12 CLIMATE CHANGE

12.1 REGIONAL CLIMATE

The region lies in the semipermanent high-pressure zone of the eastern Pacific, resulting in a mild climate characterized by warm, dry summers and cool, wet winters tempered by cool sea breezes with light average wind speeds. Monthly precipitation totals indicate the defined wet-dry seasonal pattern characteristic of coastal California locations. Most rainfall occurs during the late fall, winter, and early spring (November through March), with small amounts of rainfall during the late spring, summer, and early fall (April through October). When the latitude of the Pacific jet stream storm track decreases in winter and it maintains a position over the Southern California region, multiple successive storms can pass over the watershed. Summer storms are usually transported into the region from continental Mexico or as tropical storms off the west coast of Mexico Annual precipitation totals for the area may vary substantially from year to year due to movements in the Pacific jet stream. However, the average annual precipitation for the region is about 12 inches (USACE 2001d).

12.2 CLIMATE CHANGE

Climate change is defined as a shift in the average weather in particular region that is measured by changes in the features associated with weather, such as, temperature, wind patterns, precipitation, and storms. The Earth's climate has always been changing; however, the current climate change differs from previous climate change in terms of both its rate and its magnitude.

Naturally occurring components of the Earth's atmosphere, primarily water vapor, carbon dioxide, methane, and nitrous oxide absorb heat radiated from the Earth's surface, warming the atmosphere in a process known as the *greenhouse effect*. These same gases trap heat in the atmosphere and are referred to as greenhouse gases (GHG). Human activities are exerting a major and growing influence on some of the key factors that govern climate by changing the composition of greenhouse gases in the atmosphere and modifying the land surface. For example, the concentration of carbon dioxide in the atmosphere has increased approximately 30 percent since the late 1800s (Cal/EPA 2006).

California produces roughly 1.4 percent of the world's greenhouse gases and 6.2 percent of the total greenhouse gases in the United States. The effects of climate change on the hydrology of California, which are already being seen, include a reduction in mountain snowpack and glacial volume, an increase in the intensity of storms, an increase in the temperatures of natural waters, sea level rise, and high variability in river flows. Planning for and adapting to the consequences of these

hydrological changes, including impacts on public safety, ecosystems, and long-term reliability of the water supply, pose significant challenges for water managers throughout Southern California.

The Sierra snowpack provides as much as 65 percent of California's water supply by accumulating water in the form of snow during the wet winters and releasing it slowly when it is needed during the dry springs and summers. Warmer temperatures will cause the accumulated snow to melt faster and earlier, making it more difficult to store and use. By 2050, scientists project a loss of at least 25 percent of the Sierra Nevada snowpack, (California Climate Change Center 2009) means less water will be available for Californians to use. These effects of climate change are expected to continue in the future, and more of the precipitation will likely fall as rain instead of snow. This potential change in weather patterns will exacerbate flood risks and pose additional challenges in terms water supply reliability.

Climate change is also expected to result in more variable weather patterns throughout California, which can lead to longer and more severe droughts. In addition, the sea level will continue to rise, threatening the sustainability of the Sacramento–San Joaquin Delta, the heart of the California water supply system and the source of water for 25 million Californians and millions of acres of prime farmland (California Climate Change Center 2009).

The collaborative process of water management through IRWM planning provides a good framework for addressing the many effects of climate change on the water supply. This chapter of the IRWMP describes how the effects of climate change are considered with respect to the region's water management planning.

12.3 POTENTIAL EFFECTS OF CLIMATE CHANGE ON CENTRAL ORANGE COUNTY WATERSHED MANAGEMENT AREA

The Central Orange County WMA imports its water from Northern California, making the region susceptible to the effects of climate change. Central Orange County water planning must account for adaptations to changes in the amount, intensity, timing, quality, and variability of regional runoff and recharge due to changes in climate.

