Incorporation of Projected Climate Change into Modeling Analysis for Groundwater Sustainability Plan Development in Sonoma County

This fact sheet describes how climate scenarios were reviewed, selected, and evaluated. The science-based process was transparent and included workshops, inputs from climate scientists, and several public Advisory Committee and Board meetings. While different approaches may be used, the approach described below was deemed the current best option to meet GSP Regulations.

SGMA Requirements and General Considerations

SGMA regulations require the GSP to analyze 50 years into the future which includes a projected climate change scenario. The entire 50-year sequence (as opposed to a subset of years) of projected climate and hydrology must be evaluated, in order to look at the variability in projected future climate. While climate change science evolves with new updated information, the initial 2022 GSPs make use of current best available information. This evaluation will be revisited as part of future GSP updates to ensure that the best available science and information continues to be used as it is made available.

The purpose for including climate change considerations in the GSP evaluations is to develop projected water budgets for the 50-year planning and implementation horizon. The projected water budgets will be affected by climate change assumptions, which should be based on best available science and information that is relevant and appropriate for each basin.

Use of Models with Projected Climate Change for the GSPs

Projected climate change is very uncertain which is why climate scientists usually recommend using scenario “ensembles” or simulating several individual scenarios to compare potential effects on water resources

Groundwater models are very complex physical approximations that take several hours (sometimes days) to complete simulations

SGMA requires the incorporation of climate change as a potential projected future climate scenario for purposes of “stressing the system”, and identifying uncertainties in future conditions when evaluating projects and management actions and SMC

For the initial 2022 GSPs, it is most practical to only include one potential climate change scenario to limit number of simulations and provide better comparability between various potential projects and actions

During five-year GSP Updates, the GSAs plan to review status of science and use of climate futures and will consider modifying for the models, as appropriate

General Approach and Methodology Used in Sonoma County GSPs

The overall approach for identifying the climate change scenario was based on a technical methodology using locally representative scientific data to select the most representative climate model for the region, followed by a transparent stakeholder process to identify the greenhouse gas (GHG) emission scenario.

The groundwater analysis with climate change assumptions in the Sonoma County GSPs were based on:

- The requirements outlined in the GSP Regulations;
- DWR's Climate Change Guidance Document;
- A review of appropriate scenarios for California;
- An analysis of the applicability of CA state-wide scenarios to Sonoma County projected climate and hydrology;
- An evaluation for the selection of one Emissions Scenario (RCP), with input from the scientific community; and
- Discussions with the Advisory Committees and decision by the GSA Boards.

The best available information on climate change is California's Fourth Climate Change Assessment (Climate Assessment) which contains 10 global circulation models (GCM) and two GHG emission scenarios per model, for a total of 20 projected climate change scenarios. Although all the models contained in the Climate Assessment are representative of California, regions within the state are distinct and some models are more representative than others for each region. Accordingly, a specific approach was developed to evaluate the GCM most representative for the North Bay Region by reviewing model outputs compared to historical local objective metrics.

The incorporation of climate change assumptions in the GSP's groundwater models followed these considerations:

1. Choose GCM with specific GHG Emission Scenario
    a. Review DWR recommended GCMs and choose one GCM and one emission scenario that best represents projected median conditions for the Russian River Watershed and the groundwater basins
2. Update integrated hydrologic model inputs for:
    a. Precipitation
    b. Temperature or potential evapotranspiration
    c. Runoff and recharge for flows from outside basin (Sonoma Valley)
3. The groundwater models with projected climate change data provide simulation of:
    a. Projected hydrology in the watershed (runoff/streamflow, groundwater recharge, and groundwater elevations)
    b. Projected irrigation water demands due to changes in projected crop evapotranspiration

To identify a representative climate change model to use for these necessary inputs to the groundwater model in the GSP, the modeling team evaluated the 10 GCMs from the Climate Assessment by reviewing the following metrics: mean change in annual temperature and precipitation, mean annual Russian River streamflow, 1- and 3-year Russian River streamflow variability, Lake Sonoma annual minimum reservoir storage conditions, and Sonoma Water delivery capability. This resulted in the conclusion that the state's Northern Coast identifiers for the various scenarios did not fit the Sonoma Region well; GCMs that appear to be the most "middle" conditions, for Russian River watershed and Sonoma County Basins were reviewed, and HadGEM2-ES was identified as more in the middle and recommended for use in all three GSPs since it did not have any extreme rankings.

