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P.1 Introduction

Consistent with California state guidelines for Integrated Regional Water Management (IRWM) planning, Climate Change Analysis is now considered a critical component in the planning and implementation of water resources management projects and programs. The 2012 IRWM Guidelines require that IRWM Plans address both adaptation to the effects of climate change and mitigation of greenhouse gas (GHG) emissions resulting from IRWM project implementation. The IRWM Plan should discuss the potential effect of climate change and GHG on the IRWM region to identify the IRWM region's vulnerabilities to the effects of climate change, to provide a process that considers GHG emissions when choosing between project alternatives, and potential mitigation and adaptation responses.

In those IRWM Plan sections (**Section I – Plan Benefits and Impacts**) and appendices (**Appendix G**) evaluating benefits and impacts of designated high priority IRWM projects, a process is used to consider GHG emissions between possible project alternatives. The process includes a list of prioritized vulnerabilities based on the IRWM Region's vulnerability and the IRWM's project ranking and selection process. A component of the IRWM Plan's implementation of data management and monitoring ensures further data gathering and continuous analysis of climate change takes place in the future.

The purpose of this section is to:

1. **Educate the reader on the contributing factors and measurements of climate change** – a brief introduction to define the terminology used in the section and how each contributes to the understanding of climate change
2. **Describe how Climate Change Analysis is performed** – a discussion of the global models and downscaled data used in the analysis performed in the section's Climate Change Analysis
3. **Summarize the climate change results** – a summary of the Climate Change Analysis results breaking down the differences between the three Sub-Regions of the SLO IRWM Region

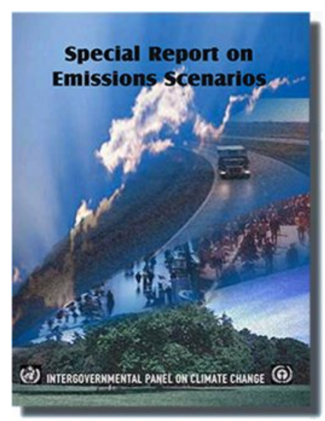
4. **Review and discuss the potential for increases in sea levels and risk of more frequent coastal flooding** – a brief overview of the impacts for sea-level rise and its potential to increase the risk for damage to coastal water supplies, property, and life
5. **Present a ranking of vulnerabilities associated each IRWM Plan Sub-Region** – a rating and explanation of vulnerabilities stemming from a thorough vulnerability assessment for each Sub-Region
6. **Provide a project ranking based on a Climate Change Adaptation analysis** – the potential for adaptation of each project based on its ability to address the regions' projected vulnerabilities

The scientific study for this section is derived from **Appendix R – Climate Change Analysis for San Luis Obispo IRWM Region** and various climate change related websites referred to in the appendix and in this section.

P.2 CLIMATE SCIENCE AND MAKING CLIMATE CHANGE PROJECTIONS

Climate change is often described as a significant and lasting change in the weather patterns over extended periods of time ranging from decades to millions of years.

P.2.1 Use of Climate Models



In the early 1990s, the Intergovernmental Panel on Climate Change (IPCC)[1] developed long-term emissions scenarios that have been widely used in the analysis of possible climate change and its impacts, with suggested options to mitigate the impacts. In 1996, the IPCC made the decision to update the emission scenarios to account for the carbon intensity of the world's energy supply, to represent the significance of the income gap between developed and developing countries, and to include sulfur emissions as a climate changing variable. In 2000, the emission scenarios (SRES, 2000) were updated again to identify regions acknowledging agreement in the direction of future climate change as well as regions where projected changes were thought to be more uncertain. Information on the statistical significance of projected changes in relation to modeled natural climate variability was included.

[1] The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. <https://www.ipcc.ch/index.htm>

Emission scenarios are alternative "storylines" of how the future might unfold (scenarios) using driving forces such as population growth, land use change, technology, and industry and how they influence future emissions of GHG. The storylines help define future concentrations of GHG in the atmosphere, and how GHG impacts temperature and climate in the oceans and on the land surface. Unfortunately, as with any forecast modeling, the possibility that any single emissions path will occur as described by the scenarios is highly uncertain.

P.3 CLIMATE SCENARIOS

The climate scenarios used in this Climate Change Analysis are defined in the Special Report on Emissions Scenarios (SRES, 2000). This report called for the use of multiple models while seeking input from the broadest community of experts and making scenario results available world-wide for review and comment. The SRES developed four storylines (**Figure P-1**) of how the world may move forward with climate change occurring.

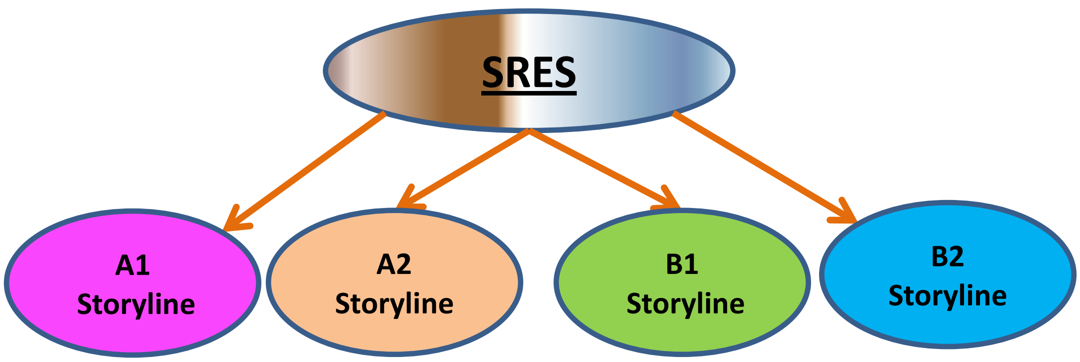


Figure P-1. SRES Storyline Schematic

The following description of the four storylines is taken from the IPCC website,
<http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3>:

> *The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis:*

> *fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).*
>
> *The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.*
>
> *The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.*
>
> *The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.*

P.4 Preferred Model for IRWM Plan Climate Change Studies

A collaborative effort by the Geos Institute[2] and Local Government Commission[3] resulted in two valuable, regional climate change resources. The two reports were titled *Projected Future Climatic and Ecological Conditions in San Luis Obispo County (April 2010)* and *Integrated Climate Change Adaptation Planning in San Luis Obispo County (November 2010)*.

At the time, the 2010 study relied on three different models to represent one emission scenario. These include the CSIRO, Australian Model; HadCM, United Kingdom (UK) Model; and

[2] The Geos Institute is a nonprofit organization that uses science to help people predict, reduce, and prepare for climate change.< http://www.geosinstitute.org/>

[3] The Local Government Commission (LGC) is a California-based nonprofit organization fostering innovation in environmental sustainability, economic prosperity and social equity.<http://www.lgc.org/slo_stakeholder_mtg_052010>

MIROC, Japan Model. These models are built on slightly different input parameters making them differ in output. The UK Model provides the wettest output and the Japan Model the driest output.

These models were selected for the study because their output facilitated input to the MC1 vegetation model that was run for the study. The study states:

> *The MAPSS team selected CSIRO, MIROC, and HadCM from the suite of available models because their outputs are readily usable for the MC1 vegetation model, which provided us with projections for such variables as growing conditions for dominant types of vegetation, wildfire, and carbon storage in biomass.*

As a result, the study had to sacrifice the ability to make use of daily downscaled data since this data is not available for all three models; instead opting to focus on climate change impacts to growing conditions. For the IRWM Plan analysis, lack of daily data limits the computation of indices indicating certain local aspects of energy and agricultural water consumption (part of an adaptation analysis). In this analysis, completed for purposes of addressing both adaptation and mitigation of GHG emissions, the importance of daily downscaled data overrides the consideration to use the MC1 vegetation model. The preferred model, which includes daily downscaled data for all scenarios, is the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL) model (results were released in 2007). The two GEOS 2010 reports; however, do form the basis for updating the climate change conditions and assessing climate change vulnerabilities in the IRWM Plan (see **Section P.10**).

P.4.1 Selected Model and Storyline for Climate Change Analysis

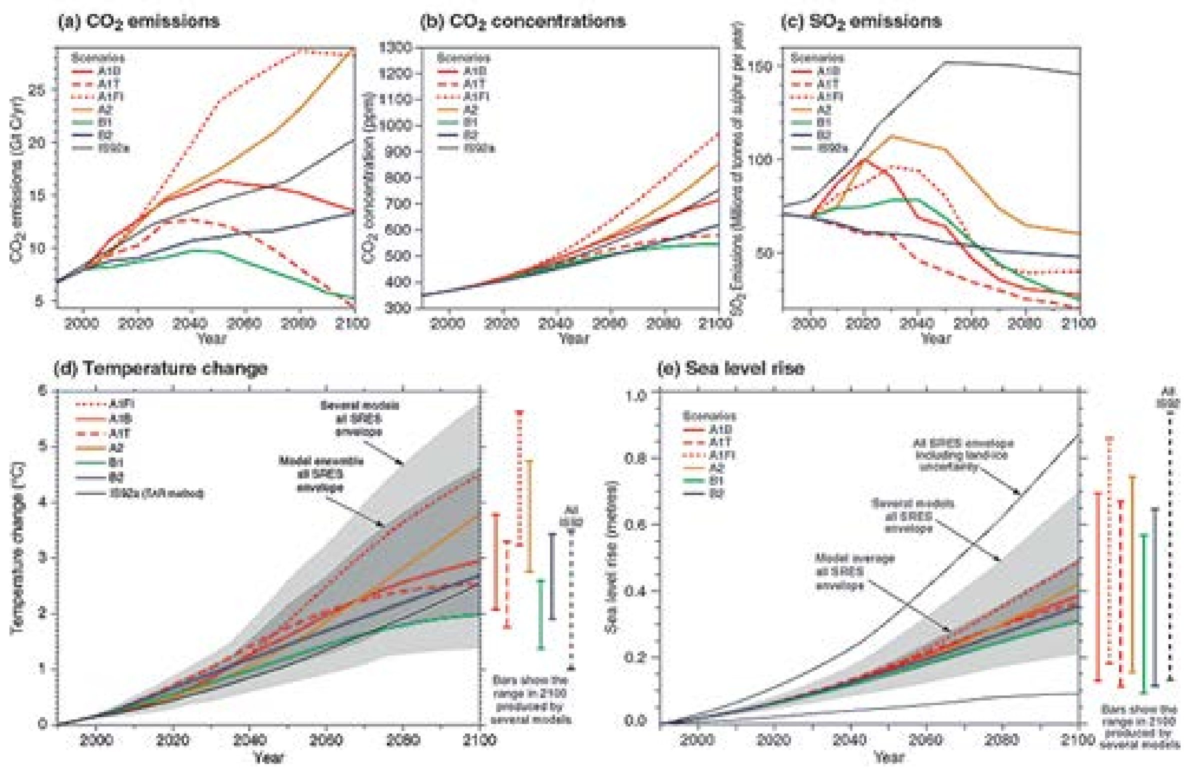
The decision to use NOAA model(s) for the climate change analysis for the SLOC IRWM Plan Update is based on the following:

- Downscaled data from the model is available at a resolution to differentiate between the potential impacts in the three Sub-Regions covered in the IRWM Plan
- Daily downscaled data is available for all emission scenarios to facilitate computing change in indices related to energy and water use
- The NOAA model(s) and approach has been utilized in three other region-developed IRWM Plans in the last 2 years (Imperial Region, Gateway Region, San Joaquin Region)

The preferred storyline (see A1 Storyline, **Figure P-1**) and scenario family applied in this section also differs from the 2010 Geos analysis by selecting the A1 storyline rather than the A2 storyline, described in the Geos and Local Government Commission's *Integrated Climate Change Adaptation Planning* report as the "business-as-usual" GHG emission scenario (referred to in past assessments by the IPCC as the IS92a Scenario published in both the 1990 (First Assessment Report [FAR]) and 1995 assessments (Second Assessment Report [SAR]). This change in storyline from the 2010 Geos analysis is a shift to a more optimistic growth scenario for the economy and a world which brings to bear technological solutions to reducing GHG starting mid-Century (2050).

Figure P-2 illustrates the differences in future emissions between the six scenarios (stemming from the four storylines described above by the 2007 IPCC assessment). Plots are briefly described as follows: (a) shows the CO_2 emissions of the six SRES scenarios with IS92a for comparison purposes with the SAR; (b) shows projected CO_2 concentrations; (c) shows anthropogenic (i.e., caused by man's activities) SO_2 emissions; (d) and (e) show the projected temperature and sea-level responses, respectively. The "several models all SRES envelope" in (d) and (e) shows the temperature and sea-level rise, respectively, for a hierarchy of models, that together, are referred to as the simple climate model.

Focusing on the (a) plot and following the A1B line, the trace shows a relatively steep increase in carbon emissions in the first half the century to the mid-century mark (2050) and then a slow gradual decrease to 2100. Intuitively, this reflects the continued use of carbon fuels until green energy technology has evolved and is brought to bear on reducing the rate of emissions. However, the A1B temperature trace shown in the (d) plot is similar to all emission scenarios and continues to rise until the end of the century. As illustrated in **Figure P-3**, the A1B scenario is a balance between the more fossil fuel intensive scenario (A1F) and the non-fossil/green-energy scenario (A1T). The A1B scenario is selected for this analysis to represent the "most-likely" set of conditions for the IRWM Region looking out to 2100.



Source: IPCC Third Assessment Report

Figure P-2. Results of SRES Climate Change Scenarios

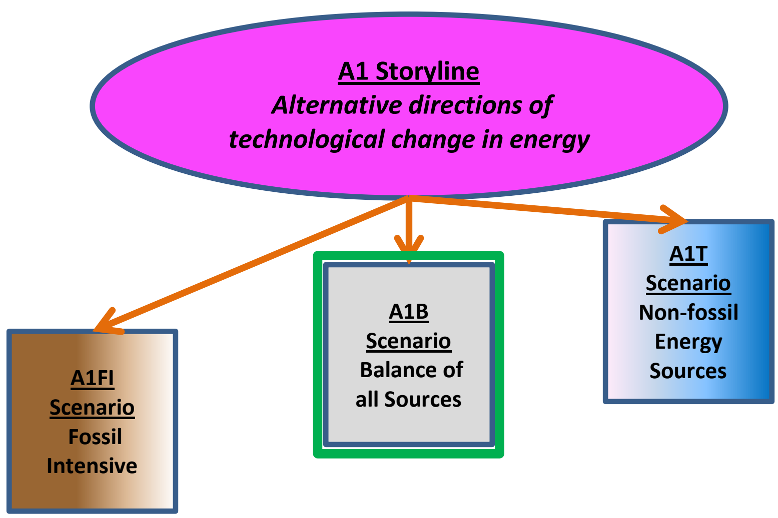


Figure P-3. A1 Storyline Scenarios

P.5 DOWNSCALING GLOBAL MODEL RESULTS

As noted above, downscaling of global data is important to a study looking at adaptation to the effects of climate change and project-specific mitigation for GHG emissions. Downscaling of global model results from the IPCC SRES scenarios refers to a process of taking the global model data on forecasted changes to climate variables (e.g., temperature and precipitation), and translating it to a finer spatial scale that is more meaningful in the context of local and regional impacts. Two general approaches are used in downscaling:

1. Dynamical, where a high resolution regional climate model with a better representation of local terrain simulates climate processes over the region of interest.
2. Statistical downscaling, where large-scale climate features are statistically related to fine-scale climate for the region.

The advantage of using dynamical downscaling is that a regional model can simulate fine-scale processes not anticipated with statistical methods. The disadvantage; however, is that the regional models are far more computationally intensive and that the end performance is highly dependent on the quality of the input data and how well regional climate influences are represented by the downscaling model. Statistical downscaling is less computationally intensive, and it is able to generate data that more closely mimics local climate variations. The main disadvantage is that statistical downscaling assumes that past relationships between regional and global climate results will continue to hold true in the future.

Global Climate simulations of future climate have been developed under the Coupled Model Inter-comparison Project (CMIP) Phase 3 conducted by the World Climate Research Programme (WCRP). The CMIP is an international effort to improve climate models by comparing multiple global model simulations to observations and to each other. The resolution of the global model is 200-300 Km^2 per grid cell (vs. cell size for a regional model is typically 15 Km^2 or finer). In the CMIP archive, simulated climate time series are presented for past (pre-2011), mid-century (2050) and end-century (2100) climate states, assuming various greenhouse gas emission scenarios.