The effects of climate change most likely to affect the region are the following (Hanak and Lund 2008):

- Rise in sea level
- Changes in runoff from mountain snowpack due to higher temperatures

- Changes in average runoff volume due to changes in precipitation and temperature
- Changes in drought persistence
- Increase in water temperature in streams and reservoirs
- Increase in water demands due to higher temperatures and increased carbon dioxide concentrations
- Increase in flood flows and flood frequencies

12.3.1 Rise in Sea Level

Flooding and erosion already pose a threat to communities along the California coast, including Orange County, and there is compelling evidence that these risks will increase in the future. Based on a set of climate scenarios prepared for the California Energy Commission's Public Interest Energy Research (PIER) Climate Change Research Center, Cayan et al. (2009) projected that, under scenarios with medium to medium-high greenhouse gas emissions, mean sea level along the California coast will rise from 1.0 to 1.4 meters by the year 2100.

The rise in sea level could alter the habitat mix in Newport Bay by reducing the acreage of marsh habitat. It could also extend the tidal influence upstream in coastal creeks and reduce the flood conveyance capacity of coastal creeks.

In 2000, an estimated 72,000 Orange County residents lived in areas vulnerable to a 100-year flood event, the highest number for any California county (Cayan et al, 2009). It is estimated that a 1.4-meter sea level rise will increase the number of people vulnerable to a 100-year flood event to 110,000 (California Climate Change Center 2009).

A rise in sea level has implications not only for coastal areas but also for the management of the Sacramento–San Joaquin Delta, an area that is a critical component of central Orange County's current water supply system. A rise in sea level will increase the elevation of salt water at the delta's western end, which will increase the risk of levee failure and seawater intrusion into the delta's fresh water. Effects of sea level rise on the water supply are also likely in some coastal aquifers. A sea level rise could increase coastal erosion and affect coastal ecological resources such as estuaries and tidal wetlands.

12.3.2 Changes in Mountain Snowpack Runoff

One of the most critical impacts on California water management may be the projected reduction in the Sierra Nevada snowpack, California's largest surface "reservoir." Snowmelt currently provides an annual average of 15 million acre-feet of water, slowly released between April and July of each year. Rising average temperatures throughout California will ultimately reduce the amount of mountain snowpack because more precipitation will fall as rain instead of snow and warmer weather will cause more snowpack to melt earlier in the year. The average early spring snowpack in the Sierra Nevada decreased by approximately 10 percent during the last century, a loss of 1.5 million acre-feet of snowpack storage (CNRA 2008a).

Much of the state's water infrastructure was designed to capture the slow spring runoff and deliver it during the drier summer and fall months. Based on historical data and modeling, DWR predicts that the Sierra Nevada snowpack will be reduced by 25 to 40 percent relative to its historical average by 2050 (California Climate Change Center 2009). Climate change is also anticipated to bring warmer storms that result in less snowfall at lower elevations, reducing the total snowpack. Reservoirs and groundwater basins that lie downstream of mountain snowpacks will likely experience large variations in water inflows, resulting in an overflow of storage volume at some times and drought conditions at other times.

12.3.3 Changes in Average Runoff

Although the effects of climate change on overall precipitation and runoff are less clear, they are of great potential importance. The existing amount of surface storage in most major streams and water storage reservoirs in Southern California provides a fair amount of capacity to accommodate shifts in inflows during most years. However, any reduction in annual runoff volumes due to decreases in precipitation or increases in evapotranspiration in reservoirs or the broader watersheds would directly reduce water supplies.

12.3.4 Changes in Drought Persistence

Droughts differ from typical emergency events such as floods or forest fires, in that they occur slowly over a multiyear period. Drought impacts increase with the duration of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline. Droughts in the western United States are often persistent. The 2009 water year (October 1, 2008–September 30, 2009) was the third consecutive year of below average precipitation for the state. Annual statewide precipitation totaled 76 percent, 72 percent, and 63 percent of average for water years 2009, 2008, and 2007, respectively As of June of the 2010 water year, statewide precipitation was below normal for a third year. Several key reservoirs dropped to

near historical lows. Statewide water storage remains below average, affecting supply, recreation, and hydropower generation.

12.3.5 Increase in Water Temperature in Streams and Reservoirs

Higher overall temperatures will increase water temperatures throughout the system, including the temperature of inflows into reservoirs, water stored within reservoirs, and water flowing downstream. Such increases will significantly affect ecosystem and human uses of the water system. Most species have evolved to survive within a specific temperature range. Increased water temperature can also reduce the amount of dissolved oxygen in the water, affecting macro- and microorganisms alike.