This approach is in line with DWR guidance for GSP climate change assumptions. A scenario representing "middle" conditions that shows increased precipitation compared to the historical average is consistent with the majority of climate change projections as shown in Appendix A of DWR's Climate Change Guidance Document. However, as discussed below, climate change can still result in greater stress on groundwater basins despite projected increase in precipitation in some years. It is important to note that most of the 20 climate change scenarios provided by the Climate Assessment indicate increased average precipitation relative to historical conditions (15 of 20 for 2006 to 2060 and 13 of 20, with one the same, for 2035 to 2065).When considering hydrologic impacts of climate change, the variability of precipitation and temperature are very important factors.

After the GCM for the region was selected, an emissions scenario, also known as the Representative Concentration Pathway (RCP) needed to be selected to simulate potential future outcomes of predicted greenhouse gas emissions. Selection of the emission scenario is not a technical or scientific issue; it is based on a person's perspective as to whether emissions will be essentially the same or less then current emissions. Since an emission scenario represents a highly uncertain pathway that society might take in the emission of greenhouse gases in the future, the selection of an RCP is a policy decision more than a technical or scientific decision.

The most likely RCPs that DWR has deemed appropriate for CA are RCP 4.5 (sometimes considered the "most likely" based on current projections of greenhouse gas emissions) and RCP 8.5 (sometimes known as the "worst-case scenario"). Also, although other RCPs have been modeled, public datasets for climate change projections are most readily available for these two RCPs. To help guide the GSP team, Advisory Committees and Boards on the selection of a single RCP, input was solicited from experts in the field, including climate scientists at UC San Diego, National Oceanic and Atmospheric Administration and US Geological Survey. Their input is summarized in the table below.

Climate Scientists In favor of RCP 4.5 [more “in the middle”]

- 8.5 is pretty extreme and not as likely, at least by end of century. Not sure that that RCP 4.5 is considered "most likely" at this point, but it is no longer advisable to use 8.5 as "business-as-usual", and therefore, maybe 4.5 is more useful.
- Using RCP 4.5 with HadGEM-ES provides something more ‘median’ for future projections.

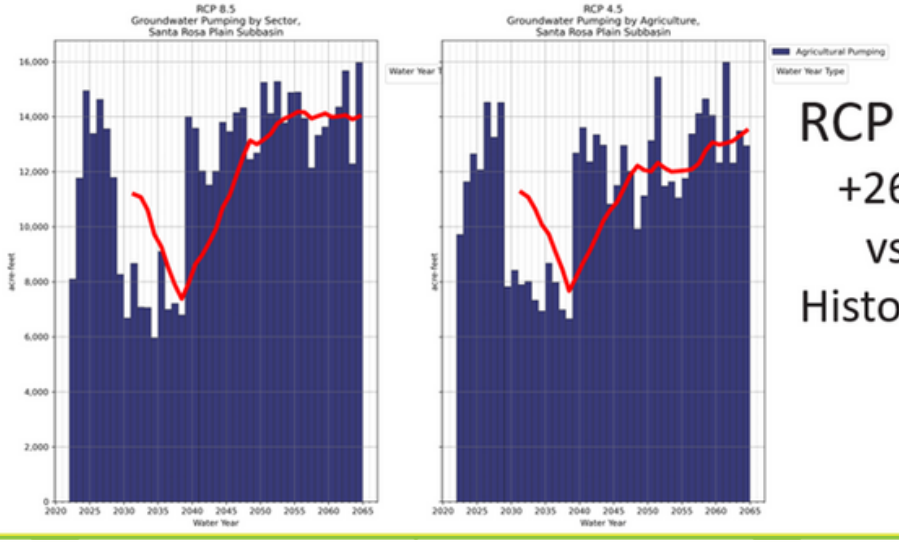
Climate Scientists In favor of RCP 8.5 [“more “extreme”]

- Leaning toward RCP 8.5
- Regarding the amount of warming, RCP 8.5 vs. RCP4.5 won't matter much until after mid-century. RCP 8.5 would provide a stiffer stress test with at least 1C greater warming by the end of the century.
- Also, it turns out that the HadGEM2-ES RCP 8.5 simulation provides a pretty remarkable drought that might be useful to consider.

These two RCPs were considered by the modeling team and input was sought from the Advisory Committees for each Basin. The process was to present information in written format and in an all-basin workshop (September 2020) and then following-up with discussion in several Advisory Committee and Board meetings. A detailed presentation including example results from the groundwater model for both RCPs as simulated in the Santa Rosa Plain Subbasin were provided to help with decision-making. Some of the results presented are provided below.

