Section O

Climate Change

Section O - Climate Change

O.1 Introduction

The act of planning, by nature, requires an estimation of future conditions. Unlike other types of resource planning, which use historical measurements to estimate future conditions, climate change planning requires the use of computer simulations to predict future climate conditions. These predictions are then used to shape the development of projects and programs to mitigate and adapt to climate change. Per Proposition 84 and California Department of Water Resources (DWR) requirements, this chapter considers the ways in which climate change may impact the Tule River Basin IRWMP area.

This section begins with a brief description of the relationship between greenhouse gasses and climate change, an account of climate change trends, both globally and within the IRWMP area, and an analysis of the region's vulnerabilities related to these trends via a climate change vulnerability assessment. The section concludes with a prioritized list of vulnerabilities in the planning area and a description of how climate change adaption and mitigation measures are integrated into the plan's resource management strategies and project selection process.

O.2 Greenhouse Gasses and Climate Change

Natural processes and human activities emit greenhouse gases. The presence of GHGs in the atmosphere affects the earth's temperature. Without the natural heat-trapping effect of GHGs, the earth's surface would be about 34ºC cooler. However, it is believed that emissions from human activities, such as electricity production and vehicle use, have elevated the concentration of these gases in the atmosphere beyond the level of naturally occurring concentrations.

The effect of greenhouse gasses on earth's temperature is equivalent to the way a greenhouse retains heat. Common GHGs include water vapor, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydro chlorofluorocarbons, and hydro fluorocarbons, per fluorocarbons, sulfur and hexafluoride. Some gases are more effective than others. The Global Warming Potential (GWP) has been calculated for each greenhouse gas to reflect how long it remains in the atmosphere, on average, and how strongly it absorbs energy. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP, and thus contribute more to global warming. For example, one pound of methane is equivalent to twenty-one pounds of carbon dioxide.

GHGs as defined by AB 32 include the following gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. GHGs as defined by AB 32 and sources are summarized in Table O-1.

Table O-1. Greenhouse Gases

Greenhouse Gas	Description and Physical Properties	Lifetime	GWP	Sources
Methane (CH_4)	Is a flammable gas and is the main component of natural gas	12 years	21	Emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.
Carbon dioxide (CO_2)	An odorless, colorless, natural greenhouse gas.	30-95 years	1	Enters the atmosphere through burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
Chloro-fluorocarbons	Gases formed synthetically by replacing all hydrogen atoms in methane or ethane with chlorine and/or fluorine atoms. They are non-toxic nonflammable, insoluble and chemically unreactive in the troposphere (the level of air at the earth's surface).	55-140 years	3,800 to 8,100	Were synthesized in 1928 for use as refrigerants, aerosol propellants, and cleaning solvents. They destroy stratospheric ozone.
Hydro-fluorocarbons	A man-made greenhouse gas. It was developed to replace ozone-depleting gases found in a variety of appliances. Composed of a group of greenhouse gases containing carbon, chlorine an at least one hydrogen atom.	14 years	140 to 11,700	Powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances. These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases.

Greenhouse Gas	Description and Physical Properties	Lifetime	GWP	Sources
Nitrous oxide (N_2O)	Commonly known as laughing gas, is a chemical compound with the formula N2O. It is an oxide of nitrogen. At room temperature, it is a colorless, non-flammable gas, with a slightly sweet odor and taste. It is used in surgery and dentistry for its anesthetic and analgesic effects.	120 years	310	Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.
Pre-fluorocarbons	Has a stable molecular structure and only breaks down by ultraviolet rays about 60 kilometers above Earth's surface.	50,000 years	6,500 to 9,200	Two main sources of pre-fluorocarbons are primary aluminum production and semiconductor manufacturing.
Sulfur hexafluoride	An inorganic, odorless, colorless, and nontoxic nonflammable gas.	3,200 years	23,900	This gas is manmade and used for insulation in electric power transmission equipment, in the magnesium industry, in semiconductor manufacturing and as a tracer gas.

Each gas's effect on climate change depends on three main factors. The first being the quantity of these gases are in the atmosphere, followed by how long they stay in the atmosphere and finally how strongly they impact global temperatures.

In regards to the quantity of these gases are in the atmosphere, we first must establish the amount of particular gas in the air, known as Concentration, or abundance, which are measured in parts per million, parts per billion and even parts per trillion**.** To put these measurement in more relatable terms, one part per million is equivalent to one drop of water diluted into about 13 gallons of water, roughly a full tank of gas in a compact car. Therefore, it can be assumed larger emission of greenhouse gases lead to a higher concentration in the atmosphere.

Each of the designated gases described above can reside in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world regardless of the source of the emission.

O.2.1 Regulatory Setting

Climate changes is a global, national, state and local issue involving greenhouse gas emissions from all around the world; therefore, countries around the world, including the United States, have established regulations to assist in the emissions of GHGs. Tables O-2, O-3, O-4, and O-5 gives a brief explanation of both international, national, state and regional regulations.

Table O-2. International Greenhouse Gas Regulations

Regulation	Adopted	Protocol
Intergovernmental Panel on Climate Change	1998	The United Nations and the World Meteorological Organization established the Intergovernmental Panel on Climate Change to assess the scientific, technical and socio-economical information relevant to understanding the scientific basis of risk of human-induced climate change and its potential impacts.
United Nations Framework Convention on Climate Change	March 21, 1994	Governments gather and share information on GHG emissions, national polices and best practices; launch national strategies for addressing GHG emissions and adapting to expected impacts.
Kyoto Protocol	Adopted: December 1, 1997 Entered into Force: February 16, 2005	Sets binding targets for 37 industrialized countries and the European community for reducing GHG emissions at an average of 5% against 1990 levels over the five-year period of 2008-2012
Paris Climate Agreement	Adopted: December 12, 2015 Entered into Force: November 4 2016	The Paris Climate Agreement an agreement within the United UNFCCC to limit global temperature rise to 2 degrees Celsius above pre industrial levels. Under the agreement, each country determines, plans, and regularly reports its own contribution to mitigate global warming. The agreement is voluntary and is not legally binding.