12.3.6 Increase in Water Demands

Higher ambient temperatures and increases of carbon dioxide in the air are likely to also change water demands throughout the state. These effects will vary considerably depending on other changes in the regional and global economy, population, and land use. The most important effect is likely to be on agricultural water demands, because higher temperatures generally increase the rate of evapotranspiration.

Urban water demands may also be affected by climate change. Increases in the rate of evapotranspiration and the length of the growing season are likely to increase the consumption of water for landscaping, which accounts for at least half of the residential water use in Southern California.

12.3.7 Increase in Flood Frequencies and Flows

Increased intensity and frequency of major storms, another anticipated effect of climate change, would further augment flood problems in Southern California. With continued increases in floodplain urbanization and the associated increase in damage potential, flooding costs due to climate change could exceed those of importing water to the southern California region. The effects of changes in flood flows on ecosystems are less well studied but could be significant.

12.4 LEGISLATIVE AND POLICY CONTEXT

There are three main pieces of policy and legislation that deal with climate change in California. Executive Order S-3-05 and the California Global Warming Solutions Act of 2006 (Assembly Bill 32,; amending California Health and Safety Code Division 25.5, Section 38500, et seq.) laid the foundation for California's response to climate change. Senate Bill 97, signed by the governor on August 24, 2007, initiated formal changes to the CEQA Guidelines, which provides guidance for the way climate

change is analyzed in CEQA documents, by adding Section 21083.05 to the Public Resources Code.
Executive Order S-3-05 made California the first state to formally establish reduction goals for greenhouse gas emissions. It includes the following reduction targets for greenhouse gas emissions in California:

- By 2010, a reduction to 2000 levels
- By 2020, a reduction to 1990 levels
- By 2050, a reduction to 80 percent below 1990 levels

The final emission target of 80 percent below 1990 levels would put the state's emissions in line with estimates of the required worldwide reductions needed to bring about long-term climate stabilization and avoidance of the most severe impacts of climate change (IPCC 2007).

Assembly Bill 32 further details and codifies the mid-term greenhouse gas reduction target established in Executive Order S-3-05. Assembly Bill 32 also identifies the California Air Resources Board (CARB) as the state agency responsible for the design and implementation of emissions limits, regulations, and other measures to meet the target.

Senate Bill 97 directed the governor's Office of Planning and Research to develop CEQA Guidelines amendments for the analysis of climate change in CEQA documents for CNRA approval.

12.5 POTENTIAL EFFECTS OF CLIMATE CHANGE

The Integrated Regional Water Planning Act (California Water Code, Section 10541(e)(10)) states that IRWMPs must include an evaluation of the adaptability of water management systems in the region to climate change. However, tools for properly assessing the risk of any one effect of climate change on a region have not been developed, and the abilities of different regions to use these tools vary considerably.

Local governments and agencies within the Central Orange County WMA play an essential role in achieving California's emissions reduction targets and reducing the local effects of climate change in the region. Local governments have broad influence and, in some cases, exclusive authority over activities that contribute to significant direct and indirect greenhouse gas emissions through their planning and permitting

processes, local ordinances, outreach and education efforts, and municipal operations.

Land use planning and urban growth decisions are also areas where successful implementation of climate change strategies relies on local government. Local governments have primary authority to plan, zone, approve, and permit how and where land is developed to accommodate population growth and the changing needs of their jurisdictions. Decisions about land use will have significant impacts on the greenhouse gas emissions that will result from the transportation, housing, industry, forestry, water, agriculture, electricity, and natural gas sectors.

A *resource management strategy* is a project, program, or policy that helps local agencies and governments manage their water and water-related resources (CNRA 2009a). Section 5 of this IRWMP outlines a comprehensive and diverse set of resource management strategies to help meet the water-related management needs of the region. These strategies can be combined in various ways to achieve the water management objectives of the region. Future decisions will factor in strategies for adapting to and mitigating climate change impacts.