GW Model Outputs for Santa Rosa Plain Ag Pumping

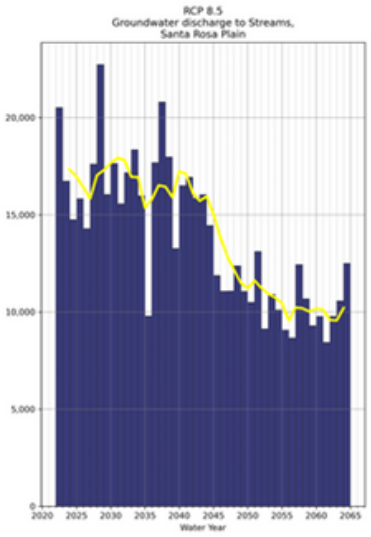
RCP 8.5
+33%
vs.
Historical

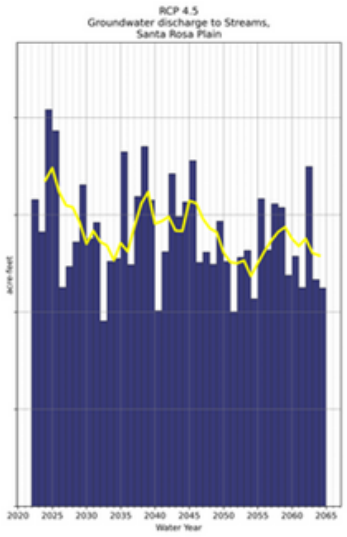


RCP 4.5
+26%
vs.
Historical

GW Model Outputs for Santa Rosa Plain Groundwater Discharge to Streams

RCP 8.5
-10%
vs.
Historical

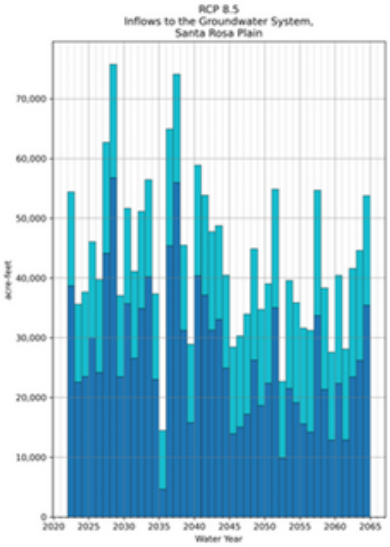


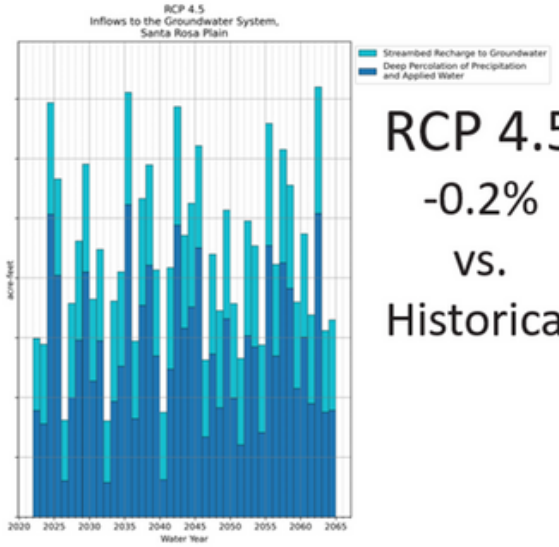


RCP 4.5
-8%
vs.
Historical

GW Model Outputs for Santa Rosa Plain Groundwater Recharge

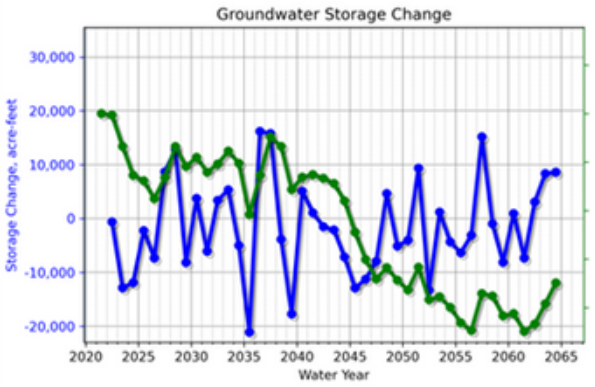
RCP 8.5
-1%
vs.
Historical



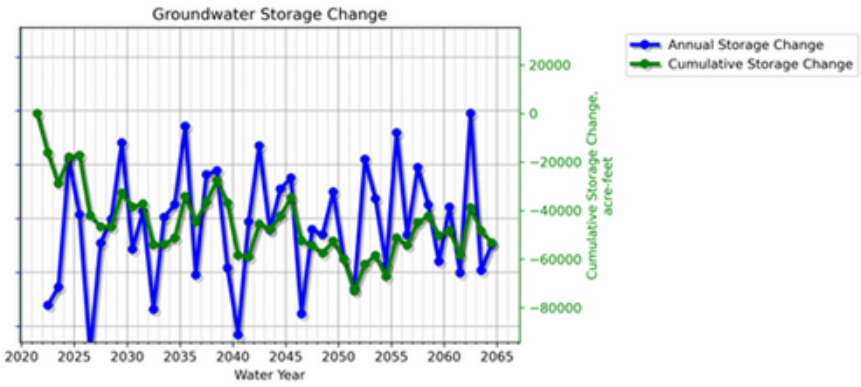


RCP 4.5
-0.2%
vs.
Historical

GW Model Outputs for Santa Rosa Plain
Change of Groundwater in Storage



RCP 8.5



RCP 4.5

Similar information was also developed for the Sonoma Valley GSP groundwater model, which is provided in Appendix 3-E of the Sonoma Valley GSP.