Table O-3. Federal Greenhouse Gas Regulations

Regulation	Adopted	Protocol
Greenhouse Gas Endangerment	December 7, 2009	The EPA Administrator signed two distinct findings regarding GHG emissions under section 2029(a) of the Clean Air Act. 1. Endangerment Finding: The Administrator finds that the current and projected concentrations of the six key well-mixed greenhouse gases — carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) 2. Cause or Contribute Finding: The Administrator finds that the combined emissions of these well-mixed greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the greenhouse gas pollution which threatens public health and welfare.
Corporate Average Fuel Economy (CAFE)	Adopted: 1975 Revised: July 29, 2011	An agreement between thirteen large automakers (accounting for 90% of all vehicles sold in the United States), the United Auto Workers, and the State of California to increase fuel economy to 54.5 miles per gallon for cars and light-duty trucks by model year 2025.

Regulation	Adopted	Protocol
Greenhouse Gas Reporting Program	September 22, 2009	Requires reporting of GHG emissions from large sources and suppliers in the United States. Any facility that emits 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to the EPA.
New Source Review	May 13, 2013	Tailors the requirements of the Clean Air Act permitting programs to limit which facilities will be required to obtain Prevention of Significant Deterioration and Title V permits.
Standards of Performance for GHG Emissions for New Stationary Sources: Electrical Utility Generating Units	March 27, 2012	The EPA proposed new performance standards for emissions of carbon dioxide for new affected fossil fuel-fired electrical utility generated units. New sources greater than 25 megawatt would be required to meet an output-based standard of 1,000 pound of carbon dioxide per megawatt-hour, based on the performance of widely used natural gas combined cycle technology
Western Climate Initiative Partner	*Yet to be formally adopted*	Jurisdictions have developed a comprehensive initiative to reduce regional GHG emissions to 15 percent below 2005 levels by 2020. The partners are California, British Columbia, Manitoba, Ontario and Quebec. Its cap and trade program is estimated to be fully implemented by 2012

Table O-4. State Greenhouse Gas Regulations

Regulation	Adopted	Protocol
Title 24	Adopted: 1978 2008 Standards Effective: January 1, 2010	California's Energy Efficiency Standards for Residential and Non-Residential Buildings. Their standards are updated periodically to allow consideration and possible incorporation of new energy efficient technologies and methods
California Green Building Standards	January 12, 2010	A comprehensive and uniform regulatory code for all residential, commercial and K-14 school buildings.
Pavley Regulations, AB 1493	July 22, 2002	Reduce GHG emissions in new passenger vehicles from 2009 through 2016. These amendments are part of California's commitment toward a nation-wide program to reduce new passenger vehicle GHGs from 2012 through 2016. ARB's September amendments will cement California's enforcement of the Pavley rule starting in 2009 while providing vehicle manufacturers with new compliance flexibility.
Low Carbon Fuel Standard-Executive Order S-01-07	January 18, 2007	Calls for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. It instructed the California Environmental Protection Agency to develop and propose a draft compliance schedule to meet the 2020 target.
SB 1368	2006	The law limits long-term investments in base load generation by the state's utilities to power plants that meet an emissions performance standard (EPS)..
SB 97	February 16, 2010	The Natural Resources Agency adopted Amendments to the CEQA Guidelines for greenhouse gas emissions.
AB 32	2006	Set the 2020 greenhouse gas emissions reduction goal into law. It directed the California Air Resources Board to begin developing discrete early actions to reduce greenhouse gases while also preparing a scoping plan to identify how best to reach the 2020 limit. The reduction measures to meet the 2020 target are to be adopted by the start of 2011.
SB 375	August 30, 2008	Enhances California's ability to reach its AB 32 goals by promoting good planning with the goal of more sustainable communities. Sustainable

Regulation	Adopted	Protocol
		Communities requires ARB to develop regional greenhouse gas emission reduction targets for passenger vehicles. ARB is to establish targets for 2020 and 2035 for each region covered by one of the State's 18 metropolitan planning organizations
Executive Order S-13-08	2009	A comprehensive "Climate Adaptation Strategy" that would identify the state's vulnerabilities and plan accordingly. State agencies will take this report into account, due in December 2010, when planning new infrastructure such as roads, bridges, and water treatment facilities. The executive order noted that the country's longest continuously operating sea level gauge, San Francisco Bay's Fort Point, recorded a seven-inch rise in sea level over the 20th century.
SB 1078, SB 107 and Executive Order S-14-08	September 12, 2002	Requires California to generate 20% of its electricity from renewable energy by 2017. SB 107 then changes the 2017 deadline ot 2010. Executive Order S-14-08 required that all retail sellers of electricity serve 33 percent of their load with renewable energy by 2020.
CEQA Guidelines Update	Adopted: April 13, 2009 Updated: May 2011	These Thresholds are designed to establish the level at which the District believed air pollution emissions would cause significant environmental impacts under CEQA and were posted on the Air District's website and included in the Air District's updated CEQA Guidelines
Executive Order B-30-15	April 20, 2015	Establishes a California GHG reduction target of 40 percent below 1990 levels by 2030.
AB 398	July 17, 2017	Extended the California Cap and Trade program through 2030.

Table O-5. Regional Greenhouse Gas Regulations

Regulation	Adopted	Protocol
San Joaquin Valley Air Pollution Control District		The San Joaquin Valley Air Pollution Control District is made up of eight counties in California's Central Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare and Kern. The Valley Air District is governed by a Governing Board consisting of representatives from the Board of Supervisors of all eight counties, one Health and Science member, one Physician, and five Valley city representatives.
Tulare County Climate Action Plan	August 2012	The Tulare County Climate Action Plan lays out a strategy, including specific policy recommendations that a state will use to address climate change and reduce its greenhouse gas emissions.
SJVAPCD CEQA Greenhouse Gas Guidance		The SJVAPCD approach is intended to streamline the process of determining if project specific GHG emissions would have a significant effect. Best Performance Standards would be established according to performance-based determinations.
San Joaquin Valley Carbon Exchange	November 2008	Intended to quantify, verify, and track voluntary GHG emissions reductions generated within the San Joaquin Valley
Rule 2301	January 19, 2012	Emission Reduction Credit Banking. Provided an administrative mechanism for sources to bank GHG emissions, mechanism for sources to transfer GHG reductions to other users and defines eligibility standards, quantitative and procedures.

