funded an effort to develop a model-based approach for evaluating plausible future scenarios of the Bay-Delta-River-Watershed system. The outcome is intended to be a strategic planning tool to CALFED agency managers and decision-makers in meeting future delta resource management goals.

Delta Protection Commission

2006–2011 Strategic Plan (2006)

The Delta Protection Commission's (DPC's) Strategic Plan is intended to protect and enhance the Delta's resources. The document summarizes current and future threats to the Delta, including changes in climate. In particular, the document identifies sea level rise as a central threat facing the future integrity of the Delta.

Ocean Protection Council

Sea Level Rise Task Force Interim Guidance Document

This document provides guidance for incorporating sea-level rise projections into planning and decision making for projects in California. Its underlying premise is that sea level rise potentially will cause many harmful economic, ecological, physical and social impacts and that incorporating sea level rise into agency decisions can help mitigate some of these potential impacts. For example, sea level rise will threaten water supplies, coastal development, and infrastructure, but early integration of projected sea level rise into project designs will lessen these potential impacts.[9]

California Department of Transportation

Climate Change Adaptation Hot Spot Map (ongoing)

The Climate Change Adaptation Hot Spot Map is a GIS-based assessment of transportation infrastructure vulnerabilities using available data and studies and to identify critical transportation hotspots. Such hotspots are areas of increased vulnerability to the effects of climate change due to their location near population centers that depend on transportation infrastructure for essential services; are heavily traveled, so a compromise in infrastructure would affect large numbers of individuals; or are particularly situated geographically to be heavily impacted by climate effects (e.g., on the coast in an area that could be inundated by rising sea levels). This research will also result in the development of a climate vulnerability plan that will assess the level and type of transportation infrastructure vulnerability, the adaptation options and strategies, and a framework for prioritizing implementation efforts. California Department of Transportation (Caltrans) will develop a framework for prioritizing implementation efforts throughout the Delta and California.

Addressing Climate Change Adaptation in Regional Transportation Plans: A Guide for California MPOs [Metropolitan Planning Organizations] and Regional Transportation Plans Agencies (ongoing)

The 2010 Regional Transportation Plans Guidelines currently provide little direction for regions to analyze and address climate change adaptation. This effort will provide the data to develop a clear methodology for regional agencies to address climate change impacts through adaptation of transportation infrastructure. The purpose of this manual is to expand knowledge and develop tools that will assist California MPOs and Regional Transportation Plans. As with incorporating climate change impacts into planning, design, engineering, and operational decisions. The final product will be a literature review of adaptation, best practices for regional agencies, and available adaptation measures for transportation infrastructure.

29.4.2 Compatibility Evaluation

The USFWS, EPA, U.S. Forest Service, U.S. Department of Agriculture, U.S. Department of the Interior, U.S. Army Corp of Engineers, CVFMP, DWR, CDFW, CDFA, DPH, California Natural Resources Agency, California Department of Forestry and Fire Protection, Delta Protection Commission, and Caltrans have developed frameworks or initiatives to ensure their respective resources are made more

[9] Source: http://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20110311/12.SLR_Resolution/SLR-Guidance-Document.pdf.

resilient to climate change. Construction and operation of the proposed water conveyance facilities and implementation of other conservation measures would not affect the ability of these agencies to implement these plans and proactive measures. Accordingly, the project would be compatible with these federal and state plans to address climate change.

The CEQ has prepared draft guidance on how federal agencies should consider the effects of climate change in their evaluation proposals. 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 CEQA guidance on climate change.

Executive Order S-13-8, California Water Code, Section 85320 (b)(2)(C), CALFED *Independent Science Board Memorandum,* and the OPC Sea Level Rise Task Force *Interim Guidance Document* address expected risk and vulnerability to future sea level rise in California. The Water Code specifically requires that, to be a part of the Delta Plan, the EIR must analyze the potential effects of climate change, possible sea level rise up to 55 inches (140 centimeters) (the high end of the projected range in sea level rise), and possible changes in total precipitation and runoff patterns on the conveyance alternatives and habitat restoration activities considered in the Plan Area. Given the inherent variability in anticipated future scenarios, a broad range of potential sea level changes (from 6 to 55 inches [15 to 140 centimeters]) was analyzed (see Appendix 5A, *BDCP/California WaterFix FEIR/FEIS Modeling Technical Appendix*). Because potential effects of sea level rise on the project were analyzed as part of this analysis, the project is considered compatible with applicable sea level rise guidance documents.

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