P.5.1 Applying Global Models to SLO IRWM Region

For the SLO IRWM Region, the downscaled global datasets need to be applicable to the three Sub-Regions defined in the IRWM Plan (North Coast, North County, and South County). The Lawrence Livermore National Labs (LLNL)[4] hosts an archive of the simulations from Global

[4] See <http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html#Welcome> for description and download of data.

Climate models from the CMIP Phase 3 effort and includes statistically-downscaled data for use in modeling smaller regions. The downscaling includes bias-corrected data to better match the magnitude of modeled precipitation and temperature to observed values in the local region. As described in **Section P.4.1**, simulations from NOAA's GFDL model runs for the A1B emissions scenario were used for the 2013/14 IRWM Plan Update analysis performed. The data grid over which the data request was made is illustrated in **Figure P-4** with the Sub-Region areas shaded to illustrate the resolution of coverage. By splitting the IRWM Region into its three Sub-Regions, the analysis shows more detail than prior efforts, to understand climate change impacts. The analysis assesses and prioritizes regional vulnerabilities prescribed by California Department of Water Resources (DWR) (**Section P.10**), while also developing a plan for future data gathering and analysis (**Section P.12**).

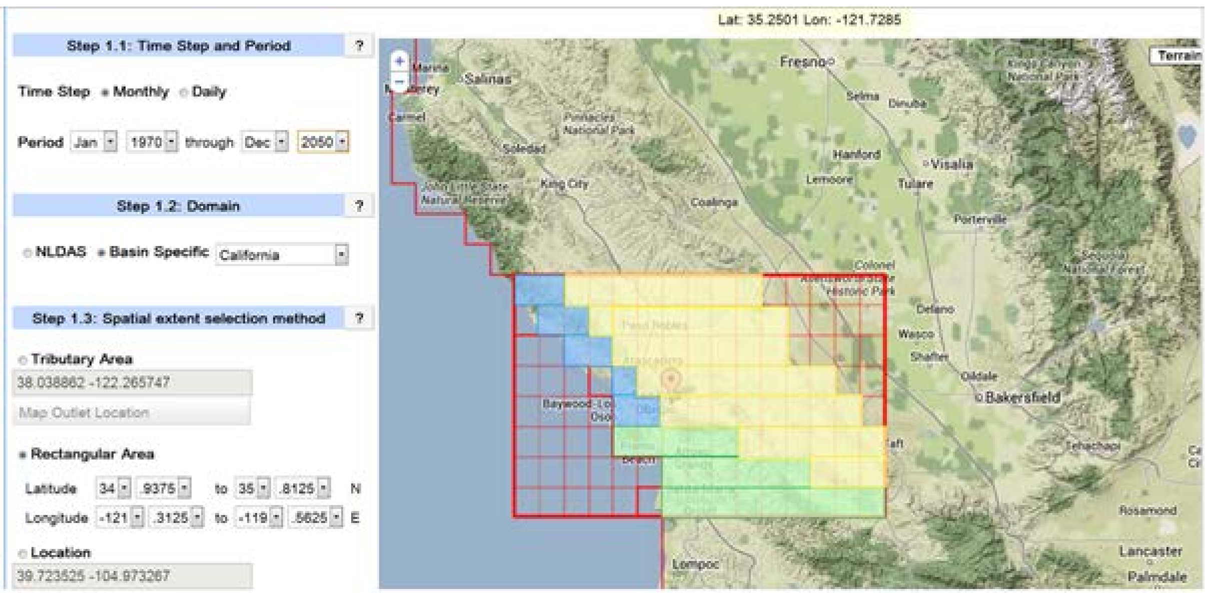


Figure P-4. Downscaled Region Model Grid Data Request for IRWM Region

P.6 APPROACH TO CLIMATE CHANGE ANALYSIS FOR SUB-REGIONS

Climate Change Analysis for the three Sub-Regions in the IRWM Plan requires sufficient time series data, both in resolution and in temporal span. The analysis requires monthly and daily time series data to characterize climate in the recent past (prior to 2011) and at mid-century (2050), approximately 40 years into the future. The use of mid-century as a future date ensures full coverage of the 20- to 25-year IRWM Planning horizon. The analysis takes the following steps:

1. Obtain 40 years of downscaled monthly and daily regional climate model time series for mid-century (future) conditions

2. Obtain 40 years of simulated monthly regional climate model time series for past (1971 to 2010) climate
3. Obtain 20 years of simulated daily regional climate model time series for past (1979 to 1999) climate
4. Analyze monthly time series and present results as seasonal changes in climate variables such as temperature and precipitation
5. Analyze daily time series and present daily results as seasonal changes in accumulated variables such as heating, cooling, and growing degree days

P.6.1 Metrics for Measuring Climate Change

Changes between historical and future global simulation results are summarized in terms of monthly and seasonal differences for precipitation, maximum temperature, minimum temperature, wind speed, evapotranspiration, and runoff. These changes are obtained by analyzing the monthly simulated data. Daily time series data is used to calculate the average seasonal change in growing degree days, heating degree days, cooling degree days, and days with precipitation of more than 1 inch. Both metric categories (i.e., monthly and seasonal) are used to quantitatively express change in the climate parameters and are described below.

P.6.1.1 Monthly Time Series Metrics

Precipitation – Average monthly rainfall amounts (inches and mm)

Maximum Temperature – Average monthly maximum daily temperatures °F (°C)

Minimum Temperature – Average monthly minimum daily temperatures °F (°C)

Wind Speed – Average monthly wind speed (m/s)

Evapotranspiration – Average monthly evapotranspiration rates (mm)

Runoff – Estimate average monthly runoff from rainfall (mm/month)

P.6.1.2 Daily Time Series Metrics

Growing Degree Days

Growing Degree Days (GDD) are associated with the regional climate and its ability to provide the optimal range in temperature for growing crops. While optimal growing conditions differ for each crop, growing conditions for all crops typically range between 46°F (8°C) for low growth and 90°F (32°C) for high growth.

On any given day of the year, if the daily mean temperature falls within this range (see figure below), the day is counted as a growing day and is weighted by how close the temperature falls to the high growth temperature. The weighting is accomplished by the formula: [5]

$GDD = ((T_{Max} + T_{Min})/2 - T_{MinBase})_{Day\ 1} + ((T_{Max} + T_{Min})/2 - T_{MinBase})_{Day\ 2} + \ldots$, where

$T_{Max} = 90°F$ if $T_{Max} >= 90°F$, or

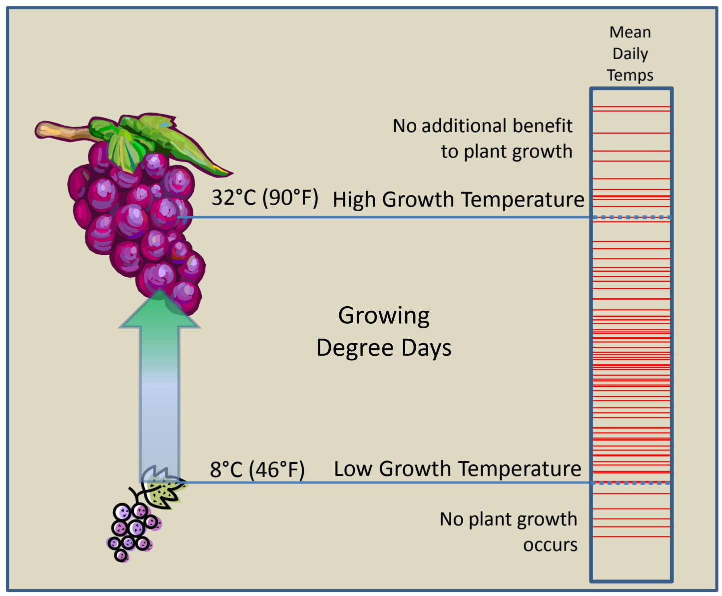
T_{Max} = Max Daily Temp

$T_{Min} = 46°F$ if $T_M =< 46°F$, or

T_{Min} = Min Daily Temp

$T_{MinBase} = 46°F$

If the daily mean temperature is greater than 90°F, the day is still counted as a growing day, but is only weighted up to the high growth temperature.[6] If the mean temperature falls below 46°F, the minimum base temperature, the day is not counted as a growing day. The sum of the differences in mean daily temperature (after above adjustment) for the period of simulation (20 years) equals the total number of GDDs, with the maximum number being 321,200 (20*365*(90-46) = 321,200 degree-days) GDDs.



As climate change affects temperature, the change in the number of growing degree days between forecasted and what is occurring present day becomes an important identifier (or metric) on the amount and impact of climate change.

[5] Recognizing there are many crop types being grown in the IRWM Region, the surrogate crop selected for the region in describing changes in growth patterns is vineyards. Optimum growth temperatures for other crop types may vary slightly from those shown.

[6] Note that a >90°F day is still considered a growth day since the heating and cooling temperature cycle falls within the growth range in the morning and early afternoon hours until a maximum temperature above the optimum growth range is reached.

Heating Degree Days

Days with a mean daily temperature below 65°F (18°C), the minimum base temperature, are considered to be Heating Degree Days (HDD) below which buildings need to be heated. The formula is similar to GDDs except the difference is calculated as follows:

$HDD = ((T_{Max} + T_{Min})/2 - T_{MinBase})_{Day\ 1} + ((T_{Max} + T_{Min})/2 - T_{MinBase})_{Day\ 2} + \ldots$, where

T_{Max} = Max Daily Temp

T_{Min} = Min Daily Temp

If $(T_{Max} + T_{Min})/2 > 65°F$ then $(T_{Max} + T_{Min})/2 = 65°F$

$T_{MinBase} = 65°F$

An increase in HDD implies more days where heating energy is expended.

Cooling Degree Days

Cooling Degree Days (CDD) occur when daily mean temperatures are above 75°F (24°C), the maximum base temperature, and buildings require air conditioning to cool temperatures. The formula is calculated as follows:

Cooling Degree Days (CDD) = $((T_{Max} + T_{Min})/2 - T_{MaxBase})_{Day\ 1} + ((T_{Max} + T_{Min})/2 - T_{MaxBase})_{Day\ 2} + \ldots$, where

T_{Max} = Max Daily Temp

T_{Min} = Min Daily Temp

If $(T_{Max} + T_{Min})/2 < 75°F$ then $(T_{Max} + T_{Min})/2 = 75°F$

$T_{MaxBase} = 75°F$

An increase in CDD implies more hot days where cooling energy is expended.

P.6.2 Conceptual Model Setup and Analysis

The analysis flow diagram shown in **Figure P-5** is illustrative of the processes and interactions taking place in the modeling of climate change. As shown in the figure, economic systems are the foundational stressors towards positive and negative changes in climate. The chosen model scenario (A1B) is closely defined by what the world economy may look like and what the human society will do about the changes taking place, and witnessed through temporal and volumetric changes in rainfall and stream/river hydrology, and in sea-level rise. The diagram indicates the feedback between each of the processes, and through each time step, a new equilibrium is reached producing the resultant set of new climate conditions.

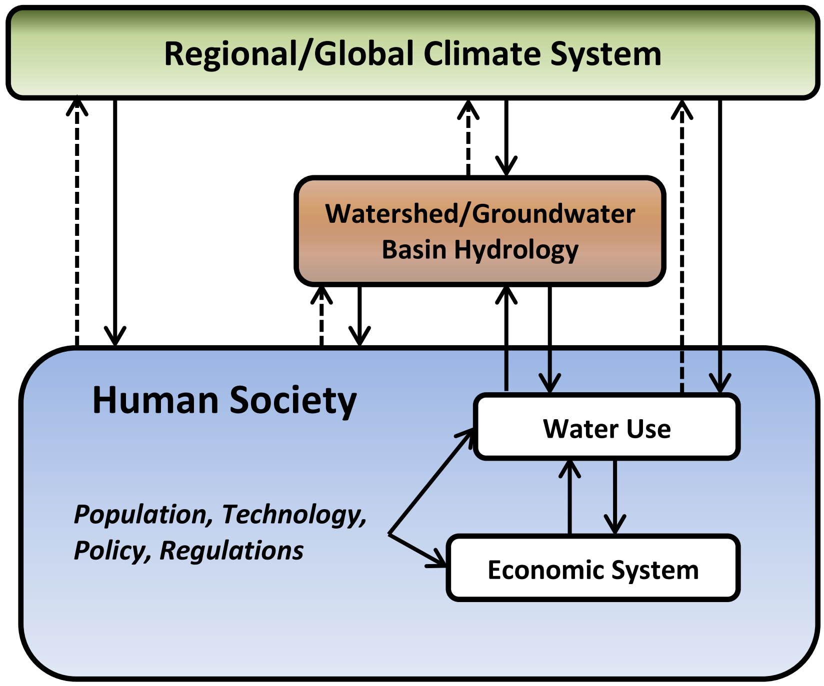


Figure P-5. Analysis Flow Diagram

Since this analysis is scoped to evaluate vulnerabilities in each of the three Sub-Regions shown in **Figure P-6**, the socio-economic and water-related drivers require quantification of what distinguishes one Sub-Region from the others before moving forward in the analysis. A general summary of the important distinguishing factors making each Sub-Region unique is summarized in **Table P-1**. The biggest driver in difference is the geographic proximity of the ocean, economic benefits from tourism, and, with the exception of the Santa Maria Groundwater Basin watershed, reliance on small watersheds and aquifers in the North Coast and South County Sub-Regions. The close contact of the Pacific Ocean with the western boundary of the two Sub-Regions generally provides cooler temperatures and higher rainfall amounts; whereas the North County Sub-Region (and inland portions of the South County Sub-Region), on average, has higher temperatures and less rainfall. The level of human ecosystem interaction is most significant in the amount of agricultural lands in the North County and South County Sub-Regions.

Urbanized land uses in the IRWM region exist in various degrees within each of the three Sub-Regions. In describing attribute differences between each Sub-Region, existing urban densities and projected planned growth as part of the adopted San Luis Obispo County General Plan, and local agency land use plans, are similar in how population and socio-economic growth and stability requirements are being met. It is widely known that most, if not all, urban areas continuously struggle with water supply, drainage, transportation, and environmental challenges regardless of their relative size, location, and local hydrology. Because of these similarities, the impacting drivers in urban areas resulting from changes in climate are not considered to be significantly different between the three IRWM Sub-Regions, and are not reflected in **Table P-1**.

