6. Future Water Demands and Supplies

As part of the WI&A, agricultural and urban demand scenarios and climate change scenarios have been developed to support analysis of potential future supplies and demands using the BBGM (Davids Engineering 2013, 2015). Demand and climate change scenarios have been developed to allow for evaluation of potential future conditions and to better understand the sensitivity of water supplies and demands in Butte County to changes in agricultural and urban water use and changes in underlying hydrology (precipitation and stream flows) that may result from climate change. The scenarios are not intended to be predictions of likely future conditions, but rather to support sensitivity analysis and provide greater understanding of Butte County's water resources to support planning.

6.1 Agricultural and Urban Demand Scenario

6.1.1. Background and Discussion

In recent years, there has been a relatively sustained reduction in field, truck, and pasture crops in the County. These crops have been replaced by orchards, primarily walnuts, which tend to have greater evapotranspiration than other, non-rice crops. Analysis of mid-summer Landsat satellite imagery suggests that vegetation density has increased over time. Rice ground in some areas has experienced a shift to orchards in recent years and may continue to some extent in the future.

As older orchards are replaced and new advances in farming occur, evapotranspiration (ET) may further increase along with crop yields. Between around 1990 and 2015, it is estimated based on Landsat that growing season ET for non-rice crops increased in aggregate by approximately 10 percent.

Review of the irrigated footprint in Butte County in recent years and soils data from the Natural Resources Conservation Service suggests that the potential for expansion of the irrigated area is somewhat limited. Two potential areas of expansion have been identified. These are the portion of the East Butte Subbasin between Thermalito Afterbay and the Feather River and the North Yuba Subbasin in Butte County (south of Oroville and North of Honcut Creek).

Transition from surface water to groundwater has been observed in some areas of the County in recent years. In particular, orchards within Butte Water District have converted to groundwater at a relatively steady rate in recent years due to a combination of factors. Additionally, lands converting from rice to orchards may have a tendency to utilize groundwater for irrigation. Lands of irrigation expansion discussed above will also likely rely on groundwater for irrigation.

Improvements in irrigation technology (application uniformity) and management (irrigation scheduling) have occurred over time, leading to increases in irrigation efficiency (defined herein as the fraction of applied water beneficially consumed by the crop as ET). Current estimates of the Consumptive Use Fraction (ET of applied water divided by applied water), equivalent herein to irrigation efficiency, in aggregate within Butte County are estimated to be approximately 0.79 on average for orchard crops.

Primary urban water suppliers in Butte County include CalWater Chico, CalWater Oroville, and the cities of Gridley and Biggs. These suppliers are currently in the process of developing mid-century demand projections as part of Urban Water Management Plan (UWMP) updates to be adopted in 2016.

6.1.2. Demand Scenario Assumptions

A scenario representing potential agricultural demands has been developed that considers changes in cropping and evapotranspiration, expansion of the irrigated area, changes in irrigation water source (conversion from surface water to groundwater in some areas), and changes in irrigation technology and management.

The demand scenario assumes the following changes:

- <u>Field, truck, and pasture crops will continue to shift to higher value crops.</u> Current land use will be updated for the agricultural demand scenario to shift remaining field, truck, and pasture crops to higher value crops. Walnuts, will be used as a surrogate for higher value crops. Current acreages in almonds and other orchard crops will not be changed. As of 2015, there are an estimated 109,000 ac of non-rice crops in the County, of which approximately 14,000 acres are field, truck, or pasture crops.
- <u>Crop evapotranspiration rates for non-rice crops will increase by approximately 10 percent.</u> As part of the agricultural demand scenario, ET rates for non-rice crops will be increased by an additional 10 percent between April and September. Winter ET rates will not be increased because ET during the winter is driven primarily by evaporation of precipitation rather than by crop transpiration.
    - For almonds and prunes, annual ETa will increase from 36.7 to 39.3 inches annually, on average.
    - For walnuts, annual ETa will increase from 40.5 to 43.6 inches annually, on average.
- <u>Rice ground will convert to orchards where shallow groundwater levels suggest limited risk of “drowning” due to high water table and flood risk. The greatest potential for these changes is believed to be along the east side of Butte Creek in the Esquon and Western Canal SIUs.</u> Land use for selected rice ground will be converted to orchards as part of the agricultural demand scenario. Walnuts will be used as a surrogate for all orchard crops. Rice ground along the eastern side of Butte Creek in the Esquon and Western Canal subregions will be considered. For any given field, the potential to shift to orchards will be evaluated based on parcel size (e.g., at least 20 acres) and based on historical spring depths to shallow groundwater following wet winters. The observed historical groundwater depths (available from DWR) will allow for a qualitative

assessment of the risk of "drowning" of orchards due to elevated shallow groundwater and potential flooding.