O.3 Climate Change Trends

There is a consensus within the scientific community that climate change is real, man-made, and already causing changes to earth's temperature and precipitation patterns. These changes have directly lead to the increased ocean temperatures, decreased amounts of snow and ice, and rising sea levels. The indirect effects of climate change are numerous and vary depending on the region.

Climate models, primarily based on GHG emission rates, are used to predict the rate of climate change. The state of California provides the Cal-Adapt data portal which provides localized climate projections for a range of variables under different climate change scenarios. The data used in Cal-Adapt tools represents the most current climate data available.

The planning team used Cal-Adapt's Community Climate System Model 3.0 (CCSM3) to identify climate projections for the planning area under high and low emissions scenarios. The CCM33 model is a climate model consisting of four separate models that simultaneously simulate earth's atmosphere, ocean, land surface, and sea ice to simulate earth's climate system. The planning team used the CCSM3 to predict the mean annual high temperature and average annual precipitation within the Tule River Basin from the present date to 2100.

The Intergovernmental Panel on Climate Change (IPCC) has developed a set of possible future GHG emissions based on various scenarios for future global population growth, economic growth, and governmental regulations of GHG's. Cal-Adapt projections are available for the following two IPCC scenarios:

- A2 is the medium-high emissions scenario. The A2 emissions scenario assumes continuous population growth and uneven economic and technological growth. It also assumes that heat-trapping emissions increase through the 21st century and that atmospheric carbon dioxide (CO2) concentration approximately triples, relative to preindustrial levels, by 2100.

- B1 is the lower emissions scenario. B1 emissions scenario assumes a world with high economic growth and a global population that peaks by mid-century and then declines. Under this scenario, there is a rapid shift toward less fossil fuel-intensive industries and the introduction of clean and resource-efficient technologies. Heat-trapping emissions peak about mid-century and then decline; CO2 concentration approximately doubles, relative to preindustrial levels, by 2100.

The planning team reviewed projected temperature and precipitation changes in the IRWMP planning area through the 21st century. The figures below show the outputs for mean annual high temperature (Figure O-1) and average annual precipitation (Figure O-2) per decade. Temperature is expected to increase over the next century under both scenarios. Under the more extreme A2 scenario, the models show that temperature in the IRWMP planning area is expected to increase on average by 0.96 degrees per decade between 2000 and 2100. These averages limit outlying temperature abnormalities such as extreme heat and heat waves, which are also expected to increase as a result of climate change. Additionally, climate change is expected to increase minimum temperatures, which would lead to reduced snowpack levels.

Models for precipitation are less straightforward. The A2 scenario shows a small decrease in average annual precipitation while the B1 scenario shows very little change in annual precipitation throughout the region. The change in precipitation is not significant in either scenario. The RWMG should continue to monitor precipitation projections as updated projections become available.

The predicted increase in temperature and variability of precipitation is consistent with climate change impacts expected throughout the state. Additionally, these changes are expected to create a multitude of indirect impacts, including increased wildfire, decreased water supply, decreased snowpack, and threats to habitat and biodiversity. The following discusses impacts likely to occur in the IRWMP area as a result of climate change.

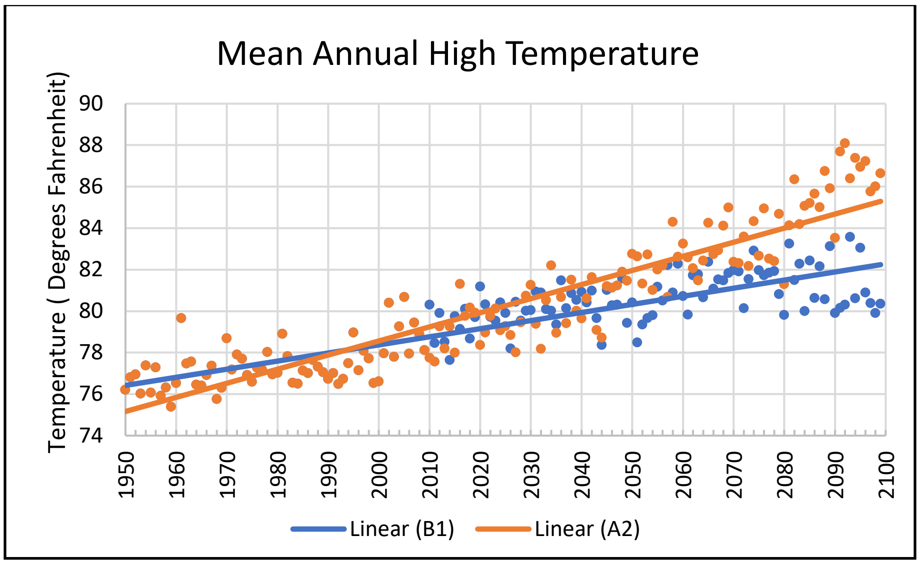

Figure O-1. Predicted change in mean annual high temperature under B1 and A2 scenarios.