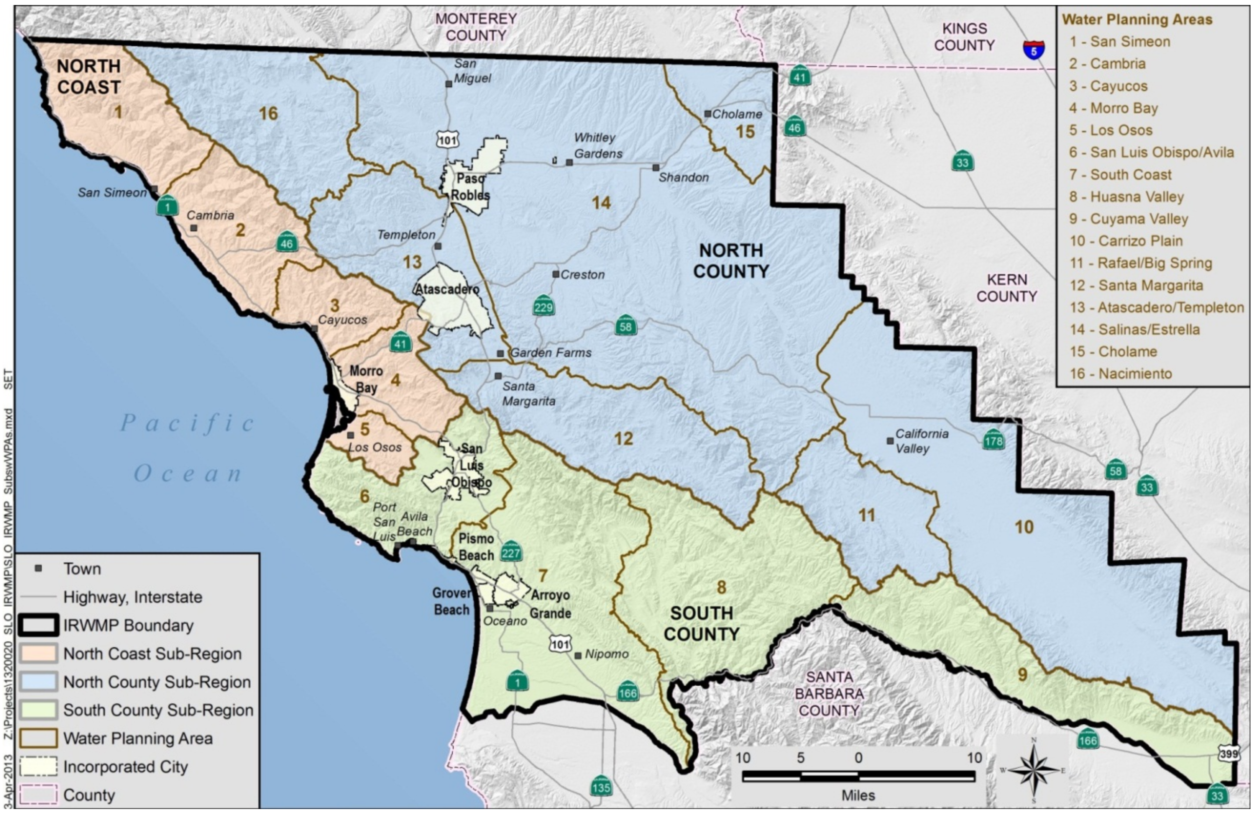


Figure P-6. IRWM Plan Sub-Region Map

Table P-1. Socio-Economic and Water Resources Considerations by Sub-Region

North Coast Sub-Region	• Sea-level rise along the coastline can significantly impact low-lying areas and groundwater supplies (often the primary source of drinking water) by saltwater intrusion • Small aquifers offer low aquifer storage capacity • Timing of rainfall and runoff is critical to recharging the region's smaller groundwater basins where groundwater storage is constrained by aquifer size and salt water intrusion (i.e., changes in rainfall patterns can cause a possible loss of natural recharge) • Local economies of communities (e.g., fishery and harbor industries), are reliant on coastal tourism requiring protection of ecosystems and infrastructure • Seawater intrusion and impacts of climate change and sea-level rise could impact Morro Bay National Estuary, a federally protected marine area with a variety of species, and other ecological preserve areas • California State Route Highway 1 coastal transportation route from approximately Carmel to the north, to San Simeon is sensitive to changing weather patterns causing slides and long-term road closures, shutting off north-bound and south-bound lanes for weeks, impacting primarily tourism
North County Sub-Region	• A larger wine and vineyard-based economy in the Paso Robles Groundwater Basin is sensitive to changing amounts of rainfall, and temperatures governing growing days and sensitive harvest periods • Agricultural water demands also have the potential to change (up or down) as a result of the need to change cropping patterns or cropping cycles to accommodate rainfall patterns • Local economies of communities (such as lake recreation and agricultural-related industries) are reliant on tourism requiring the ability to sustain the attractions and natural resources • Changes in the flow patterns of the Salinas River dictate the amount of irrigation water and natural recharge to the Paso Robles Groundwater Basin on an annual basis • The region contains critical ecosystems, such as 180,000-acre Carrizo Plain, one of the largest intact California grasslands, home to more endangered species than anywhere else in California, and home to Soda Lake, a sensitive ecosystem • State Water Project water is potentially available to increase imported surface water; however, these supplies are projected to have lower reliability with the potential for stressing local and regional groundwater resources and exacerbating salinity intrusion
South County Sub-Region	• A larger agricultural economy in the Santa Maria Groundwater Basin is sensitive to changing amounts of natural groundwater recharge and temperatures governing growing days • Agricultural water demands also have the potential to change (up or down) as a result of the need to change cropping patterns or cropping cycles to accommodate rainfall patterns • Local coastal economies of communities sustained by recreation and tourist-related industries are reliant on maintaining the attractive natural resources of beaches, estuaries, and woodlands • California State Water Project water contracts are available and being used to increase imported surface water; however, these supplies are projected to have lower reliability with the potential for stressing local and regional groundwater resources and exacerbating salinity intrusion • Seawater intrusion, sea-level rise, and impacts of climate change could impact the Guadalupe-Nipomo Dunes Wetland (and oil field), the largest coastal dune ecosystem in the Western U.S. with a variety of species, and other ecological preserve areas • Sea-level rise can significantly impact the coastal low lying urban areas at risk of flooding from the Arroyo Grande, Pismo Creek, and Meadow Creek watersheds; especially, during periods of coincident high tide and flooding resulting from increased rain storm intensity • Diablo Canyon Nuclear Power Plant uses seawater for cooling and can be impacted through coastal storms, flooding, and sea-level rise

P.7 Climate Change Analysis Results

The Climate Change Analysis is the execution of the model assuming the mid-century (2050) carbon production conditions of the A1B Scenario shown in **Figure P-2**, and running those conditions through 40 years of monthly hydrology and 20 years of daily hydrology to develop a statistical average of the various climate variables. In this way, the model results are presented so the mid-century results of climate variables are representative of an average over a hydrologic period of record to account for the naturally occurring dry- and wet-period hydrology.

Table P-2 below provides results of the Climate Change Analysis using monthly data aggregated to seasonal time periods for the mid-century (2050) point in time. The table and figures below illustrate the change in average seasonal amounts for each of the key climate variables defined above in **Section P.6.1.1.**

Table P-2. Projected Changes in Monthly Climate Metrics by Mid-Century (2050)

Variable	Sub-Regions	Change in Variables Projected by GFDL Medium Warming Scenario (A1B)				
		Winter	Spring	Summer	Fall	Annual
Precipitation (see note)	North Coast	7.2%	-26.2%	-38.5%	3.2%	-3.66%
	South County	7.0%	-27.5%	-32.5%	0.9%	-5.02%
	North County	6.9%	-27.2%	-41.0%	-1.4%	-5.15%
Maximum Temperature	North Coast	6.5%	4.2%	5.8%	5.6%	5.48%
	South County	6.6%	4.6%	6.1%	6.0%	5.81%
	North County	7.5%	4.5%	5.0%	5.9%	5.55%
Minimum Temperature	North Coast	18.8%	13.5%	9.8%	17.0%	13.91%
	South County	23.2%	14.1%	11.2%	18.8%	15.40%
	North County	49.9%	15.4%	12.1%	21.8%	17.76%
Wind Speed	North Coast	-0.1%	-1.8%	0.2%	1.2%	-0.25%
	South County	0.2%	-1.2%	-0.8%	0.7%	-0.32%
	North County	0.3%	-1.0%	-0.6%	0.8%	-0.21%
Evapotranspiration	North Coast	-3.6%	3.9%	7.0%	6.1%	4.79%
	South County	-1.8%	3.8%	7.1%	6.0%	4.90%
	North County	-4.0%	4.6%	6.2%	5.2%	4.37%
Runoff	North Coast	15.7%	-27.8%	-3.3%	-1.4%	-3.47%
	South County	12.8%	-33.7%	-4.4%	1.7%	-8.78%
	North County	16.2%	-27.8%	-3.2%	-0.5%	-3.70%

Note: Percentage amounts also provide the level of sensitivity of the current average amount to the model change (i.e., current small value amounts of rainfall in spring are more sensitive to change than larger values in winter.)

In the table above, the cells with green backgrounds indicate increases of 3 percent change for current seasonal average or more; red backgrounds indicate decreases of 3 percent or more; and white backgrounds indicate no significant change. The table values provide a sense of the order of magnitude of change projected in 2050 as a result of climate change assuming the A1B Scenario conditions of carbon productions shown in **Figure P-2.** Each of these key climate variables and the effects of climate change on the Sub-Regions are described in this section.

P.7.1 Precipitation Changes

Precipitation is a key indicator of climate change, both when (temporal) and how much (volume) rainfall occurs has a significant impact to the region's infrastructure and river systems in their capacity to convey flood waters and naturally recharge freshwater aquifers, respectively. The change in the above table showing rainfall percent changes occurring in winter and spring represent more rainfall in the winter and less rainfall in the spring. As noted in **Table P-2**, the order of magnitude in the change seen in spring stems from the small amount of rainfall that occurs during the spring months of the year. The approximate 0.4-inch seasonal average decrease in rainfall over the North County Sub-Region area in spring, with a current seasonal average rainfall of 1.6-inches, produces a 27 percent decrease; whereas, a 0.5-inch increase over the same area in winter, with a 6-inch average rainfall, produces a 6.9 percent increase.

Precipitation also drives many of the interactions taking place in the analysis flow diagram shown in **Figure P-5.** What is important to quantify from the results is the shift in rainfall from month to month, as shown for the North Coast Sub-Region in **Figure P-7.** The graph clearly shows a shift (overlying transparent green) in the average rainfall pattern where the future projected rainfall is less in the spring months (exposed red) and more in the late fall and winter months. **Figure P-8** provides a monthly average precipitation difference comparison of the three Sub-Regions. The bars aligned together for each month indicate that most of the change is taking place in the North Coast Sub-Region with a reduction in change moving inland from the ocean.

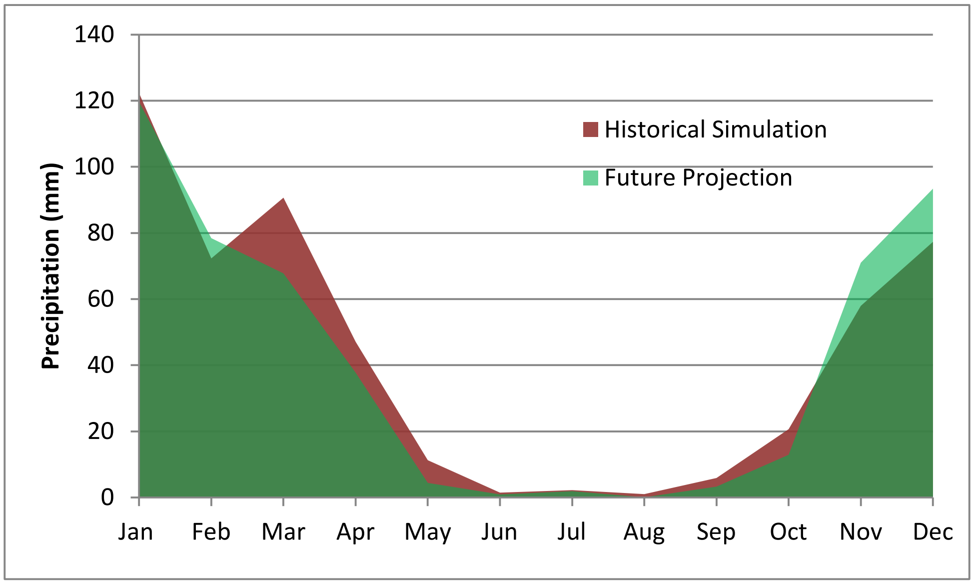


Figure P-7. Historical and Future Precipitation (North Coast)

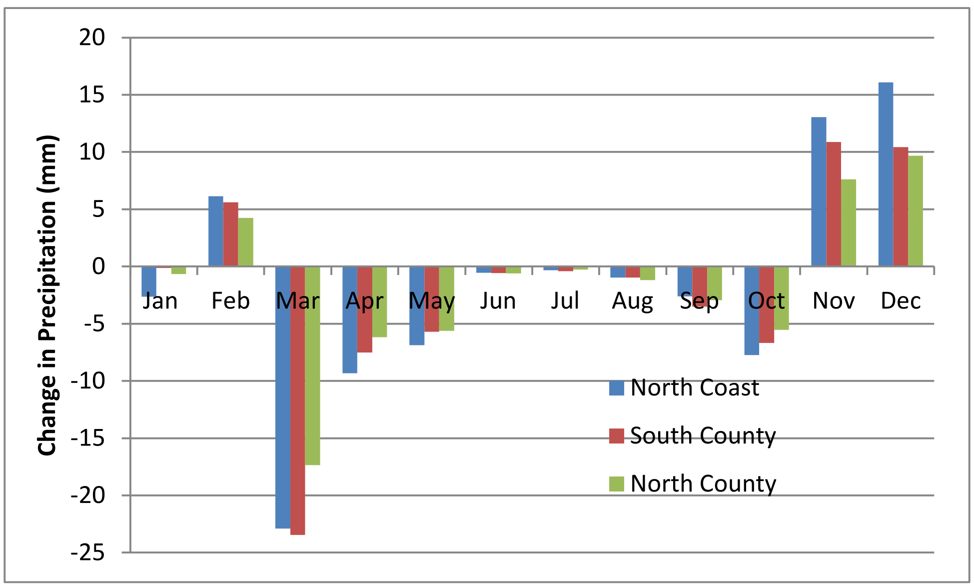


Figure P-8. Differences in Average Monthly Precipitation

P.7.2 Temperature Changes

Temperature drives how much water is needed to satisfy both human and natural water demands, and a shift in temperature can reduce or increase this need for water over the months of the year. An increase in temperature raises the amount of evapotranspiration from agricultural production and outdoor landscaping which, in turn, necessitates the application of additional irrigation water. **Figure P-9** and **Figure P-10** illustrate the increased shift in temperatures (transparent green on top of red) over the 12 months of the year for the North Coast and the North County (highest forecasted change) Sub-Regions with the differences resulting in the percent changes shown in **Table P-2**.

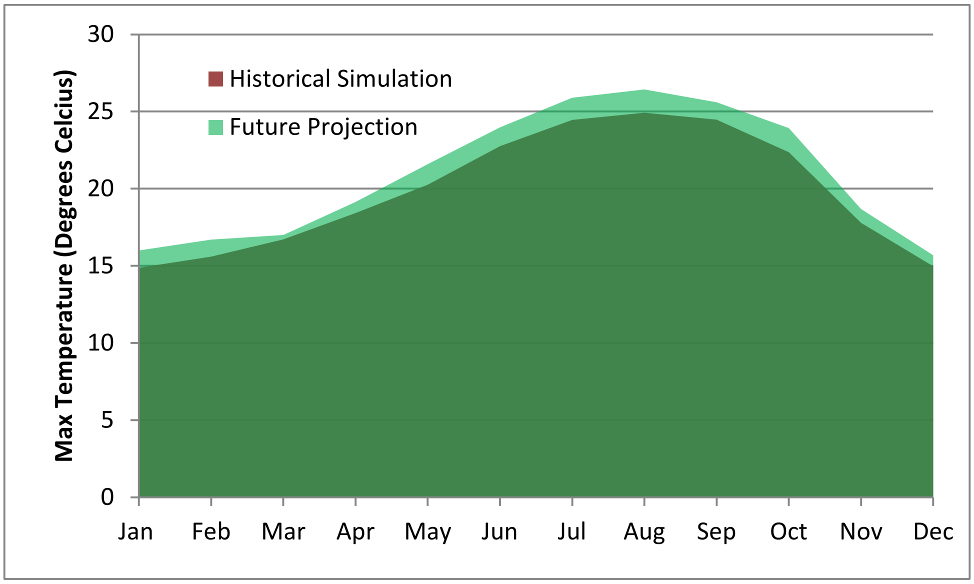


Figure P-9. Historical and Future Maximum Temperature (North Coast)

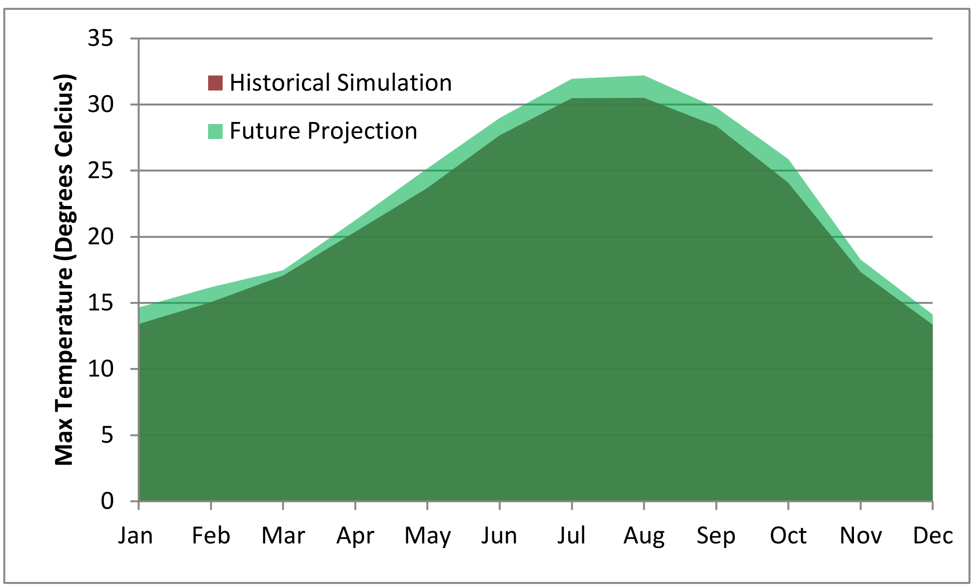


Figure P-10. Historical and Future Maximum Temperature (North County)

Figure P-11 and **Figure P-12** provide the differences in maximum and minimum daily temperatures. A rise in maximum temperatures indicates hotter day time temperatures and a rise in minimum temperatures indicate hotter night time temperatures (when compared with existing conditions). The two graphs indicate that the entire region will see an increase in temperature year-round, and, for the most part, the inland regions. The South County Sub-Region extends further inland (see **Figure P-6**) than the North Coast Sub-Region and so has similar characteristics to the North County Sub-Region in terms of temperature change in some months of the year. The greatest absolute and comparative difference between the Sub-Regions occurs during the summer months.