The Central Orange County WMA stakeholders understand that the region's water supply depends on the amount, intensity, timing, quality, and variability of runoff and recharge, as well as on water imported from outside the region. Therefore, the Central Orange County WMA stakeholders are committed to addressing the effects of climate change on the region's water supply by incorporating climate change considerations into the region's resource management strategies. Likewise, as IRWM projects are developed and selected for implementation, the ability of the projects to adapt to the effects of climate change will be considered in the project review process (see Section 6).

Among the various sources of information on climate change, the IRWMP Stakeholder Group considered the following three documents during the development of resource management strategies and the selection of projects.

The Climate Change Scoping Plan that was adopted by CARB in 2008 discusses different business sectors including water management and recommends specific strategies that may help reduce greenhouse gas emissions (Cal/EPA 2008).

DWR published a white paper urging a new approach to managing California's water resources and other natural resources in the face of climate change (CNRA 2008b).

The recommendations in the white paper were incorporated into Volume 1, Chapter 7, of California Water Plan Update 2009 (CNRA 2009a).

The California Natural Resources Agency (CNRA published a report that discusses statewide and sector-specific vulnerability assessments (CNRA 2009b). CNRA and the California Energy Commission have released Cal-Adapt, a web-based climate change adaptation tool that enables city and county planners, government agencies, and the public to identify potential climate change risks in specific areas throughout California. Cal-Adapt combines volumes of climate change research and presents it in a visually graphic, accessible, and intuitive format intended to benefit local planning efforts as well as inform California citizens of the potential impacts of climate change.

When it comes to water management considerations, water managers must include both adaptation and mitigation into their planning strategies. *Adaptation* refers to the ways in which our society and culture will need to change to cope with a changing climate. Several of the resource management strategies and projects in this IRWMP will help the region adapt to climate change.

Mitigation refers to the reduction of greenhouse gas emissions resulting from water-related energy use. Water management results in the consumption of significant amounts of energy in California and the accompanying production of greenhouse gas emissions, especially where water must be pumped from long distances, from the ground, or over significant elevations. Water utilities use energy to reliably provide high-quality water to customers, while wastewater utilities in turn use energy to safely collect, treat, and dispose of wastewater to protect public health and the environment. The reduction of greenhouse gas emissions is a critical responsibility of water managers, and efficiency in water and energy use should be pursued at every opportunity. At the same time, water provides California with hydroelectric power, the state's largest source of energy that is free of greenhouse gas emissions.

The Central Orange County IRWM stakeholders are aware of the potential detriment to the region that would result from inaction on climate change, including the costs. A warming California climate would generate more smoggy days by contributing to ozone formation while also fostering more large brush and forest fires. Continuing increases in global greenhouse gas emissions at current rates would result, by late in the century, in a 90 percent loss of the Sierra Nevada snowpack in California, a sea level rise of more than 20 inches, and a three- to four-fold increase in heat wave days. These impacts will translate into real costs for California, including flood damage and

flood control costs that could amount to several billion dollars in many regions. Water supply costs due to scarcity and increased operating costs would also increase.

A failure to address climate change also carries with it the risk of substantial public health costs, primarily as a result of rising temperatures. Sustained triple-digit heat waves increase the health risk for several segments of the population, especially the elderly. But higher average temperatures will also increase the interactions of smog-causing chemicals with sunlight and the atmosphere to produce higher volumes of toxic byproducts than those that would otherwise occur. Low-income communities are disproportionately affected by climate change, lacking the resources to avoid or adapt to these impacts. For example, low-income residents are less likely to have access to air conditioning to prevent heat stroke and death during heat waves. Taking action to help mitigate the impacts of climate change will help reduce the rate of the temperature rise. This in turn will likely result in fewer premature deaths from respiratory and heat-related causes and many thousands fewer hospital visits and days of illness (Cal/EPA 2008).

As more information about the effects of climate change on the region becomes available and as new technologies are developed to reduce or offset the impacts, the Central Orange County WMA stakeholders will revise and update this IRWMP accordingly.

12.6 ANALYSIS OF GREENHOUSE GAS EMISSIONS

Because greenhouses gas emissions are directly related to the effects of climate change, the Central Orange County IRWM stakeholders are dedicated to analyzing the greenhouse gas emissions associated with potential projects and providing the results to all stakeholders before selecting projects for implementation.