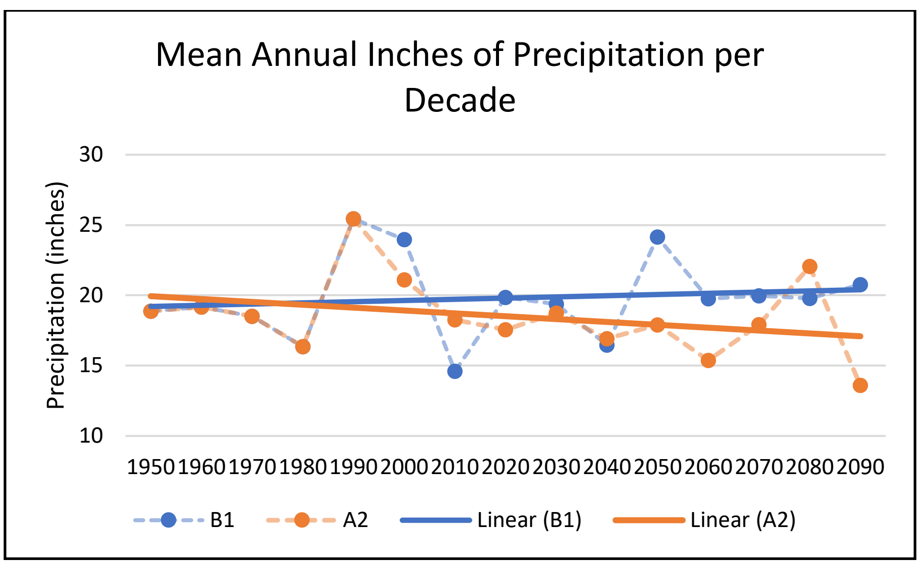

Figure O-2. Predicted change in mean annual Inches of precipitation under B1 and A2 scenarios.

O.4 Climate Change Impacts

The direct impacts of climate change described above will have a variety of indirect impacts on the region. Although extreme effort should be taken to reduce GHG emissions in order to reduce the impacts of climate change, climate change impacts are unavoidable. For this reason, recognizing these impacts and developing strategies to adapt to them is essential to create regional resiliency.

The following climate change impacts are those that are related to water and are most likely to occur within the IRWMP region. This list is not exhaustive, and climate change impacts should continue to be reassessed as additional information becomes available.

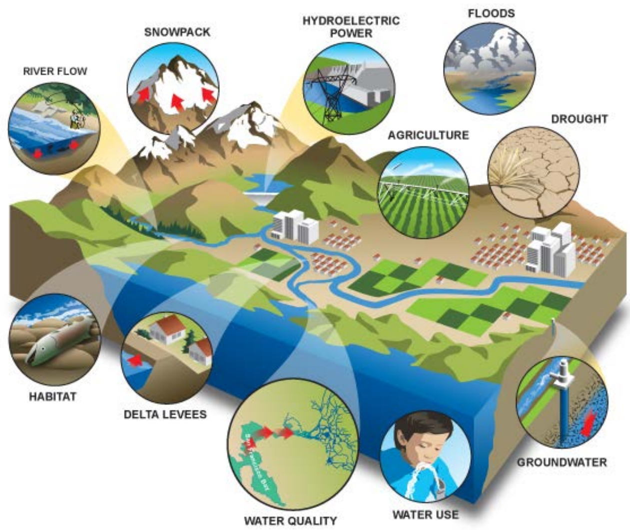

Figure O-3. Visual overview of climate change impacts.

O.4.1 Water Supply

Water supply is a primary concern for the IRWMP region with regard to climate change. Agriculture is a primary drier of the local economy and farmlands within the region provide food resources to the rest of the country. For these reasons, water availability for agricultural use is crucial. A number of factors related to climate change could lead to reduced water supplies.

<u>Limited Water Storage Capacity</u>

Additional water storage may be needed if a greater portion of precipitation occurs as rainfall, or if there are more rain-on-snow events. A reasonable option for increasing surface storage at Lake Success is being pursued. Storage could be increased by constructing Temperance Flat Dam upstream of Friant Dam, but the future of the proposed project is uncertain and it would require a lengthy period of time to permit, design and construct. The region must therefore currently rely on groundwater storage to increase water reserves and reliability. Recharge basins are not as effective as surface storage in capturing water supplies since they can only accommodate limited flows and the capacity of the Friant-Kern Canal is limited.

Precipitation

Climate change can directly affect the volume, timing, and type of precipitation, which could then impact water availability. Climate change could cause a reduction in surface water supplies from the Delta, San Joaquin River watershed (Friant CVP water) and Tule River watershed through changes in precipitation patterns and/or a shift to more rain and less snow.

The impacts of climate change on rainfall is unclear, however it is predicted that climate change will cause an increase in the number and severity of extreme weather events, including storms and droughts. Periods without rain are expected to become longer, creating increasingly severe drought events. Although the region has depended on groundwater resources during past drought events, additional strategies are needed to increase resiliency as drought events become more severe.

Although a significant amount of snow does not fall within the IRWMP region, the majority of surface water is supplied by snowmelt from the Sierra Nevada Mountains to the east. The agriculture community depends on snowmelt as it supplies a steady source of water during the dry late spring and summer months. Warmer temperatures will cause more precipitation to fall as rain instead of snow, which will decrease the amount of snowpack and the amount of water available water during dry months. Additionally, the precipitation that does fall as snow will melt sooner and more quickly, which will make it difficult to store and use.

Evapotranspiration

Evapotranspiration is a primary factor regulating land surface moisture and the process by which surface water enters the atmosphere. Evapotranspiration is the combined name of evaporation and transpiration and refers to the process by which water is evaporated from leaves through plant transpiration during photosynthesis. It varies due to a multitude of factors including wind, temperature, humidity, water availability, and plant type. These factors can increase a plant's evapotranspiration rate, which increases its water demand.

Temperature has a positive correlation with evapotranspiration, meaning that increasing temperature will lead to increased evapotranspiration, which will then increase the demand for water. Because temperature is projected to increase under both climate scenarios, evapotranspiration rates are expected to increase significantly over the next century.