These results indicate that both projected climate scenarios (using RCP 4.5 and 8.5) exhibit the following compared to historical conditions:
(1) increased groundwater pumping;
(2) reduced groundwater discharge to streams;
(3) reduced overall groundwater recharge; and
(4) reduced groundwater storage. Further, the RCP 8.5 scenario indicates each of the parameters will be more severe relative to RCP 4.5 due to increased temperatures and a severe sustained multi-year dry period associated with RCP 8.5.

Based on all this information provided and after much deliberation, the three Advisory Committees recommended the use of RCP 8.5 ("worst-case") over the RCP 4.5 (mitigated GHG emissions scenario), which was confirmed by the GSA Boards.

Climate change data alone do not provide the answer to how the groundwater management decisions were evaluated in the GSP. It is important to consider the analysis in its entirety and consider what the results are on the groundwater modeling and the aquifer. The scenario selected for the GSPs, does not show an increase in groundwater recharge, but an overall decrease. It also shows less discharge to streams. Therefore, the simulations help evaluate stresses to the basin, with added land use changes, population growth AND a different climate.

Additional Considerations

Additional information to consider when reviewing the GSP, based on questions and comments received:

1. There are various approaches to use a "stress test" on projected future conditions and developing a sensitivity analysis; a simplified approach consists in using a series of synthetic precipitation scenarios. Another approach (which we used) is applying best-available climate change research scenarios that seem most applicable to the region of interest. The approach used in these GSPs is based on data and models vetted by the scientific community and applicable to CA. Therefore, the modeling analysis used the best available science that was available at the time the GSP was developed. The California 4th Climate Change Assessment is the current benchmark in climate change analysis for the state.

2. It is important to remember that precipitation is not the only factor in climate change considerations. Temperature (and therefore ET) increases are another very important factor to consider. We have seen that in agricultural basins, even if precipitation is projected to increase slightly, the increased temperature results in additional crop ET, which in turn adds to increased pumping demands. This factor drives the stress on the basin more than precipitation, since precipitation falls in the winter, and temperature/ET increases in the summer, when most of the water is needed.

3. Climate change and warming effects are shown to result in more extreme weather conditions, both with droughts and floods, as evidenced by this summer's extreme floods in Germany, and the East Coast. Preparing for both extremes is wise and not just looking at severe droughts.

4. The GSP is not a climate change analysis but a groundwater resources management approach based on potential future climate changes; different models and scenarios can and will be tested in future updates, or during the first few years of implementation.

5. Adaptive management and updates to data and science in the future will allow to re-evaluate climate scenarios and effects of GSP implementation through the assessments every 5 years.

6. During GSP implementation additional climate change scenarios should be considered and evaluated as deemed necessary, specifically when evaluating projects and management actions in more detail.

Incorporation of Projected Climate Change into Modeling Analysis for Groundwater Sustainability Plan Development in Sonoma County

The three Groundwater Sustainability Plans were submitted to the California Department of Water Resources (DWR) in January 2022. Public comments may be made on the DWR SGMA portal through April 23, 2022.

What is a GSA?

Groundwater Sustainability Agencies (GSAs) are public agencies formed to sustainably manage groundwater in local groundwater basins.

What is a Groundwater Sustainability Plan?

A GSP is a 20-year plan to ensure the sustainable use of groundwater within a groundwater basin. The GSA is required by state law, the Sustainable Groundwater Management Act, to develop a GSP by January 31, 2022.

What is the goal of the GSP?

The goal of the GSP is to establish a standard for sustainability of groundwater management and use, and to determine how the basin will achieve this standard.

43k

Around 43,000 people in the three basins rely solely on groundwater for drinking and other basic needs

21.8k+

+21,800 acres of crops and vines combined depend on groundwater for irrigation in the three basin

10.1B

Estimated 10.1 billion gallons annually for the three basins came from groundwater

sonomacountygroundwater.org

SANTA ROSA PLAIN • PETALUMA VALLEY • SONOMA VALLEY
GROUNDWATER SUSTAINABILITY AGENCIES