12.6.1 CEQA Project-Level Analysis

On March 8, 2010, CNRA implemented the Climate Change amendments to the CEQA Guidelines for greenhouse gases that were developed by the governor's Office of Planning and Research in accordance with Senate Bill 97. The CEQA Guidelines amendments for greenhouse gas emissions fit within the existing CEQA framework for environmental analysis, which calls for lead agencies to determine baseline conditions and levels of significance and to evaluate mitigation measures. The CEQA Guidelines amendments do not identify a threshold of significance for greenhouse gas emissions nor do they prescribe assessment methodologies or specific mitigation measures. The CEQA Guidelines amendments encourage lead agencies to consider many factors in performing a CEQA analysis but preserve the discretion that CEQA

grants lead agencies to make their own determinations based on substantial evidence.

These CEQA project-level analyses in the area of climate change may provide the IRWM Stakeholder Group with a means of disclosing and evaluating the greenhouse gas emissions associated with various project alternatives. In analyzing project-level greenhouse gas emissions, project proponents should estimate greenhouse gas emissions expected from the project, establish significance criteria, identify those project components that may supply carbon sequestration, and, if applicable, explain how the project may help reduce the effects of climate change.

Emission sources typically applicable to projects that may result in a reduction of greenhouse gases include the following:

- Operation of construction equipment
- Passenger vehicle trips during construction and operation
- Transport of construction materials and equipment
- Transport of material inputs for operation and maintenance
- Transport of material outputs or production
- Generation of electricity used for project operation
- Waste generation and disposal of materials during construction and operation

Where appropriate, project analysis will consider all known applicable BMPs or other mitigation measures to reduce greenhouse gas emissions. In considering the appropriate level of analysis for a specific project, the project proponent may use the Office of Planning and Research Technical Advisory on CEQA and Climate Change (OPR, 2011), the California Air Pollution Control officers Association white paper (CAPCOA, 2008), CARB's early action measures, the six key elements and the 39 measures for greenhouse gas reduction in the Climate Change Scoping Plan (Cal/EPA 2008), the California Attorney General's Office website (www.oag.ca.gov), and other relevant studies and resources.

12.6.2 California Climate Action Registry

As part of future climate change planning, the IRWMP Stakeholder Group will consider joining the California Climate Action Registry (CCAR), http://www.climateregistry.org. The CCAR is a private nonprofit organization that serves as a voluntary greenhouse gas registry to protect and promote early actions by organizations to reduce greenhouse gas emissions. Participation in this registry

allows access to tools and consistent reporting formats that may promote an understanding of the region's greenhouse gas emissions and ways to reduce them.

12.6.3 Reporting Protocol for Greenhouse Gas Emissions

For assessments of project-level greenhouse gas emissions, the analysis of greenhouse gases will use an emissions reporting protocol developed by the World Resources Institute in cooperation with the World Business Council for Sustainable Development. This protocol was used as the basis for the CCAR. The World Resources Institute established emissions reporting protocols guidelines for voluntary accounting of greenhouse gas emissions and provide a peer-reviewed and widely accepted methodology for calculating greenhouse gas emissions. The World Resources Institute has also published several calculation tools to simplify and document the procedure (http://www.ghgprotocol.org/calculationtools/all-tools). In general, the protocols describe to the process for estimating emissions from mobile combustion sources, electricity consumption, and industrial processes. Both the state and the federal government require reporting of emissions for regulated entities that emit 25,000 metric tons of carbon dioxide or more per year.

Once the emissions from a proposed project have been determined, the CEQA lead agency must assess the impacts of these emissions and make a determination of significance. A threshold of significance is used to gauge the project effects. The threshold of significance may be a quantitative, qualitative, or performance level of a particular environmental effect above which the impacts will normally be considered significant. Three basic strategies have been outlined in the technical guidance documents published to date: (1) establish a significance threshold of net-zero, (2) establish a non-zero significance threshold based on compliance with Assembly Bill 32, and (3) other established strategies for reducing greenhouse gases.