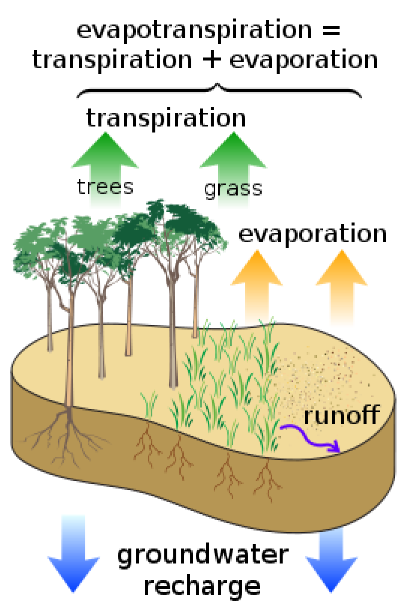

Figure O-4. Diagram of Evapotranspiration

O.4.2 Water Quality

Although water quality within the Tule River Basin is generally considered good, contamination does exist. This contamination is primarily caused by irrigated agriculture in the region. Although many programs are in place to identify and limit the discharge of pollutants from farmlands, it is still a key factor for managing water quality in the region.

Although it is unclear how precipitation will be impacted by climate change, it is likely that storm severity will increase. This would increase erosion, which would increase surface water turbidity. Increased air temperatures would also decrease dissolved oxygen content in waterbodies, which could be exacerbated by algal blooms leading to eutrophication.

The increased risk of wildfires as a result of climate change could create bare soil which may result in in runoff and sedimentation. The loss of stream bank vegetation as a result of wildfire may also lead to stream instability and stream bank erosion, which cause increased sediment loads and decreased water quality.

O.4.3 Flooding

Flooding poses numerous risks to infrastructure within the IRWMP region. Significant infrastructure, including some critical infrastructure, lies within the 200-year floodplain of the Tule River. Climate change may contribute to flooding through extreme storm events, increased wildfire, and rain on snow events.

Extreme storm events, including short periods of heavy rain, can cause flooding as water accumulates on the ground surface faster than infiltration. This can degrade the quality of habitat and threaten native species, as well as pose risk to critical infrastructure.

Wildfire reduces vegetative groundcover, which in turn limits the ability of water to infiltrate into the soil. Wildfire can also lead to hydrophobic soils. Hydrophobic soils are water resistant and cause high runoff, which can contribute to flooding.

Increased temperatures may lead to rain on snow events. Because snow is not able to infiltrate into the soil, this increases the probability of high runoff.

O.4.4 Wildfire

Wildfire is a natural form of disturbance and provides significant benefits to certain ecosystems. However, wildfire can lead to poor water quality and flooding by reducing infiltration and increasing eriosion and turbidity. Rising temperatures and extreme drought events are both anticipated in the IRWMP region as a result of climate change. Both increased temperature and drought contribute to decreased moisture levels in the area, which is then highly susceptible to high-intensity wildfire.

O.4.5 Effects of Climate Change on Runoff and Recharge

As discussed above, climate change has multiple impacts on the amount, intensity, timing, quality, and variability of runoff and recharge. The intensity and amount of runoff may be increased as a result of wildfire and rain on snow events, and exacerbated by extreme storm events. High runoff contributes to flooding and diminished water quality as sediment loads are increased.

Climate change may limit recharge in a variety of ways. Increased evapotranspiration leads to increased water use by plants, which limits the amount of water available for recharge. Wildfire limits vegetative cover and promotes hydrophobic soils which reduces soil infiltration and can lead to flooding. Extreme storm events and flooding cause water to be trapped at the surface, which allows the water to evaporate before recharge can occur.

O.4.6 Effects of Sea Level Rise

Although the region is approximately 100 miles from the ocean, sea level rise could significantly impact water availability. Approximately 24% of the Region's total water demand is met through federally contracted water from the Sacramento-San Joaquin Delta, which is at risk because of salt-water intrusion.

Saltwater intrusion is the movement of saline water into fresh aquifers and is exacerbated by sea level rise. Saltwater intrusion is usually the result of excessive over drafting of coastal aquifers which results in seawater being "pulled" into the coastal aquifer. This increases the salinity of the water in the aquifer, which causes it to be unsuitable for beneficial uses. Saltwater intrusion in the Sacramento-San Joaquin Delta could significantly decrease the region's surface water supply.

O.5 Regional Climate Change Vulnerability Assessment

A vulnerability assessment was performed for the Tule Basin using the 'Vulnerability Assessment Checklist' found in the *Climate Change Handbook for Regional Water Planning* (DWR and EPA, 2011). The assessment, provided below, offers a practical evaluation of climate change vulnerabilities related to water demand, water supply, water quality, flooding, ecosystems, habitats, and hydropower.

1. Water Demand

1.a - Are there major industries that require cooling/process water in your planning region?
Yes. The region includes fruit, vegetable, cheese and milk processing plants, but the temperature of the process water is not likely a major factor, and in many cases groundwater is used. No major power plant or industrial/processing plants that rely on cool water are found in the region.

1.b - Does water use vary by more than 50% seasonally in parts of your region?
Yes. Seasonal water use varies substantially (greater than 50%) in the Tule River Basin. Most of the water is used from late spring to the end of summer for crop irrigation and urban landscape irrigation. Approximately one-third of urban water demands occur in the winter with the other two-thirds in the summer. Irrigation water demands are typically low in the winter since effective precipitation can provide most of the needed water. Some of the crop land is also idled in the winter or is planted to permanent crops that are dormant in winter.

1.c - Are crops grown in your region climate-sensitive? Would shifts in daily heat patterns, such as how long heat lingers before night-time cooling, be prohibitive for some crops?
The region experiences hot dry summers. As a result, many of the crops grown have good resistance to heat. Therefore, changes in heat patterns would probably only impact crop yields if there is a significant increase in temperature. The primary concern with higher temperatures is that it will increase evapotranspiration and thus increase water demands. Freezing temperatures are sometimes a problem and can damage crops, but they are also beneficial to some permanent crops that need a certain number of chilling hours for an effective dormancy and to kill certain pests. Therefore, a reduction in the number of freezing days could negatively impact some crops.