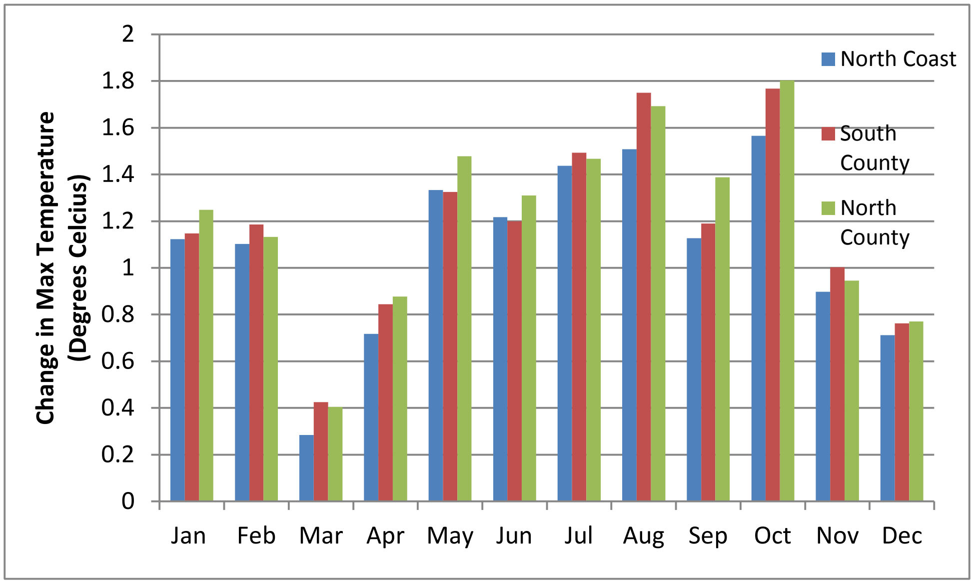


Figure P-11. Differences in Average Monthly Maximum Temperatures

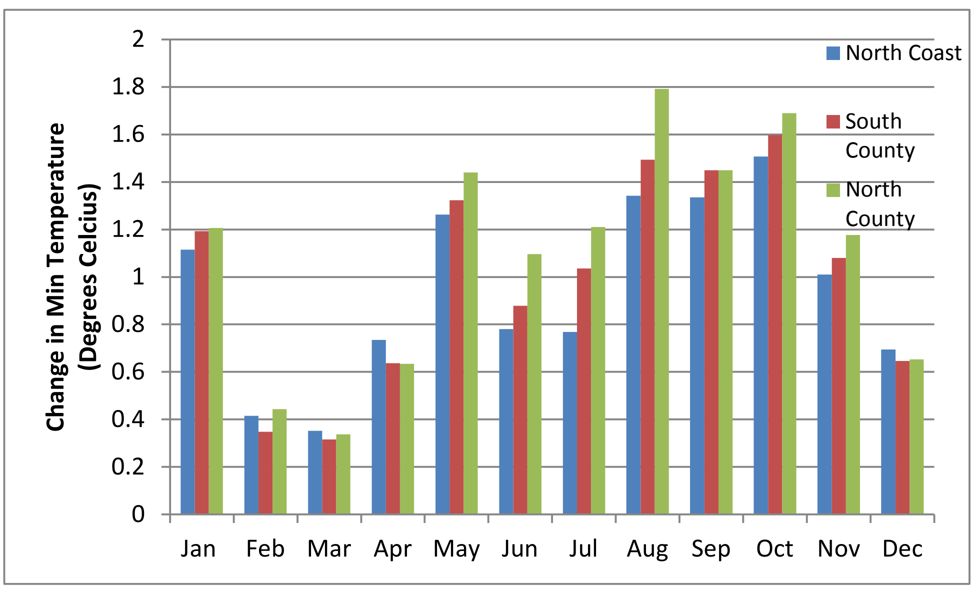


Figure P-12. Differences in Average Monthly Minimum Temperatures

P.7.3 Wind Speed Changes

Wind speed changes in **Table P-2** show minimal Sub-Region differences in the four seasonal periods. No additional analysis is available for wind speed changes.

P.7.4 Evapotranspiration Changes

Evapotranspiration (ET) is a measure of how the suns radiation affects the amount of water needed by plants to sustain growth. An increase, or positive change in **Table P-2**, represents an increase for water needed by the plant. **Figure P-13** shows the expected increase in the summer months when plants require water the most. **Figure P-14** provides the comparison amongst all three Sub-Regions, showing relatively little difference between the three Sub-Regions with the North Coast Sub-Region[7] having slightly less of an increase in ET than the North County Sub-Region in the spring months and more in the fall months. Most notably, the North County Sub-Region agricultural community reflects increased ET taking place during the spring growing season. The net result is an increased need for already constrained groundwater supplies in the Paso Robles Groundwater Basin.

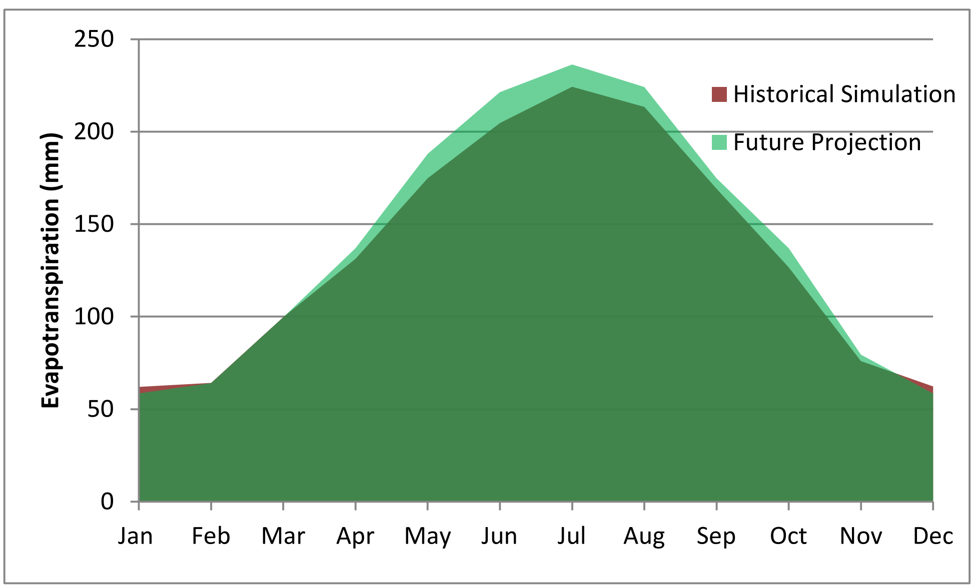


Figure P-13. Historical and Future Evapotranspiration (North County)

[7] While fog drip from the presence of dense marine layer is not treated separately in the Global Climate Change models as a component of precipitation, evapotranspiration rates in plants do inherently vary as available moisture and radiation decreases moving east away from areas influenced by the coastal marine layer.

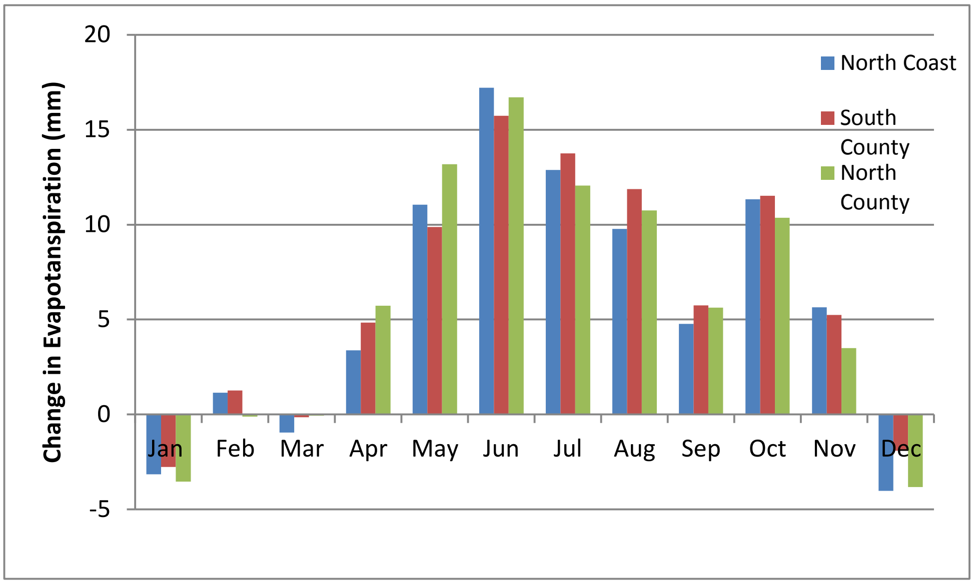


Figure P-14. Differences in Monthly Evapotranspiration

P.7.5 Runoff Changes

Runoff is an indicator of how much rainfall hits the ground and does not infiltrate or percolate to replenish groundwater supplies. This is an indicator of the intensity of storms, the size of the aquifers, and the soil moisture conditions. When rainfall events are spaced out and of low intensity, the region has an improved chance of capturing the water through deep percolation to groundwater supplies (or possibly to fractured rock). When soil moisture conditions reject the water, or aquifers become full, runoff occurs and is routed down streams and rivers, with some or all of the water stored in natural or manmade reservoirs. A change in the intensity and frequency of rainfall events resulting in changes in runoff can significantly impact a reservoir's operations resulting in insufficient stored water to meet water demands during the peak irrigation season. **Figure P-15** illustrates the shift in runoff over the 12 months of the year and the percent differences in the seasonal runoff volumes shown in **Table P-2**. **Figure P-16** indicates the North Coast Sub-Region experiencing the highest monthly change in runoff, with reduced change toward the inland regions. The smaller watersheds and small capacity aquifers along the north coast create shorter response times making it more sensitive to changes in storm event patterns. This sensitivity in the North Coast Sub-Region is seen in the runoff difference graph, especially when compared to the precipitation changes in **Figure P-8** for the same months.

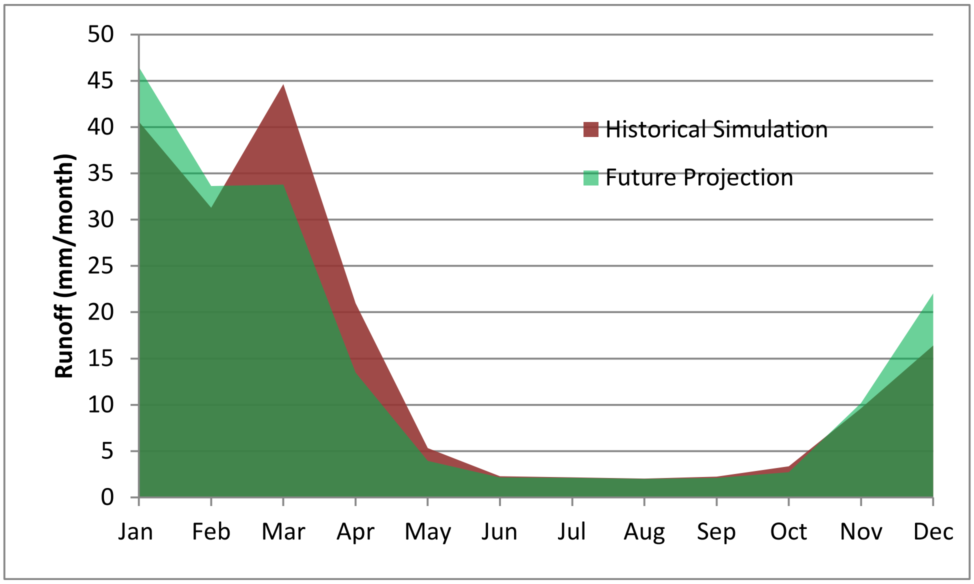


Figure P-15. Historical and Future Runoff (North Coast)

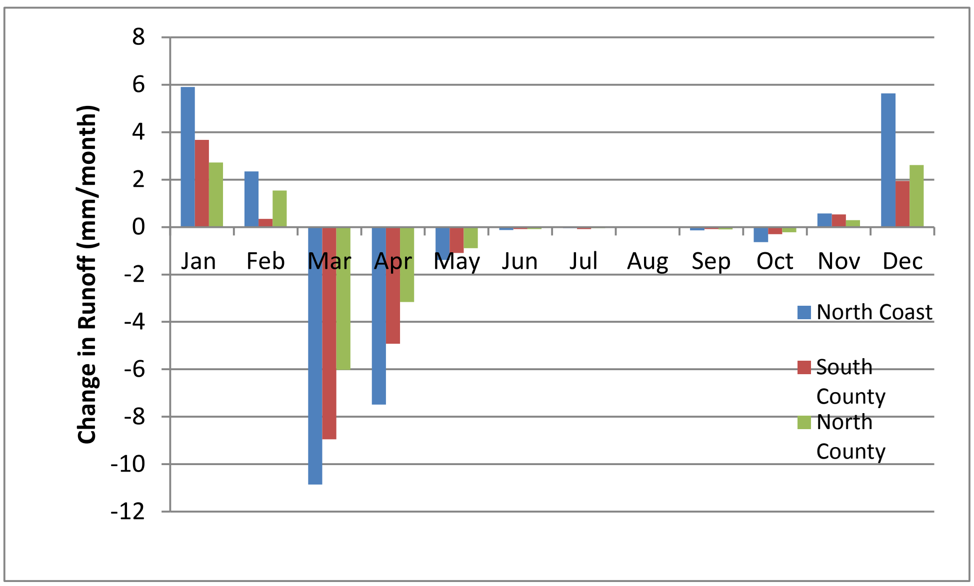


Figure P-16. Differences in Average Monthly Runoff

P.7.6 Daily Climate Change Results Expressed as Degree Days and Precipitation

With daily simulation data, the resolution of change significantly increases to the point where more can be said about how climate change affects the economy by considering how much hotter or cooler the temperatures will be, on average, for any given day of the year. **Section P.6.1.2** defines the concept of degree days and its purpose being to provide a metric of change that relates to the use of water and energy both impacting the human economy. **Table P-3** below shows summation of projected daily changes in the climate's daily metrics by mid-century (2050) with increases shown in green background and decreases shown in red backgrounds. Cells with white backgrounds indicate no significant change.

P.7.6.1 Changes in Growing Degree Days

A good example for GDDs is the change occurring in the North County Sub-Region. Using vineyards again as a surrogate for agricultural crops in the SLO Region, the number of GDDs increases with an increase in temperature.

The difference in the number of summer GDDs for the two coastal Sub-Regions appears to be slightly higher. This is caused by two factors: higher minimum temperatures due to temperate ocean influence along the coastline, and lower current number of GDDs along the coast than in the North County Sub-Region.

Table P-3. Projected Changes in Daily Climate Metrics by Mid-Century (2050)

Variable		Change in variables projected by GFDL Medium Emissions (A1B)			
		Winter	Spring	Summer	Fall
Growing Degree Days	North Coast	148.84	239.77	435.81	303.29
	South County	150.04	240.46	423.37	283.37
	North County	147.33	249.11	363.65	283.60
Heating Degree Days	North Coast	-288.00	-337.35	-214.49	-279.32
	South County	-296.08	-338.93	-190.82	-264.11
	North County	-306.75	-311.36	-48.87	-244.22
Cooling Degree Days	North Coast	0.00	0.00	1.16	0.37
	South County	0.00	0.05	1.51	0.41
	North County	0.00	0.69	80.83	10.44

Notes: Degree Days are represented using degrees Fahrenheit.
Differences are based on the equations provided in **Section P.6.1.2**

Figure P-17 and **Figure P-18** are histogram plots of the maximum and minimum daily temperatures. Both plots indicate a forward shift towards higher temperatures in the future. The mean maximum and minimum difference (i.e., shift in average) in temperatures is approximately 4.3°F (2.5°C) and 4.2°F (2.3°C), respectively. **Figure P-19** illustrates the shift in GDDs by representing the average daily temperature (average of maximum and minimum) and shows that the temperature shift is reducing the total number of days with an average temperature of less than 46°F (8°C) by a total of 33 days (see cross-hatched area representing days no longer less than minimum temperature) thereby increasing the number of growing days throughout the year.