1.d - Do groundwater supplies in your region lack resiliency after drought events?
No, groundwater supplies have generally been resilient over the long-term. The region experiences years where almost 100% of demands are met with groundwater and other years when the vast majority of demands are met with surface water. After dry periods, the groundwater has generally recovered after a sufficient wet period, aided by a large network of groundwater recharge basins and natural groundwater recharge. The region experienced historic groundwater level lows in the 1930's and 1940's, but fully recovered by the 1980's due to surface water development and wet periods. Recently, with consecutive dry years coupled with impacts from San Joaquin River Restoration, groundwater levels are in a state of decline. Reductions in State Water Project (SWP) water supply reliability have further aggravated the recovery.

1.e - Are water use curtailment measures effective in your region?
Urban agencies, such as the City of Porterville, have a variety of conservation measures and these are effective at reducing demands in dry years. Agricultural water supplies are ultimately controlled by the

hydrology and less surface water is delivered in dry years. This does not actually reduce water demands as growers pump groundwater to meet the remaining demand. If, however, groundwater levels continue to decline, then groundwater will become less reliable as the primary supply. The area has some hardened demand due to a large number of permanent plantings, so new (additional) water conservation programs may have to be implemented in the future if less surface water is available. Future curtailments may also be necessary due to recent State legislation that will require groundwater supplies to be managed for long-term sustainability.

1.f - Are some instream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?
All rivers and streams in the region are ephemeral and have never maintained year round fisheries. There are no minimum environmental releases in the local rivers and streams.

2. Water Supply

2.a - Does a portion of the water supply in your region come from snowmelt?
Yes, the majority of surface water comes from snowmelt in the Tule River watershed. The watershed extends up to a maximum elevation of 9,300 feet and much of the precipitation occurs as snowfall. As a result, the region is vulnerable to climate change impacts on snow including earlier spring runoffs, less water storage as snowpack and more frequent rain-on-snow events that could result in more reservoir flood releases.

2.b - Does part of your region rely on water diverted from the Delta, imported from the Colorado River, or imported from other climate-sensitive systems outside your region?
No water is imported from the Colorado River into the Region. Water is imported from the San Joaquin River watershed, which generally has the same climate change vulnerabilities as the Tule River watershed. Delta water is not directly used in the region, but Delta water curtailments do have an important indirect impact on local groundwater supplies. Several water agencies located just west of the IRWMP area use Delta water. When Delta water deliveries are reduced they increase their reliance on large well fields located near the western border of the IRWMP area. These large well fields have notable impacts on groundwater levels in the region. The Friant Division, CVP contracts are based on an exchange requiring movement of water from the Delta to the exchanging entities and without the Delta diversions, the San Joaquin River Supply contribution to satisfying local demands would be considerably reduced.

2.c - Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?
No. The region does not rely on coastal aquifers.

2.d - Would your region have difficulty in storing carryover supply surpluses from year to year?
Storage reservoirs that serve the region include Kaweah Lake (Kaweah River) and Millerton Lake (San Joaquin River). Success Reservoir is operated by the USACE primarily for flood control. The reservoir volume is typically reduced to less than 10,000 AF in the fall to provide space for floodwaters. As a result, there is little to no potential for carryover storage. Millerton Lake has some limited capacity to store carryover water from year to year. The space to store the water and ability to keep it in storage, depends on the annual hydrology. In some years, agencies can carryover water, but in many years they cannot. The only real potential for improving carryover storage is through groundwater recharge and banking projects, unless new additional surface storage is built.

2.e - Has your region faced a drought in the past during which it failed to meet local water demands?
Yes. Surface water supplies are reduced during droughts, but groundwater is generally used to meet shortfalls. As a result, almost all water demands have been met in past droughts. Recently, groundwater levels have reached close to historic lows and some wells have gone dry. Due to a very high demand for well drillers, some landowners have had to endure without a well for a period of time. But, in Terra Bella Irrigation District, the lack of surface water during drought conditions have failed to meet water demands of the District causing landowners to abandon farms.

2.f - Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas?
Some invasive plant species, such as Arundo Donax, can clog natural channels and canals if they are not properly managed, so most agencies include this as part of their maintenance activities. Agencies in the area have also been alerted to the potential for invasive species such as quagga mussels and how to help prevent their spread.

3. Water Quality

3.a - Are increased wildfires a threat in your region? If so, does your region include reservoirs with fire-susceptible vegetation nearby which could pose a water quality concern from increased erosion?
No major reservoirs are located in the IRWMP area, but Success Reservoir is located just east of the Tule River Basin. Wildfires around the reservoir and in the Tule River watershed could result in flooding or water quality problems in the local rivers.

3.b - Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change?
Local agencies use algaecides such as copper sulfate to control algae in conveyance facilities. These efforts are effective, but may have to be increased if climate change creates conditions that promote more algae growth.

3.c - Are seasonal low flows decreasing for some waterbodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity?
The region has experienced very dry years, where groundwater meets all water demands, to very wet years, where surface water meets most demands. Changes in annual low flows from climate change would be difficult to identify since low flows already vary due to natural climate variations and management of reservoir releases. The region will, however, continue to monitor and evaluate hydrologic data for long-term trends.

3.d - Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?
No. Generally the surface waters have excellent quality, largely because they are derived from Sierra snowmelt. In a few isolated areas, the water has had quality problems from anthropogenic sources, such as herbicides.

3.e Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?
Yes. Surface waters in the region generally have good to excellent quality, but during storms turbidity values can increase substantially and can affect operations at groundwater recharge facilities.

4. Sea Level Rise

The Tule Basin is approximately 100 miles from the ocean and several hundred feet above existing sea level, so sea level rise is not a concern.

5. Flooding

5.a - Does critical infrastructure in your region lie within the 200-year floodplain? DWR's best available floodplain maps are available at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fes/best_available_maps/.
Significant infrastructure, including some critical infrastructure, lies within the 200-year floodplain of the Tule River.

5.b - Does part of your region lie within the Sacramento-San Joaquin Drainage District?
No.

5.c - Does aging critical flood protection infrastructure exist in your region?
No significant levee system is associated with the Tule River. Success Dam was constructed in the 1958 - 1961, but is considered to be in good condition.

5.d - Have flood control facilities (such as impoundment structures) been insufficient in the past?
No. Flood control facilities have performed adequately in the past. Large floods in the 1950s prompted the construction of Success Dam, whose primarily function is flood control. Since then the dam has prevented large scale flooding in the Tule River Basin, although the reservoir is undersized for a very large flood. Localized flooding does commonly occur along creeks and due to poor drainage in some areas.

5.e - Are wildfires a concern in parts of your region?
Wildfires are generally not a concern in the region. They are a concern, however, in the Tule River watershed. Wildfires can result in flooding, severe short-term erosion and water quality degradation of surface waters.

6. Ecosystem and Habitat Vulnerability

6.a - Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?
No.

6.b - Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?
No.

6.c - Do climate-sensitive fauna or flora populations live in your region?
Yes. A large variety of flora and fauna are found in the Tule River Basin and some are likely climate sensitive. The region is highly developed so some have limited ability to migrate as a means of adapting to climate change.

6.d - Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?
Yes, a number of threatened and endangered species are found in the Tule River Basin. It is unknown if species distribution is occurring due to climate change since little data is available on the topic.

6.e - Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?
There are limited recreational opportunities in the local river system, including swimming, canoeing and bird watching. These have a relatively small impact on the local economy.

6.f - Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?
The Tule River and Deer Creek have historically been ephemeral and do not have minimum flow requirements. They have never supported a year-round fishery.

6.g - Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?
No.

6.h - Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change (http://www.itsgettinghotoutthere.org/)?
The Tule River Basin is not included in the list of 'Top 10 Habitats Vulnerable to Climate Change' referenced above. The watershed, however, is located in the Sierra Nevada Mountains, which is on the list.

6.i - Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? Are there movement corridors for species to naturally migrate? Are there infrastructure projects planned that might preclude species movement?
The area is largely developed with agriculture, ranches and urban areas. Habitat is generally fragmented in the Tule River Basin. Wildlife could feasibly travel between habitat areas through agricultural land, ranch land or along the river corridors. No large infrastructure projects are planned that would further preclude species movement.

7. Hydropower

7.a - Is hydropower a source of electricity in your region?
No hydropower facilities are located in the Tule River Basin below Success Dam. The upstream Tule River power generating facility is located on the discharge from Success Reservoir, which is outside the Tule River IWRM Boundary.

7.b - Are energy needs in your region expected to increase in the future? If so, are there future plans for hydropower generation facilities or conditions for hydropower generation in your region?
Energy demands will likely increase due to population growth. Energy conservation could help to reverse this trend. No major hydropower projects are planned for the area, with a second unit expansion of the Success Powerplant being deemed currently not feasible. Some small hydropower projects might be developed along canals, but these would be very small and produce only a small amount of energy.

O.5.1 Summary of Vulnerability Assessment

Table O-6. Resource Management Strategies to Address Local Climate Change Vulnerabilities

Category	Vulnerabilities	Resource Management Strategies
Water Demand	Seasonal variability, climate-sensitive crops, high crop water demands	Agricultural water use efficiency; Urban water use efficiency; Agricultural lands stewardship; Economic Incentives; Outreach and Engagement;
Water Supply	Decreased snowpack storage, Diminished groundwater supplies, extreme drought events,	Conveyance – Regional/Local; System reoperation; Conjunctive Management and Groundwater Storage; Precipitation Enhancement; Recycled municipal water; Surface Storage – CALFED; Surface Storage – Regional/Local; Watershed Management;
Water Quality	Lower dissolved oxygen levels in waterbodies, increased sedimentation and turbidity, potential algal blooms and eutrophication	Agricultural lands stewardship; Ecosystem restoration; Recharge Area Protection; Sediment Management; Drinking Water Treatment and Distribution; Groundwater Remediation /Aquifer Remediation; Land Use Planning and Management; Matching Quality to Use; Pollution Prevention; Salt and Salinity Management; Urban Runoff Management; Watershed Management;
Sea Level Rise	Basin is not coastal	N/A
Flooding	High runoff from wildfire and rain-on-snow events	Flood risk planning; Agricultural lands stewardship; Land Use Planning and Management; Urban Runoff Management;
Ecosystem and Habitat Vulnerability	Climate sensitive flora and fauna32, endangered or threatened species, climate sensitive habitats31, habitat fragmentation and degradation	Agricultural lands stewardship; Ecosystem restoration; Forest Management; Recharge Area Protection; Sediment Management; Land Use Planning and Management; Pollution Prevention; Salt and Salinity Management; Watershed Management;
Hydropower	Increased energy demands	System Reoperation; Agricultural water use efficiency; Urban water use efficiency; Conjunctive Management and Groundwater Storage;

O.5.2 Vulnerability Prioritization

The assessment identified above noted climate change vulnerabilities in the Tule River Basin. These all need to be addressed to some extent, but the higher priority vulnerabilities are described below. These vulnerabilities are listed in their order of importance based on urgency, risk, and feasibility of addressing vulnerability using the previously mentioned resource management strategies.

Table O-7. Vulnerabilities are Prioritized based on Urgency, Feasibility to Address and Risk

Priority	Category	Vulnerability	Urgency	Feasibility of Addressing Vulnerability	Risk
1	Water Demand	Seasonal Variability	High	High	High
1	Water Supply	Decreased Snowpack Storage	High	High	High
1	Water Quality	Increased Sedimentation and Turbidity	High	Medium	High
1	Water Quality	Algal Blooms, Eutrophication and other water quality problems	High	Low	High
1	Flooding	Wildfires	High	Medium	High
2	Water Demand	Increasing Crop Water Demands	Medium	Low	High
2	Water Supply	Drought	High	Low	Medium
2	Flooding	Rain-On snow events	High	Low	Medium
2	Ecosystem and Habitat Vulnerability	Habitat Fragmentation and Degradation	Medium	High	Medium
2	Ecosystem and Habitat Vulnerability	Climate Sensitive Flora and Fauna	Low	Low	High
3	Water Demand	Climate Sensitive Crops	Low	Medium	Medium
3	Water Supply	Diminished Groundwater Supplies	Low	Low	Medium
3	Hydropower	Increased Energy Demands	Medium	Medium	Low

O.5.3 Further Data Gathering and Analysis of Prioritized Vulnerabilities

Future data gathering and analysis will fall under two broad categories: 1) hydrologic and meteorologic data to characterize climate change trends, and 2) climate change literature and related legislation.