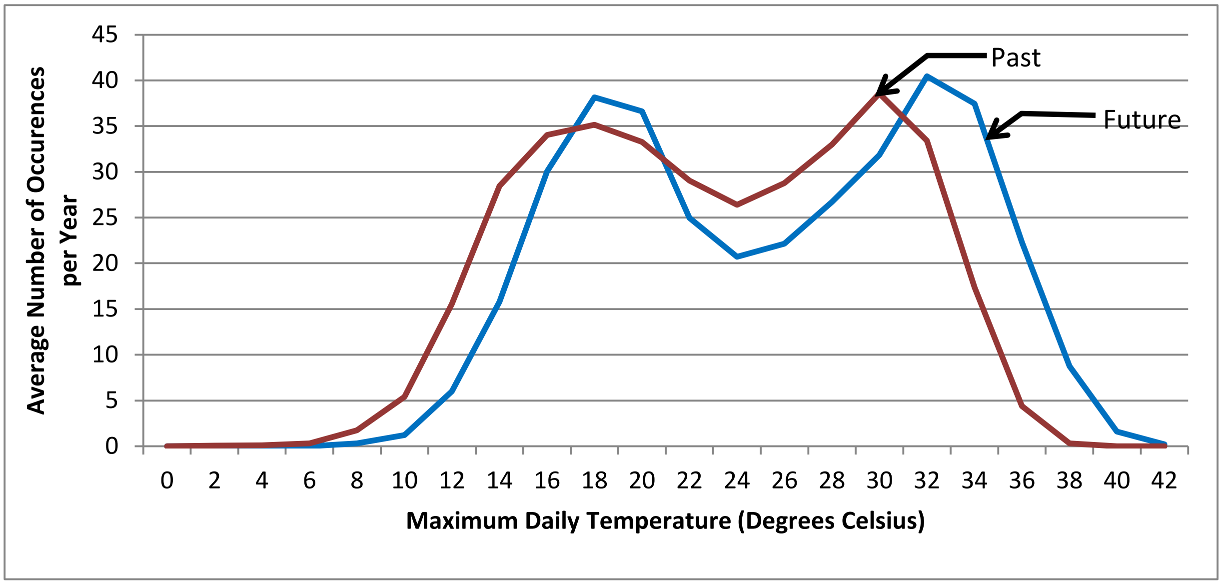


Figure P-17. Histogram Plot of Maximum Daily Temperatures

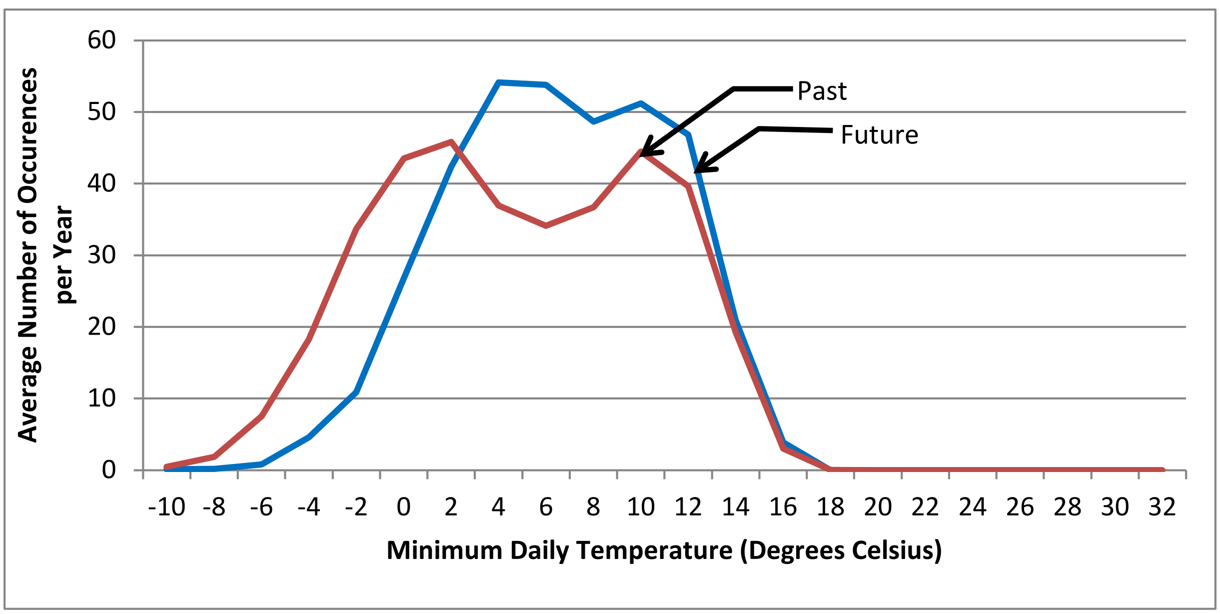


Figure P-18. Histogram Plot of Minimum Daily Temperatures

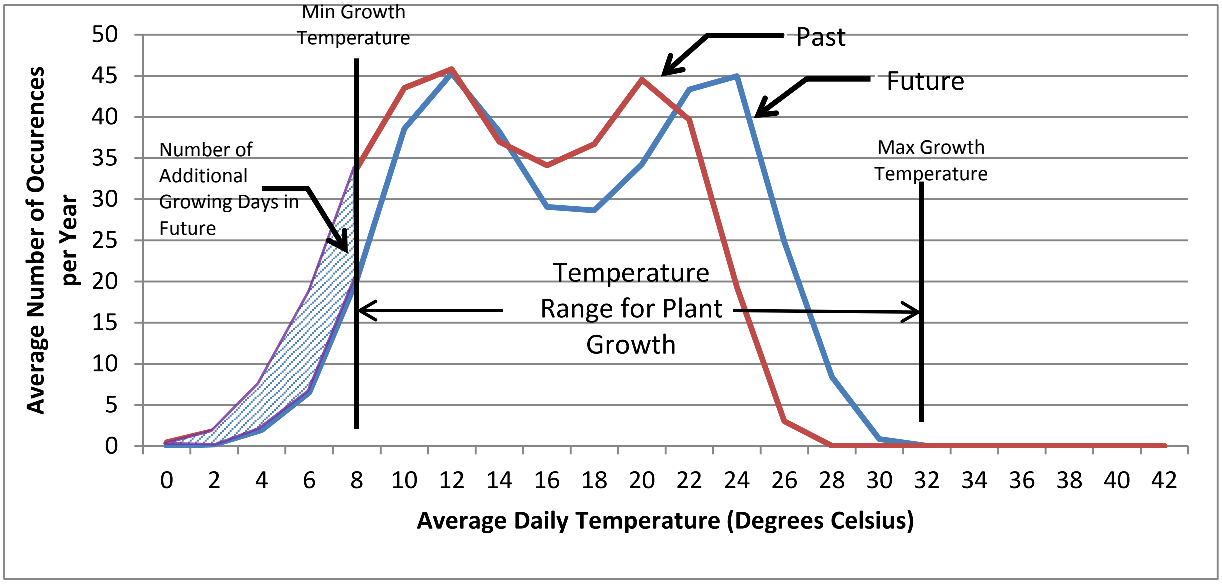


Figure P-19. Histogram Plot of Average Daily Temperatures

P.7.7 Overall Sub-Region Findings for Climate Change Analysis

Table P-4 provides additional details and general findings substantiating the results presented above for each Sub-Region.

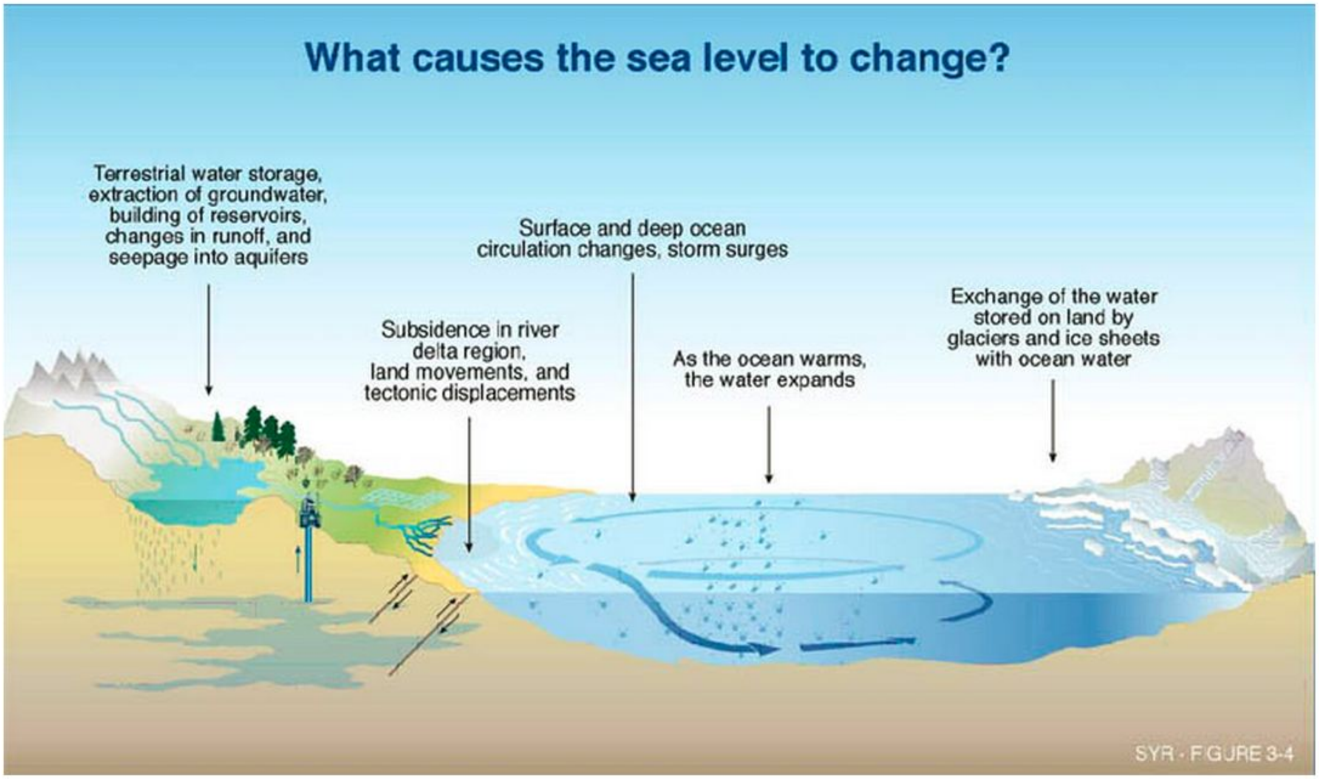
P.8 SEA-LEVEL RISE

In the history of the world, sea levels have been hundreds of feet higher and lower than what they are today due to the natural climate change cycle of ice ages and interglacial periods. Changes in sea level can happen due to many factors, including changes in the amount of ice and snow stored on land in the form of ice sheets and glaciers; the local shoreline moving up or down; or through larger scale processes such as global climate change. See **Figure P-20** for a depiction of events causing changes in sea level, and **Figure P-21** for a historical depiction of sea-level rise (SLR) over the past 140 years. The average rate of increase is approximately six tenths of a foot a year with the rate increasing to seven tenths over the past 65 years.

Being adjacent to the Pacific Ocean with approximately 100 miles of coastline, the SLO IRWM Region is concerned with SLR and has an interest in quantifying the changes in sea level that may occur in the coming years. While not completely understood, the forecasting of SLR in the modeling community, and hence different numerical and empirical approaches, estimates the rise at different geographic scales. There is no industry-accepted model currently in use.

Table P-4. Summary of Climate Change Findings as Related to Changes in Regional Water Resources

Climate Variables	North Coast Sub-Region	North County Sub-Region	South County Sub-Region
Rainfall	Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 38% indicate a shift in precipitation cycles, with an overall decrease in annual precipitation up to 4%	Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 41% indicate shift in precipitation cycles, with an overall decrease in annual precipitation up to 5%	Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 32% indicate shift in precipitation cycles, with an overall decrease in annual precipitation up to 5%
Maximum Temperature	Increases by 4.2% - 6.5% in maximum temperatures throughout the year (in degree Celsius) indicate an overall increase in warming patterns	Increases by 4.5% - 7.5% in maximum temperatures throughout the year (in degree Celsius) indicate an overall increase in warming patterns	Increases by 4.6% - 6.6% in maximum temperatures throughout the year (in degree Celsius) indicate an overall increase in warming patterns
Minimum Temperature	Increases by 9.8% - 18.8% in minimum temperatures throughout the year (in degree Celsius) indicate warmer night time temperatures	Increases by 12.1% - 49.9% in minimum temperatures throughout the year (in degree Celsius) indicate warmer night time temperatures. This region has below freezing winter temperatures, hence the changed values are sensitive to small changes in temperatures	Increases by 11.2% - 23.2% in minimum temperatures throughout the year (in degree Celsius) indicate warmer night time temperatures
Wind Speed	Minor changes in wind speeds ranging from increases up to 1% and decreases up to 2% possibly affecting evapotranspiration	Only minor changes in wind speeds ranging from increases of less than 1% and decreases up to 1%	Only minor changes in wind speeds ranging from increases of less than 1% and decreases up to 1%
Evapo-transpiration	Increases up to 7% expected in evapotranspiration in all seasons except winter where a decrease up to 3% indicate the need for a shift in irrigation patterns	Increases up to 6% expected in evapotranspiration in all seasons except winter where a decrease up to 4% indicate the need for a potential shift in irrigation patterns	Increases up to 7% expected in evapotranspiration in all seasons except winter where a decrease up to 2% indicate the need shift in irrigation patterns
Runoff	Increases in runoff in the winter by 15.7% and decreased runoff in the dry seasons up to 27.8% indicate shift in runoff patterns	Increases in runoff in the winter by 16.2% and decreases in runoff in the dry seasons up to 27.8% indicate shift in runoff pattern	Increases in runoff in the winter by 12.8% and decreased runoff in the dry seasons up to 33.7% indicate shift in runoff patterns
Heating/Cooling Degree Days	Significant decreases in heating requirements (heating degree days) through all the seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in summer and fall indicate higher energy costs in cooling building	Significant decreases in heating requirements (heating degree days) through all the seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in spring, summer and fall indicate higher energy costs in cooling buildings	Significant decreases in heating requirements (heating degree days) through all the seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in spring, summer and fall indicate higher energy cost in cooling buildings
Growing Degree Days	Increases in ambient growing temperatures (growing degree days) for plants in all seasons indicate need to alter crop types and water requirements	Increases in ambient growing temperatures (growing degree days) for plants in all seasons indicate need to alter crop types and water requirements	Increases in ambient growing temperatures (growing degree days) for plants in all seasons indicates a need to alter crop types and water requirements
Rainfall Events	Slight change in the number of precipitation events in winter and spring indicate shift in runoff and irrigation patterns	Slight change in the number of precipitation events in winter and spring indicate shift in runoff and irrigation patterns	Slight change in the number of precipitation events in winter and spring indicate shift in runoff and irrigation patterns



Source: IPCC Climate Change 2001 Synthesis Report

Figure P-20. Causes of Changes in Sea Level

A literature search indicates that, for the most part, the projected rise in sea level estimated by various studies using different approaches all fall within the same order of magnitude, as categorized and presented in **Table P-5**. The overall finding is that SLR is occurring and is tied to many of the same climate variables discussed above. In general, a change of less than 1 foot is likely to occur at mid-century and less than 3 feet by end of century (2100). This change combined with forecasted increases in storm surge and high tidal effects make for concerned on-shore impacts in the coming years. The 2010 GEOS Report stated the following regarding SLR:

> *Any SLR is considered to have large economic and natural resources impacts. In a report commissioned for the California Energy Commission, Cayan et al. (2009) indicate that by the end of the century, sea level is expected to rise 3.3 – 4.6 feet (1.0 – 1.4 meters) based on projections from six different global climate models run under the same A2 "business-as-usual" emissions scenario used in this report. Sea-level rise could accelerate even more, however, due to melting ice sheets. Sea-level rise will cause erosion along the coast as well as increased risk of damaging floods during large storms. Additionally, sea-level rise causes saltwater intrusion into wells and freshwater ecosystems near the coast. (GEOS, 2010)*

While the above SLR of over 4 feet is higher than other estimates in **Table P-5**, the more conservative (in terms of using a less moderate climate change scenario) A2 scenario represents an upper bound to the possible SLR for the region. A prevalent concern with SLR is the impact to coastal low lying urban areas at risk of flooding during periods of coincident high tide and flooding resulting from increased rain storm intensity. Further quantification of the implications of these changes is beyond the scope of this effort; however, through continued monitoring and adaptation, the SLO Region can adjust to the slow changes in sea level as they occur over the coming years.

Table P-5. Sea-level Rise Literature Search Results

Scale	Emissions Scenario	Projected Rise (m)	Projected Rise (ft)	Period	Climate Model	Data Source
Mid-Century						
Port San Luis	Historical	0.011-0.047 m	0.036-0.15 ft	2050	Extrapolation of Historical Trend	NOAA
California	Historical	0.15 m	0.49 ft	Mid-century	Extrapolation of Historical Trend	California DWR
California	Multi-Scenario	0.24 - 0.31 m	0.78-1.02 ft	Mid-century	Semi Empirical (Rahmstorf's) Approach	California DWR
California	Multi-Scenario	0.087 - 0.095 m	0.28-0.31 ft	2020 - 2049	PCM	Journal Publication
California	Multi-Scenario	0.116 - 0.127 m	0.38-0.41 ft	2020 - 2049	HadCM3	Journal Publication
California	Multi-Scenario	0.04 - 0.3 m	0.13-0.98 ft	2030	Multi-model Ensemble	National Academy
California	Multi-Scenario	0.12 - 0.6 m	0.39-1.96 ft	2050	Multi-model Ensemble	National Academy
Global	A1B	0.063 - 0.284 m	0.2-0.93 ft	2050	Multi-model Ensemble	IPCC
Late-Century						
California	Multi-Scenario	0.54 - 0.94 m	1.77-3.08 ft	End-Century	Semi Empirical (Rahmstorf's) Approach	California DWR
California	Multi-Scenario	0.192 - 0.288 m	0.63-0.94 ft	2070 - 2099	PCM	Journal Publication
California	Multi-Scenario	0.268 - 0.409 m	0.87-3.08 ft	2070 - 2099	HadCM3	Journal Publication
California	Multi-Scenario	0.42 - 1.67 m	1.37-5.47 ft	2100	Multi-model Ensemble	National Academy
Global	A1B	0.21 - 0.45 m	0.69-1.47 ft	2090 - 2099	Multi-model Ensemble	IPCC

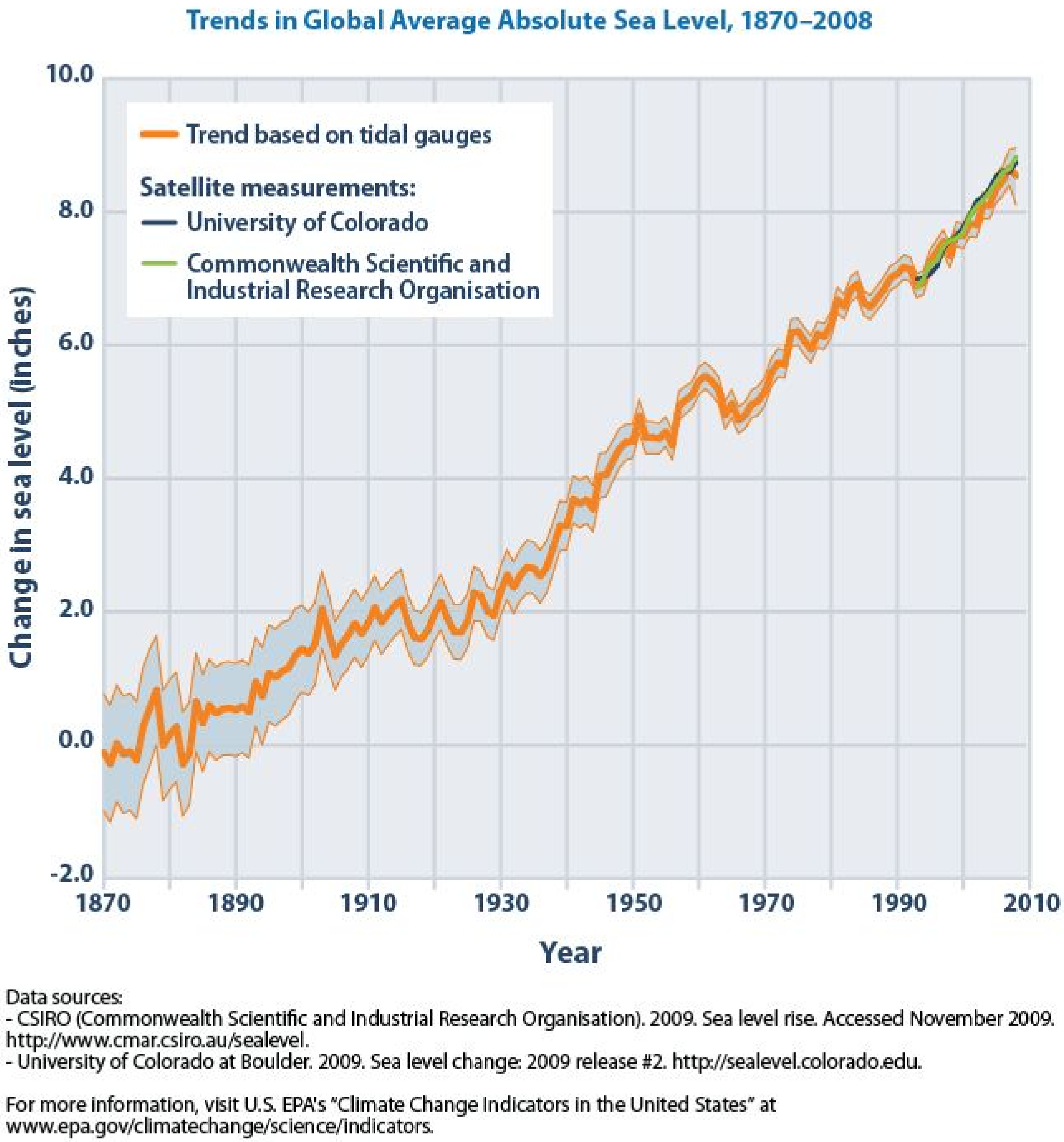


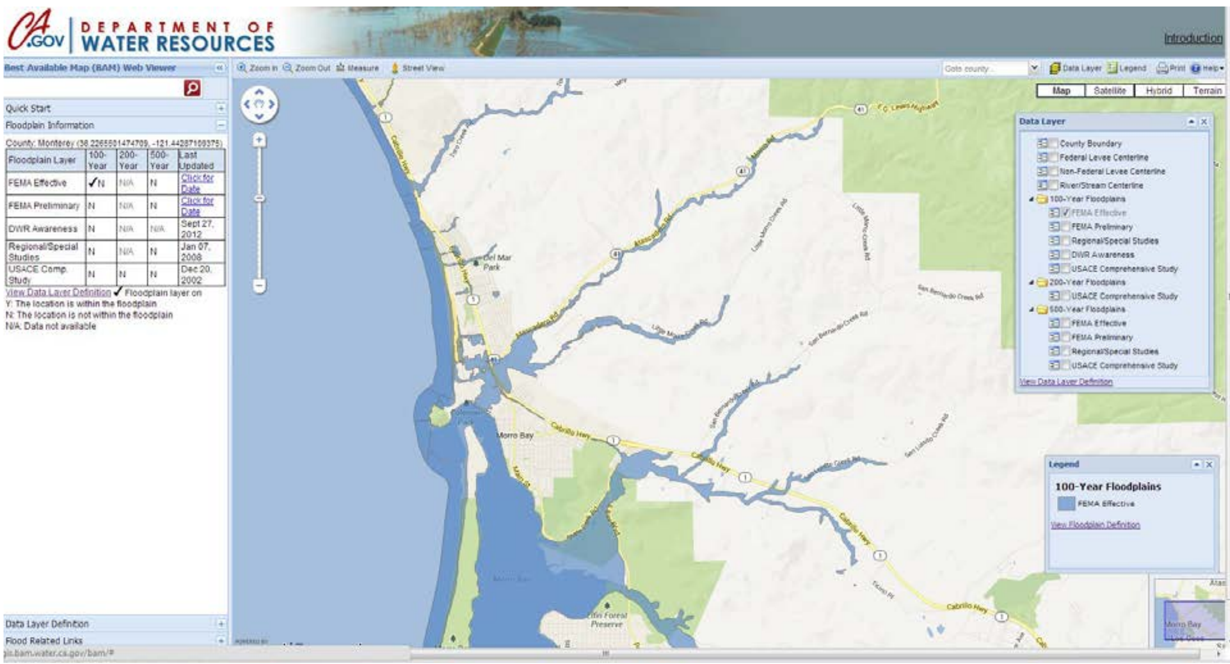
Figure P-21. Sea-level Rise Based on A1B Scenario Multi-model Ensemble

P.9 FLOODING DUE TO CLIMATE CHANGE AND EXTREME PRECIPITATION EVENTS

Though global climate models present uncertainty in the nature of projected changes in flooding and the increased intensity of precipitation events indicate a relatively low threat in the SLO IRWM Region. The changes in rainfall and runoff presented in **Section P.7** can be said to change floodplains set forth by the Federal Emergency Management Agency (FEMA).

Regardless of climate change, with continued flood management and monitoring activities, FEMA floodplain maps will require updating and structural remedies constructed to ensure the continued safety of life and property. Regulated rivers also require constant monitoring and modification in operations and structural/hydraulic design to mitigate for changed and unforeseen conditions in the weather patterns. **Figure P-22** is used solely as a source for where to find the FEMA floodplain maps as they may change over time because of climate change monitoring.

Note: This analysis does not take into consideration the effects of the "Pineapple Express" storms as the current global simulation models do not incorporate the physics of this event.



Source: <http://gis.bam.water.ca.gov/bam/>

Figure P-22. Current FEMA 100-Year Floodplain in the Morro Bay Region

P.10 VULNERABILITY ASSESSMENT

The Vulnerability Assessment incorporates the effort of the GEOS Institute and Local Government Commission (*Projected Future Climatic and Ecological Conditions in San Luis Obispo County, April 2010*, and *Integrated Climate Change Adaptation Planning in San Luis Obispo County, November 2010*) to evaluate climate change vulnerabilities in the IRWM Region as they relate to the region's water resources. For a complete and thorough listing of possible impacts and climate change vulnerabilities, the reader is encouraged to read the 2010 GEOS report at:

<http://www.geosinstitute.org/images/stories/pdfs/Publications/ClimateWise/sloclimatewisefinal.pdf>.

The purpose of the assessment provided below is to develop a working list of prioritized vulnerabilities to compare against IRWM projects in their selection and ranking in the IRWM Plan. Only those vulnerabilities believed to have the potential for further impact from IRWM Plan implementation are included in this list. The major categories of water resources-related vulnerabilities and their connection with water include:

Recreation/Tourism

- Fishing – streams and recreational lakes
- Birdwatching – wildlife areas including estuaries and wetlands
- Kayaking – natural streams and lakes
- Wine Country Touring – vineyard irrigation
- Camping – recreational lakes

Natural Water Dependent Activities

- Water Supplies – sufficient groundwater and surface water replenishment and storage
- Protected Fisheries – sufficient minimum in-stream surface water flows
- Food Production – sufficient water and moisture to maintain a healthy and sustainable food chain
- Groundwater Recharge – sufficient recharge water to recover each year
- Sediment Filtration – sufficient natural filtration through streambed and reservoir recharge
- Water Storage – sufficient surface water to fill natural and manmade reservoirs
- Hydroelectricity – sufficient surface water flows to run hydroelectric turbines
- Removal of Pollutants from Waterways – sufficient stream flows to reduce harmful concentrations

Agriculture/Timber

- Cattle Grazing – require irrigation sources
- Timber or firewood – require native woodlands
- Aquaculture – require water source for ponds
- Seasonal/Permanent Crops – require irrigation sources

As part of this analysis and with the knowledge of the three Sub-Regions (i.e., climate and socio-economic variables), each Sub-Region is examined individually using a list of questions intended to better understand the unique vulnerabilities of climate change. Each Sub-Region includes a set of categories and a scoring system[8] to assist in prioritizing projects intended to address the vulnerabilities based on the level of impact and the ability to mitigate for climate change in whole or in part. Prioritization of each Sub-Region is as follows:

> **Priority Rating 1** – significant vulnerabilities that have far-reaching impacts, are very likely to occur, have a willingness to pay[9] and can be addressed through well-defined near-term projects[10] where/when feasible.[11]
>
> **Priority Rating 2** – significant vulnerabilities with a high adaptive capacity and can be addressed through specific projects and planning studies and/or monitoring programs where/when feasible.
>
> **Priority Rating 3** – less than significant vulnerabilities for consideration in future long-term projects and planning studies and/or monitoring programs where/when feasible.

Shown in **Table P-6** are the rating categories and their ranking for each Sub-Region. The listing of vulnerabilities begins below the table.

Table P-6. Sub-Region Vulnerability Rating Categories and Ranking

Sub-Region	Rating Categories	Rating
North Coast Sub-Region	Inadequate Storage Capacity	1
	Saltwater Intrusion and Coastal Inundation	1
	Ecosystems and Habitat	2
	Water Quality	2
	Water Demand	3
	Flooding	3
North County Sub-Region	Water Supply	1
	Water Demand	1
	Water Quality	2
	Ecosystems and Habitat	2
	Flooding	3
South County Sub-Region	Decreased Water Supply	1
	Coastal Inundation	1
	Water Demand	2
	Water Quality	2
	Ecosystems and Habitat	2
	Flooding	2

[8] The scoring system used derived from *Section 4. Assessing Regional Vulnerability to Climate Change, of Climate Change Handbook for Regional Water Planning* <http://www.water.ca.gov/climatechange/CCHandbook.cfm> (DWR, 2011).
[9] Willingness to pay implies local funding is available to address vulnerability.
[10] Near-term projects are typically smaller projects with a shorter time frame to reach implementation.
[11] Addressing high priority vulnerabilities also alleviates vulnerabilities with lower priority (e.g., maintaining groundwater elevations would also prevent saltwater intrusion and reduce the risk to water quality).

P.10.1 North Coast Vulnerabilities

Inadequate Storage Capacity: Priority Rating 1

1. The indicated shift in precipitation from the dry seasons (summer and spring) to wetter seasons (fall and winter) implies a shift in traditional water storage operations.
2. North Coast Sub-Region aquifers may have reduced recharge from the change in the timing of excess precipitation.
3. The North Coast Sub-Region is dependent on coastal aquifers and limited diversion of surface water for their water supplies. Due to low storage capacity of the aquifers, the increased precipitation in the wetter months would become runoff and travel downstream to the ocean.
4. The smaller coastal groundwater aquifers of the North Coast Sub-Region are not resilient to droughts, and typical conjunctive-use solutions are limited because the aquifers' holding capacity limits the water that can be stored in years of available surplus in surface water supplies.
5. With reduced precipitation in spring, surface waters fed by natural springs (or high groundwater) are likely to become unreliable in the dry seasons. Perennial surface water sources are more likely to dry-up during the summer months, depleting the only source of drinking water supply, such as Pico Creek for the community of San Simeon.
6. The Whale Rock Reservoir that supplies water to some parts of the North Coast Sub-Region has similar challenges in storage of water due to the shift in the precipitation cycle.

Saltwater intrusion and Coastal Inundation: Priority Rating 1

1. The Ghyben-Herzberg principle that governs saltwater-freshwater relationships in coastal aquifers states that, "for each unit that freshwater level drops below sea level, the saltwater-freshwater interface will rise by 40 units in salt concentration." The region's coastal aquifers such as the Pico Creek Valley are the only source of water for smaller communities like San Simeon (also a disadvantage community [DAC]). Any rise in sea level would lead to salt water intrusion, increasing the likelihood of impairing their water supplies thus reducing the water available for urban uses.
2. As this is the coastal region, saltwater intrusion into sensitive estuaries and creeks is also a threat to wildlife and recreation requiring more water to flow downstream to

support ecosystem services, thus creating a conflict among users of limited water supplies (urban, agriculture, and rural users).

3. Critical coastal infrastructure such as Highway 1 and the 28 miles of coastal roads, and communities such as Morro Bay, Cambria, and San Simeon, are vulnerable to flooding due to rise in sea levels especially during coastal storm events.