The Tule River Basin includes an extensive monitoring network that provides data on streams, rivers, reservoirs, groundwater and climate. This data will continue to be evaluated on a regular basis and potential trends will be identified. Changes in hydrology and climate can be caused by climate change or simply natural variability, but long-term consistent changes could point towards climate change. These monitoring programs are evaluated on a regular basis and, if needed, they will be expanded so they can adequately assess climate change.

A substantial number of climate change publications are produced each year, including some that assess local climatic conditions in the Tule River area. These studies are performed by various government agencies, non-governmental organizations, academic institutions and graduate students. The Regional Water Management Group will take advantage of these efforts and regularly review literature that comes from reputable sources.

The Regional Water Management Group will also monitor climate change related legislation that could impact project operations, regulatory requirements, project funding and greenhouse gas emissions.

O.6 Climate Change Adaption

Due to the unavoidability of Climate Change impacts, adaption is a primary component of effective Climate Action Planning. Climate change adaption involves assessing regional vulnerabilities to climate change impacts in order to develop strategies to increase regional resiliency if, and when, those impacts do occur. Adaption strategies can range from infrastructure improvements to changes in public policy, however they must have the goal to help the region adapt to climate change impacts.

This section will address the direct impacts of climate change on the region, discuss their implications on local ecology, the economy, and public safety, and identify adaption solutions to increase the region's resilience to climate change.

O.6.1 Water Supply

As previously discussed, increased temperatures and irregular precipitation patterns would impact water supply in a variety of ways. A reduction in water supply would have the greatest impact on agriculture, which is the region's primary economic driver. Decreased water supply could reduce the region's agricultural productivity, which would greatly impact the local economy. Additionally, a reduction in water supply could lead to water shortages in the region's low income unincorporated communities which could result in impacts to public safety.

Adapting to reductions in water supply caused by climate change will involve two overarching strategies: Reducing water demand and increasing water supply. Strategies to reduce water demand include technological investments to increase agricultural and urban water use efficiency, promotion of low water or drought tolerant crops, monetary incentives, and public outreach and education. Strategies to expand water supplies include conjunctive management, recycling of wastewater, and expanding surface water storage and groundwater recharge facilities.

O.6.2 Water Quality

Increased water temperature, storm severity and stream instability could lead to eutrophication, as well as excess runoff and sedimentation which would have a large impact on water quality in the region. This, in turn, would impact ecosystem health and pubic safety.

Increased temperatures could decrease the oxygen content in water, which would negatively impact aquatic ecosystems. This impact could be reduced through the creation of deep pools or artificial logjams, which would provide shade or deep water that limits direct heating from sunlight. These would serve as a biotic refugia to support biological communities.

Impacts of excessive runoff and sedimentation can be reduced through green infrastructure strategies, including implementation of retention ponds and stormwater tree trenches to store and filter stormwater runoff. Impacts of impaired water quality on public safety can be addressed through implementation of water treatment facilities.

O.6.3 Flooding

Flooding as a result of increased storm severity and reduced vegetative cover could cause significant impacts to infrastructure and public safety. The impacts of flooding can be minimized by increasing capacity for wastewater and stormwater collection and treatment and building flood barriers to protect major infrastructure. Additionally, policies can be implemented to restrict building in flood-prone areas and relocate critical facilities to higher elevations.

O.6.4 Saltwater Intrusion

Saltwater intrusion as a result of sea level rise would impair water supply from the San Joaquin Delta, which would significantly impact the region's total water supply. Adapting to saltwater intrusion will require reducing dependence on the Delta to support agricultural production. The regions dependence on the delta can be reduced by increasing agricultural water use efficiency, promoting drought tolerant / low water crops, and practicing conjunctive management strategies.

O.7 Consideration of Greenhouse Gas Emissions in Project Review Process

Climate change mitigation can be achieved by reducing energy demands, improving energy efficiency and carbon sequestration. These will help to reduce greenhouse gas (GHG) concentrations in the atmosphere. Climate change mitigation will require global cooperation, but the Regional Water Management Group supports reasonable efforts to make their own local contribution. As a result, it is sensible to consider impacts to GHG when selecting and prioritizing projects. This criterion will generally be a lower priority than water supply or water quality, but it is still considered important. When projects are reviewed and prioritized the project proponents will need to answer the following questions:

1. Will this project increase greenhouse gas emissions? If yes, explain how and quantify.
2. Will this project result in reduced greenhouse gas emissions? If yes, explain how and quantify.

O.8 Consideration of Climate Change in Project Review Process

As previously discussed, climate change could have many adverse effects on the region including changes in the timing and amount of precipitation, higher evaporation and transpiration from higher temperatures, increased frequency of droughts and floods, reduction in water quality, increased wildfires and increased presence of certain pests.

Developing projects that can address these issues is important. When projects are reviewed and prioritized their contribution to addressing climate change will be considered. In particular, project proponents will need to answer the following questions:

1. Will the proposed project reduce vulnerability to anticipated impacts from climate change? If yes, explain and quantify.
2. Will the proposed project help the region to adapt to climate change impacts, or increase resiliency to climate change impacts? If yes, explain and quantify.
3. Will the proposed project help to increase the region's understanding of climate change impacts and local vulnerabilities? If yes, please explain.