Ecosystems and Habitat: Priority Rating 2

1. Loss of species at higher elevations such as loss of coastal oak woodlands and coniferous forests is expected as temperature and precipitation patterns change.
2. With changes in climate and reduced natural foraging areas, most sensitive wildlife species are expected to migrate to higher elevations or northward to find habitats conducive to their growth cycle.
3. Sensitive wetlands, the Morro Bay National Estuary, and ecosystems are at great risk in parts of the North Coast Sub-Region where they are already impacted due to urban development. Changes in rainfall and temperature interfere with conditions required for ecosystems and thriving habitats along the confluences of the ocean and the estuaries.
4. Higher water temperatures affect cold water aquatic habitats and related species dependent upon that environment.
5. Increased beach erosion (sand movement) occurs from rising sea levels in the region.

Water Quality: Priority Rating 2

1. The forested region of the North Coast Sub-Region is prone to wildfires in the drier seasons. Wildfires are projected to increase in the region due to drier conditions and warmer temperatures. Post-wildfire impacts compromise water quality by the development of mudslides and burnt residue transported through runoff and wind. Both produce undesirable chemical concentrations in rivers, streams, and lakes; affecting water quality of downstream drinking water supplies, fisheries, and recreation.
2. Water quality for both urban and agricultural uses in the North Coast Sub-Region changes with the intrusion of salt water from the ocean into coastal aquifers and natural streams.
3. Lower base flows in streams and rivers lead to higher concentrations of minerals and lower water quality.
4. Lower groundwater elevations in small coastal aquifers increase the concentration of nitrates, sulfates and total dissolved solids in the water.

5. Increased outside temperatures lead to increases in temperature of surface water supplies that is often associated with poor water quality. (There is not enough literature on the effects of increased temperatures on groundwater as a result of higher surface water recharge temperatures; however, changes in solubility of geochemicals do affect water quality.)
6. Increased runoff in winter increases the sediment load in surface water supplies affecting water quality.

Water Demand: Priority Rating 3

1. Increased temperatures are responsible for changes in water consumption for agriculture and outdoor urban landscape areas due to changed growing cycles and increased evapotranspiration.
2. Plant growth is conducive to warmer temperatures, and, as the climate in the region gets warmer, a potential growth in agricultural production occurs especially for winter crops.
3. Population growth in the region has been constrained by the already limited supply of drinking water.
4. Despite the growth moratoriums in the region, the water demands of the already existing communities expect to increase along with increased evapotranspiration demands from the domestic use of outdoor water used for watering lawns and landscaping.
5. Environmental water demands, similar to agriculture, increase during dry seasons with insufficient instream flows needed to support aquatic habitats and migratory flow requirements.
6. Reduced spring precipitation and runoff affects (or shift) the monthly water demand pattern; however, the majority of this shift results in the reduction of supply and not an increase in demand.
7. Projected increases in wildfires due to drier conditions result in the increased need for water required for fighting wildfires, and an increased potential of placing urban and rural communities at risk for the protection of life and property.

Flooding: Priority Rating 3

1. The coastline of the North Coast Sub-Region is located inside the FEMA 100-year effective floodplain. With the shift in precipitation and increase in runoff in the winter season, the region becomes more vulnerable to floods both in frequency and intensity.

2. Sea-level rise causes inundation of certain areas of coastal communities, which can increase the extent and severity of storm-related flooding events inland where there was historically no flooding (or less severe).

P.10.2 North County Vulnerabilities

Water Supply: Priority Rating 1

1. The North County Sub-Region relies almost entirely on groundwater. The Paso Robles Basin, Atascadero Sub-Basin, Pozo Valley Basin, and Carrizo Basin are the larger groundwater basins in the region. Maintaining or stabilizing groundwater levels is a critical water issue in the region. Climate change exacerbates these issues assuming increased urban and agricultural water demand on the groundwater supplies.
2. The overall decrease in precipitation projected in the North County Sub-Region reduces the total amount of water available for groundwater recharge, exacerbating the decline in groundwater levels.
3. A shift projected in the precipitation cycle with the bulk of precipitation occurring in winter and reduced amounts projected in the spring and summer produces drier spring and summer months when needed water for peak agricultural irrigation and increased urban and rural demands will not be available.
4. The shift in the precipitation cycle directly affects the volume of runoff with the winter seeing higher volumes and spring seeing lower volumes.
5. Snow melt reductions change the reliability of imported state water deliveries.

Water Demand: Priority Rating 1

1. Agriculture is a major industry in the Sub-Region and accounts for a majority of the water consumption. With the likely increase in temperatures, growth cycles in crops increase causing a shift in the cropping patterns and subsequently increase water demands in the region.
2. Drier springs and summers with average temperatures up to 71˚F, and warmer night time temperatures are conducive for the quality and quantity of grape vines. The wine production in the region has increased in recent years and is likely to continue to increase with climate change becoming more conducive to growing vineyards. Since temperatures are known to affect the quality of crops, the crop selection (i.e., variety of grapes or change from vineyards to feed crops) is uncertain but shift towards new crops could increase water demands.

3. Warmer temperatures and other climate variables increase evapotranspiration leading to increased water demands for agriculture and increased outdoor water demands for domestic use in urban and rural areas.
4. Projected increases in wildfires due to drier conditions result in the increased need for water required for fighting wildfires. Increased wildfire potential placing urban and rural communities at risk result in the need for increased above ground water storage to control the fires and to protect life and property.

Water Quality: Priority Rating 2

1. An overall reduction in precipitation and potential decline in groundwater elevations lead to increased dissolved solids, salts, concentration of minerals, and potentially geothermal influences in the water. These problems are exacerbated in the drier months due to the shift in precipitation towards winter.
2. The potential increase in agriculture in the region leads to increased use of pesticides and fertilizers. The chemicals and nutrients from these applications are likely to leach into the groundwater along with the return flow and deteriorate drinking water supplies.
3. Projected increased wildfires in the region due to drier conditions and warmer temperatures create environmental and drinking water impacts. Post-wildfire impacts compromise water quality by the development of mudslides and burnt residue transported through runoff and wind. Both produce undesirable chemical concentrations in rivers, streams and lakes, affecting water quality of downstream drinking water supplies.
4. Increased runoff in winter increases the sediment load in surface water supplies affecting water quality.
5. Increases in water temperatures in winter months interfere with mixing cycles of water in large water bodies, such as Salinas and Nacimiento reservoirs, in turn affecting water quality and recreation.
6. Lower base flows in streams and rivers lead to higher concentrations of minerals and lower water quality.

Ecosystems and Habitats: Priority Rating 2

1. Expected loss of plant species at higher elevations such as loss of coastal oak woodlands and coniferous forests occurs as temperature and precipitation patterns change.

2. Projected increases in wildfires adversely affect ecosystems by the destruction of flora and fauna.
3. Changing climate leads to flora and fauna migrating elsewhere or to higher altitudes to reach habitats conducive to their growth cycle. Extended periods of dry riverbeds associated with the Salinas, Nacimiento, and other river systems could reduce populations of species dependent upon live flow during certain migratory periods, such as Steelhead Salmon. It could also reduce water available to sustain riparian habitats.
4. Many aquatic and terrestrial species are known to be susceptible to poor water quality and higher water temperatures, and will be negatively affected by the impacts of climate change. This includes species and habitats associated with the Carrizo Plains and Soda Lake, Salinas Reservoir and river system, and other sensitive ecosystems.

Flooding: Priority Rating 3

1. The areas surrounding the Salinas and Nacimiento rivers and related streams, as well as the Carrizo Plains all lie in the FEMA 100-year effective floodplain. Increased precipitation and runoff in the winter season makes these regions vulnerable to increased intensity and frequency of flooding events.

P.10.3 South County

Decreased Water Supply: Priority Rating 1

1. Projections of precipitation indicate decreases in the average annual precipitation and a shift in the precipitation patterns with more precipitation occurring in winter and reduced precipitation in spring and summer. These conditions pose water supply challenges similar to that in the North Coast Sub-Region.
2. The shift in precipitation patterns towards the winter months coupled with an overall projected annual reduction in precipitation requires that water be stored in the wet months for later use in the drier spring and summer months.
3. Part of the South County Sub-Region overlies the adjudicated Santa Maria Basin thus limiting the amount of water supplied from the basin, in turn, increasing the dependence of the Sub-Region on surface waters.
4. Water sources in the region include groundwater, the California State Water Project, Lopez Reservoir, Whale Rock Reservoir, Nacimiento Water Project, and the Salinas Reservoir. In addition to groundwater constraint, sources of surface water are expected to become less reliable, especially the California State Water Project, which is reliant on snow melt in the Sacramento Valley.

5. The overall reduction in precipitation in the region results in less reliable surface water supplies in the drier months.
6. As a result of intense upper watershed rain storms and/or post wildfire events, reservoir capacities are expected to be impacted by mud flows and sediment depositions; both causing reductions in storage.

Coastal Inundation: Priority Rating 1

1. The South County Sub-Region includes recreational beaches and tourist destinations like Pismo and Avila beaches, Pismo State Park, Oceano State Vehicular Recreational Area, and Port San Luis, which are critical to sustaining the local economy. Also included are sensitive coastal ecosystems and habitats. These locations are all vulnerable to coastal inundation through increased flooding, storm surges, and sea-level rise.
2. The Diablo Nuclear Power Plant is also located along the coast of the South County Sub-Region and is vulnerable to the effects of coastal inundation on infrastructure and processes (as a result of sea-level rise and storm surges).
3. Highway 1 runs along the coast of the South County Sub-Region and is vulnerable to flooding due to sea-level rise especially during coastal storms. Closures impact businesses, the safety of low-lying residential areas and recreational areas.

Water Demand: Priority Rating 2

1. The South County Sub-Region's agricultural community, such as in the Arroyo Grande, Edna Valley, Osos Flaco, and Nipomo area, can expect increases in temperature affecting the number of Growing Degree Days. This affects the crop types, cropping patterns, and crop irrigation requirements. During the summer, creek and stream flows cease to run when increased groundwater extractions occur.
2. Increases in evapotranspiration result in an increased use of water for urban and agricultural irrigation.
3. Small oil fields are located in the South County Region and require water for cooling in their processes. Increased surface water temperatures result in larger requirements for water to achieve the same level of cooling.
4. Projected increases in wildfires due to drier conditions result in the increased need for water required for fighting wildfires. Increased wildfire potential placing urban and rural communities at risk result in the need for increased above-ground water storage to control the fires and to protect life and property.

5. Reduced summer runoff makes it difficult to meet in-stream flow requirements for sustaining ecosystems and habitats.

Water Quality: Priority Rating 2

1. Increases in water temperatures in winter months interfere with mixing cycles of water in large water bodies, such as Lopez Reservoir, in turn affecting water quality.
2. Projected increased wildfires in the region due to drier conditions and warmer temperatures impact environmental and drinking water. Post-wildfire impacts compromise water quality by the development of mudslides and burnt residue transported through runoff and wind. Both produce undesirable chemical concentrations in rivers, streams, and lakes; affecting water quality of downstream drinking water supplies.
3. Saltwater intrusion in coastal aquifers is a threat to drinking water quality.
4. Lower groundwater elevations in the inland areas of the Santa Maria Groundwater Basin may suffer from increased concentration of nitrates, sulfates, and total dissolved solids in the water.
5. Increases in water temperature reduce dissolved oxygen in water bodies and streams, leads to poor water quality.
6. Increased runoff in winter increases the sediment load in surface waters affecting water quality.
7. Lower base flows in streams and rivers lead to higher concentrations of minerals and lower water quality.

Ecosystems and Habitats: Priority Rating 2

1. Ecosystems already impacted due to urban development face increased impacts with rising sea levels and reduced stream flows.
2. Beach erosion (sand movement) occurs from rising sea levels and tidal effects in the region.
3. Many aquatic and terrestrial species are susceptible to poor water quality and higher water temperatures, and negatively affected by the impacts of climate change.
4. Loss of species such as coastal oak woodlands, riparian habitats, and coniferous forests occurs as temperature and precipitation patterns change.

Flooding: Priority Rating 2

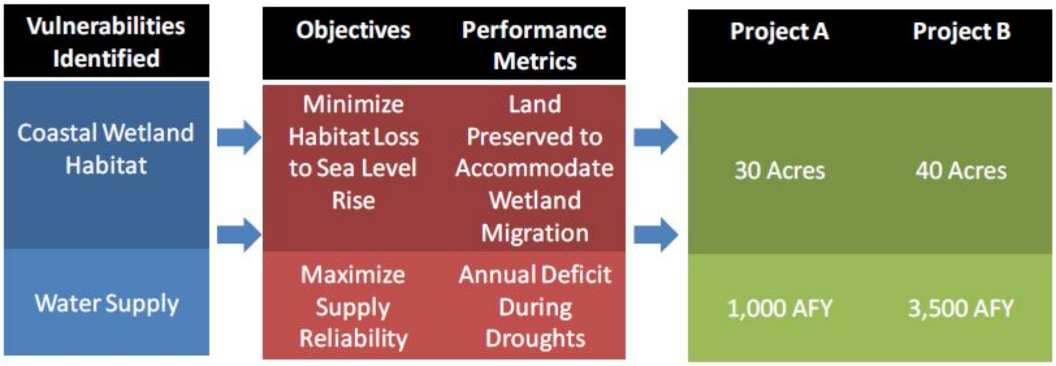
1. The coastline along the South County Sub-Region and some inland areas such as Pismo Beach are situated in the FEMA 100-year floodplain areas.
2. Low lying coastal communities, such as Oceano, Grover Beach, and Pismo, have a significant amount of urban development in historical wetlands and marshes. The shift in the precipitation cycle to winter and increased runoff from higher intensity storms will likely make these communities more susceptible to flooding.
3. Sea-level rise causes inundation of certain areas of coastal communities, which can increase the extent and severity of storm-related flooding events.

P.11 ADAPTATION STRATEGIES

Climate change incorporated into the SLO Region IRWM Plan's Objectives and Performance metrics provide the necessary assurances to address adaption strategies and methods of mitigating climate change. Project development and evaluation includes both climate change mitigation and GHG emissions reduction (from a baseline) and GHG sequestration opportunities. Because of this, a single performance metric for climate change adaptation does not work. Instead, the total extent to which a concept, project, or program, and the IRWM Plan as a whole, helps the region adapt to climate change is considered a better method of describing adaptation. Consideration of the risks that would occur if the region did not address climate change would also aid in describing adaptation.

When evaluating projects, the combined numerical or qualitative values for ranking the project should reflect climate change as one of the benefits of that project. If climate change is added to the project, such as digression from predicted effects of climate change (increased flooding and increase water demand), the climate change adaptation benefits of the project will be quantified and included in the project numerical ranking.

An example per the *Climate Change Handbook for Regional Water Planning* (State Handbook) (DWR,2011) is shown in **Figure P-23**, where both projects contribute to climate change adaptation. Project B preserves more habitat area than Project A, but Project A is better than Project B in maximizing drought reliability. The planner may choose to create a composite index of climate change adaptation performance using the performance metrics values for each project, as well as information on the weight or priority of the planning objectives. This type of composite evaluation and weighting helps planners evaluate and incorporate tradeoffs involved with various project alternatives.



Source: Climate Change Handbook for Regional Water Planning

Figure P-23. Example of Project Contributions to Climate Change Adaptation

The State Handbook goes on to provide:

Performance metric evaluation in an IRWMP occurs at three stages: the baseline level, the project level (individual or integrated), and at the IRWMP level for a portfolio of projects… Climate change considerations are incorporated into this evaluation process in three ways:

1. *Any performance metric that may be influenced by climate change impacts needs to be quantified in a manner that accounts for this possible influence…An example would be the annual yield of a storage project, which is an important metric to characterize such a project, but can be impacted by climate change….*

2. *Some performance metrics may explicitly address climate change adaptation. These performance metrics must be quantified and added to the mix of performance metrics that contribute to overall project portfolio ranking and weighting…*

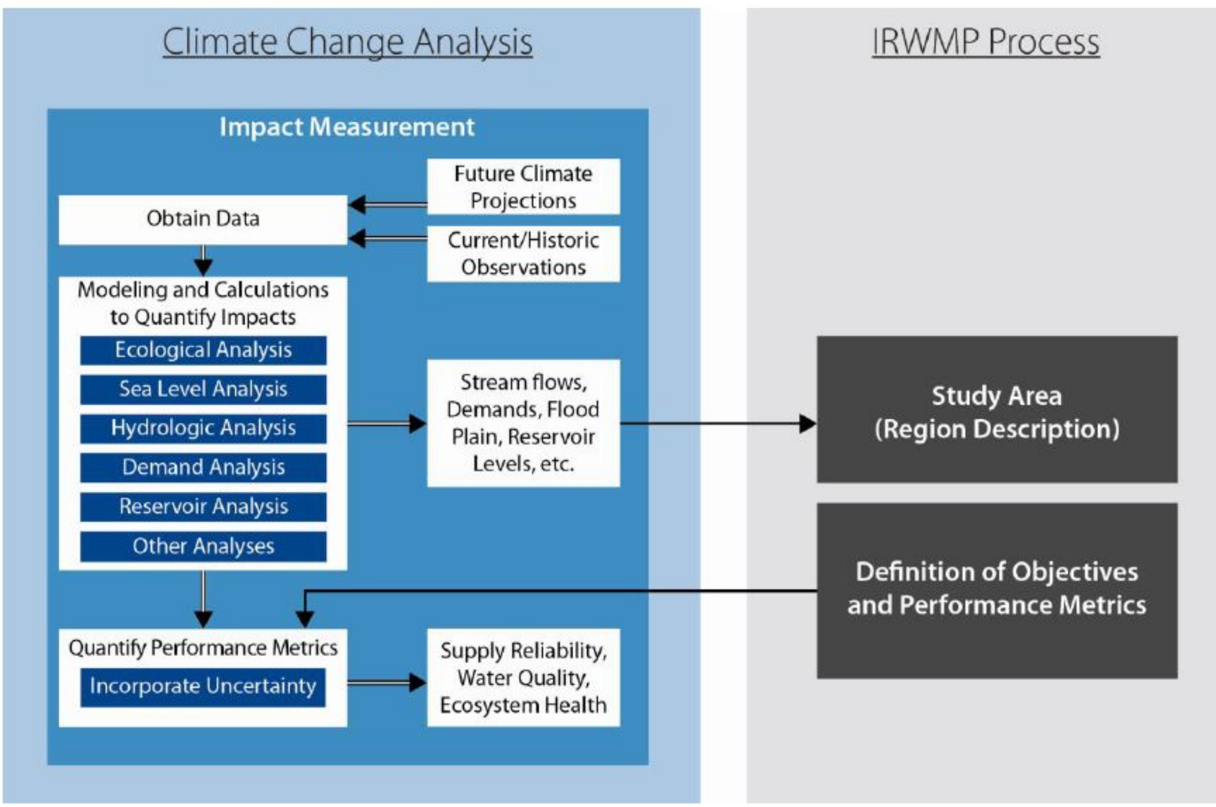
3. *At least one performance metric should explicitly address climate change mitigation. These performance metrics must be quantified and added to the mix of performance metrics that contribute to overall project portfolio ranking and weighting.*

P.12 FUTURE DATA GATHERING AND ANALYSIS

Chapter 5 of the State Handbook, *Measuring Regional Impacts (DWR, 2011)*, provides the definitive methodology in data gathering and analysis to measure climate change and assess its impacts through the IRWM Planning process. **Figure P-24** (excerpted from Chapter 5) below illustrates the connectivity between the need to quantify climate change variables for purposes of satisfying the requirements of the IRWM Planning process and in defining the Objectives and Performance Metrics. This section is a very brief summary and highlights only the beginning of a long data collection and modeling process of making future projections and then monitoring the essential climate change variables to validate or invalidate the projections; then continue to make projections and continue to monitor in perpetuity. Modeling and monitoring work hand-in-hand to continuously define better models that define the Objectives and Performance Metrics of the IRWM Plan.

By carefully selecting the available models, and interpreting the results, this section provides the baseline of monitoring climate variables most meaningful to describing the region's most important water-related concerns as follows:

1. Water Demand
2. Water Supply
3. Water Quality
4. Ecosystem and Habitat Vulnerability
5. Sea-level Rise
6. Flooding



Source: Figure 5-1 of State Climate Change Handbook

Figure P-24. Process for Measuring Impacts of Climate Change as Part of IRWM Plan

P.12.1 Water Demands

Obtaining data for water demands (or demand analysis) is shown in **Figure P-24** as informing models and performing calculations to quantify impacts. This information is then shown to be used in the IRWM planning process for purposes of the Region Description[12] and, like all water-related concerns, for defining the Objectives and Performance Metrics.

Water demands and climate variables are collected as part of the Data Management Program described in **Section K – Data Management**. The monitoring results provide the correlation between water demands and increased temperatures, changed precipitation patterns, increased evaporation and plant transpiration (also referred to as ET), and decreased runoff, as described in **Section P.7**. Of all the water demand sectors, urban demands are most accurate due to current state-mandated monitoring requirements, and they offer the best opportunity to begin monitoring changes in climate as a function of changes in water demand. The State Handbook states:

> *The general approach of regression analysis involves developing a regression relationship between water demand versus temperature and precipitation. Planners can then use this relationship to evaluate future conditions.*

Agricultural demands are a function of precipitation, temperature, and ET climate variables, but vary significantly based on crop types and crop-specific ET requirements. To simplify and provide a meaningful correlation, a preferred approach is to identify changes in ET to both temperature and precipitation. This information, in turn, allows for the calculation of agricultural water demands based on the ET, irrigated area, crop type, precipitation, and temperature. The same relationship between the climate change variables and agricultural water demands can be used to model future conditions.

P.12.2 Water Supplies

Measurement of water supplies and quantifying supply reliability focuses on: 1.) water supply sources within the region, 2.) water imported into the region, and 3.) supplies for environmental needs. Many of the tools and data collection systems already in place throughout the region monitor these three supply elements and report based on need and available resources. Correlating changes in the amount of water supply with the climate variables of rainfall, temperature, and runoff provides the relationships to make model adjustments in rainfall runoff, imported water reliability, and in-stream flow requirements for

[12] Due to the number of public water agencies and water planning areas, **Section D – Water Supply, Demand, and Water Budget**, is separated from **Section C – Region Description**.

environmental demands. Many local and state models use the climate variables in their projection of available water supplies and especially for California State Water Project contractors who rely on these supplies, including San Luis Obispo County.

P.12.3 Water Quality

Surface water quality affects both drinking water supplies and ecological/environmental needs. The IRWM Region's near-coastal drinking water intakes and estuarine habitats are both susceptible to salt water intrusion. Fish in local rivers and streams are susceptible to higher temperatures. Rivers, reservoirs, lakes, and coastal areas are all susceptible to low dissolved oxygen that accompany higher temperatures.

As quoted in the State Handbook, Water quality models are by their very nature "*labor intensive and require a high level of technical expertise*" (DWR, 2011). The expectation to monitor climate variables associated with water quality is high with water quality monitoring programs planned to increase in breadth over time. Monitoring programs outside of the IRWM Planning process will provide necessary data for modeling; however; the application of the water quality data and performing correlations with climate change variables and validating water quality models are not proposed within the IRWM Planning process.

P.12.4 Ecosystem and Habitat Vulnerability

The approaches to measuring potential impacts of climate change on the environment, including flora and fauna, are varied. While more vulnerability metrics and methods for assessing them can be found in the literature, the IRWM Plan's implementation of data management and monitoring programs can only consider stream water temperature, water quantity, estuarine salinity, and coastal habitat loss from sea-level rise.

Data collection activities surrounding the protection of water supplies from salinity intrusion also protects the estuary and coastal wetland areas dependent on freshwater. Changes in the water quality could have a significant impact on aquatic life, but require the same models described above in Water Quality. Streamflow estimations can be easily calculated and modeled to assess potential ecosystem impacts as a result of reduced rainfall and runoff. While modeling tools are available to estimate future marsh and wetland migration or loss, this modeling effort is also allocated outside the planned work effort of the IRWM Plan process. Simple comparisons can take place, such as between the areas of coastal habitat and the projected sea-level rise impacts.

P.12.5 Sea-level Rise

Data collection of SLR takes place through local monitoring of the Central Coast Region. In addition, publication of global SLR data informs the region of continued threat to similar coastal regions. The State Handbook explains:

> *One method for quantifying SLR climate change impacts is to superimpose projected SLR onto elevations for existing coastal floodplains….With new floodplains mapped, it is possible to compare existing infrastructure and resource locations with these flood plains.*

Tracking and reporting SLR data is considered to be a long-term monitoring effort with frequent reporting and comparisons with climate change model forecasting. Models calibrated to the measured SLR stand to benefit from this data collection effort. Though necessary models and data will be utilized, the process of collecting the information will not be included as part of the San Luis Obispo IRWM Plan implementation.

P.12.6 Increased Flooding

The fact that global climate change models work on the low resolution of a monthly time step, they do not capture the higher resolution storm events occurring over days within the months. Extreme storm events (e.g., the "Pineapple Express" as described in **Section P.9**) can occur over a period of hours or days. Monitoring of severe storm events currently occurs as part of the flood protection responsibilities of the region. However, there are few examples of alternative tools and methods to correlate storm events to changes in the climate variables, and most are either not available or need to be specifically tailored to incorporating climate change considerations into flood planning in the region. Therefore, the direct monitoring of flood events itself for purposes of monitoring climate change will not be incorporated within the IRWM planning process. Nonetheless, the region recognizes that the assessment of climate change impacts on future flooding is an important aspect of regional water planning.

P.13 PROJECT RATINGS BASED ON CLIMATE CHANGE

The top 15 projects listed in Table G-3 of **Section G – Project Solicitation, Selection and Prioritization** were individually evaluated and rated based on two criteria -

1. Potential of adaptation to the projected effects of climate change in the region
2. Potential of reducing greenhouse gas emissions due to water related activities

P.13.1 Adaptation Analysis

The potential for adaptation of each project has been analyzed based on its ability to address the regions' projected vulnerabilities. In the above sections, projected changes in the climate variables have been associated to vulnerabilities related to water resources in each respective Sub-Region. The vulnerabilities identified are – Decreased Water Supply, Saltwater intrusion and Coastal Inundation, Ecosystem and Habitats, Water Quality, Increased Water Demands, and Flooding. **Table P-6** indicates the prioritized vulnerabilities for each region.

What follows is a scoring of the primary list of projects based on the vulnerabilities alleviated from, or benefited by, each project's implementation. Vulnerabilities alleviated by the project contribute points (see **Table P-7**) towards a cumulative score for the project. The projects are then categorized into 'High Adaptation Potential', 'Medium Adaptation Potential' and 'Low Adaptation Potential' categories.

Table P-7. Point Chart for Each Vulnerability Alleviated by Projects for All Sub-Regions

Potential Vulnerabilities Alleviated by Projects	North Coast	North County	South County
Supply Benefits	3	3	3
Prevention of Saltwater Intrusion and Coastal Inundation	3	n/a	3
Enhancement or Conservation of Groundwater	2	2	2
Improving Water Quality	2	2	2
Demand Reduction	1	3	2
Benefits to the Ecosystem & Habitat	2	2	2
Flood management	1	1	1

Note: Point values represent number of projects in the Sub-Region alleviating a given vulnerability.

P.13.2 Mitigation Analysis

The mitigation potential of projects has been analyzed by examining the energy intensive activities involved and averted by each of the projects. Electricity is required to pump, treat, distribute and recycle water and wastewater. During the process of generating this electricity, burning of fossil fuels leads to emissions of greenhouse gases. These emissions can indirectly be associated with the energy expended for the water-related activities of each project; however, water savings or excess water needs from the proposed projects cannot be quantified at the current planning level. The emissions factor for energy generation also varies between the projects. Hence, the projects have been qualitatively compared for their potential of GHG emissions reduction. **Table P-8** presents a baseline of emissions typically associated with water related activities. A California wide emissions factor of 0.492859 lbs/kWh (Emission factor obtained from the San Luis Obispo County Climate Action Plan Appendix A) has been used to estimate the emissions associated with each water intensive activity. To rank the projects for their emissions reduction potential, the change in emissions due to water related activities, relative to the baseline emissions, of every project has been categorized into "Positive", "Neutral" or "Negative".

Table P-8. Baseline Emissions from Water Related Activities per AF

Activity	Energy intensity (in kWh/AF)	Associated Emissions (in lbs of CO_2e/AF)	Regional Extent
Groundwater Pumping	450	221	Central Coast (Average between 1999- 2005)
Recycling	1,129	556	Statewide
Water Distribution	1,000	493	Statewide
Water Treatment	312	154	Statewide
Desalination Brackish	1,689	8,324	Central Coast
Desalination Sea Water	4,000	19,714	Central Coast
Wastewater treatment	2,012	992	Statewide

Source: Embedded Energy in Water Studies- Study 1

P.13.3 Ranking Projects on Climate Change

The adaptation and mitigation potential of each of the projects is used to Rank the projects from the values 1 through 5. Projects with the highest adaptation potential and a positive mitigation potential have been ranked 1 and projects with a low adaptation potential and negative mitigation potential have been ranked 5. **Table P-9** shows the summary of the analysis with ranking values ranging from 1 to 5 (see last column) based on the various relative levels of adaptation (i.e., HIGH, MEDIUM, and LOW) and mitigation (i.e., Positive, Neutral, and Negative) potential.

Table P-9. Project Notes and Rankings

Projects	Name	Region	Notes	Relative Adaptation Potential	Relative Mitigation Potential	Climate Change Rank
MLTP_ECO1	Livestock & Land Program	Multiple Regions	Project focuses on educating private property , horse property homes to implement best management practicing and contain animal waste from entering natural streams.	LOW	Negative	5
MLTP_WMT2	LID Pilot Program	Multiple Regions	Project includes rebate programs to support low impact development with up to 60% cost recovery of installations with free assessments for homeowners.	MEDIUM	Negative	3
NCNT_ECO1	North County Fertilizer Regions_Precision Agriculture	North County	Project proposes to evaluate best fertilizer application and management strategies on different soil types by selecting test sites in the region and then developing fertilizer practice maps and information for public use.	MEDIUM	Positive	2

Table P-9. Project Notes and Rankings, Continued

Projects	Name	Region	Notes	Relative Adaptation Potential	Relative Mitigation Potential	Climate Change Rank
NCNT_ECO2	Attiyeh Ranch Conservation Easement	North County	Project is a Conservation Easement of Attiyeh Ranch to facilitate conservation of local flora and fauna and reduce urban development and associated increases in water demands, and impacts on water quality.	HIGH	Positive	1
NCNT_GWM1	Atascadero Groundwater Basin Augmentation Expansion Project	North County	Project directs wastewater to one location through conveyance and treatment providing enhanced recharge from recycled water to improve the sustainable use of groundwater in the basin .	HIGH	Negative	2
NCNT_WMT1	Community Based Social Marketing	North County	Project is a public outreach and marketing campaign to educate local farmers and groundwater users about the sustainable use and protection of quality in groundwater supplies.	LOW	Negative	5
NCNT_WMT2	North County Precision Irrigation Research Program _ Precision Agriculture	North County	Project provides for an Educational and Experimental Program for improving agricultural water efficiencies.	MEDIUM	Negative	3
NCNT_WSP1	City of Paso Robles Lake Nacimiento Water Treatment Plant Construction	North County	Project includes the construction of a water treatment plant on the Nacimiento Pipeline increasing usable surface water supplies and reducing groundwater dependency.	LOW	Positive	4
NCNT_WSP2	San Miguel Critical Water System Improvement	North County	Project includes six critical infrastructure upgrades to an aging water supply and delivery system. Not all of the proposed projects are related to climate change adaptation or mitigation.	MEDIUM	Neutral	2
NCST_GWM1	8th Street Upper Aquifer Well Nitrate Removal Faciliy	North Coast	Project aims at setting up a well and nitrate treatment facility in the upper aquifer reducing the stress on the lower aquifer in the Los Osos area. Benefits include reduction in Salt water intrusion in to drinking water aquifers.	MEDIUM	Negative	3
NCST_FLD1	Los Padres CCC Center- Stormwater LID Treatment Project	North Coast	Project is an experimental low impact development project that engages community members in environmental and water conservation programs.	MEDIUM	Positive	2
SCNT_FLD2	Oceanic Drainage Improvement Project - Hwy 1 & 13th	South County	Project aims at improving infrastructure to drain highways, in turn improving the groundwater recharge. These drains are currently undersized for small storms.	LOW	Positive	4
SCNT_WMT1	Water Treatment Plant Expansion	South County	Project proposes to improve water quality by the addition of water filtration membrane units to the already existing water treatment plant. The assumption is that this would improve reliability during peak demand periods and also utilize the unused water allocations and reduce stress on critical groundwater resources.	HIGH	Positive	1
SCNT_WSP2	Recycle Water Distribution System Expansion	South County	Project proposes building new infrastructure to deliver recycled water in turn reducing the stress on GW resources in the region	LOW	Positive	4
SCNT_WSP4	Pismo Beach Recycled Water Treatment Plant	South County	Project addresses the need for reliable water supply during periods of drought, reduces the City's dependence on imported SWP water, and reduces demands on the South County Sub-Region's potable water supplies.	LOW	Negative	5