- Irrigation will expand through new orchard plantings on class 3, 4, or 5 lands[1], primarily in the East Butte SIU between Thermalito Afterbay and the Feather River and in the North Yuba SIU south of Oroville and north of Honcut Creek. In order to evaluate potential impacts of expansion of irrigation in the East Butte and North Yuba SIUs, selected class 3, 4, or 5 lands that are not currently irrigated will be assumed to transition to orchards (with walnuts as a surrogate for all orchard crops). Individual parcels will be selected based on a minimum parcel size (e.g., at least 20 acres).
- Orchards within the Butte SIU, rice ground converted to orchards, and areas of irrigation expansion within the East Butte and North Yuba IUs will rely on groundwater for irrigation. To evaluate potential impacts of increased reliance on groundwater for irrigation, the following areas will be assumed to rely on groundwater as part of the agricultural demand scenario:
    - Orchards within Butte Water District
    - Rice ground converted to orchards, as described above
    - Areas of irrigation expansion within the East Butte and North Yuba subbasins, as described above
- Irrigation efficiency for orchards will increase by approximately five percent. As part of the agricultural demands scenario, it is assumed that an additional 5 percent increase in irrigation efficiency will occur.
- Urban demand estimates will be modified based on updated urban water management plans that are expected to be available later in 2016. Historical pumping estimates will be modified so that demand volumes match the most recent UWMP projections for each supplier.

6.2 Climate Change Scenario

6.1.3. Background and Discussion

Evaluation of the potential impacts and effects of climate change on water management in Butte County will support evaluation of the following and other questions:

- Warmer air temperatures may lead to more winter precipitation, more rain, and less snow. What effect does this have on basin hydrology in general and on groundwater conditions in particular?
- What is the vulnerability of the system to potential climate change impacts?

[1] As defined by Agriculture Handbook No. 210, issued by the USDA Soil Conservation Service (SCS 1961). Also described in Davids Engineering technical memorandum on *Agricultural and Urban Demand Scenarios and Climate Change Scenarios for BBGM Update* (2015)

- What would be the effects of a prolonged drought? For example, what if we had not experienced several wet years after the 1990s drought?

Potential impacts of climate change are estimated based on projected changes in greenhouse gasses under different emission scenarios. These scenarios are driven by assumptions related to population growth, economic activity, societal attitudes and behavior, and technological advancement. Based on the emission scenarios, global climate models (GCMs) are developed by climate scientists to project changes in climate such as temperature and precipitation. There are a large number of GCMs and emission scenarios available.

In California, the Governor's Climate Action Team selected six GCMs and two emission scenarios, resulting in 12 climate change scenarios and recommended them for the 2009 California Water Plan update. To demonstrate the range in variability in future conditions among scenarios, projections of temperature and precipitation from the studies are shown in Figures 6.1 and 6.2, respectively. As indicated, the scenarios project increases in temperature. Results vary substantially among GCMs in the timing and degree of temperature increase; however, temperature increases under the high emission scenario (A2) tend to be greater than the lower emission scenario (B1). With respect to precipitation, the results are somewhat more mixed, with a general projection of decreasing annual precipitation as the century progresses.

Increased temperature and reduced precipitation are expected to result in reduced winter snowpack and increased runoff earlier in the year, which will reduce available surface water supplies and increase reliance on groundwater. Additionally, applied water demands will increase as less precipitation is available to support crop growth. A more in-depth discussion of climate change and groundwater in California has been developed by Fisher et al. (2013) and is available at the California Water Blog (http://californiawaterblog.com/2013/10/09/groundwater-and-climate-change-in-california/).

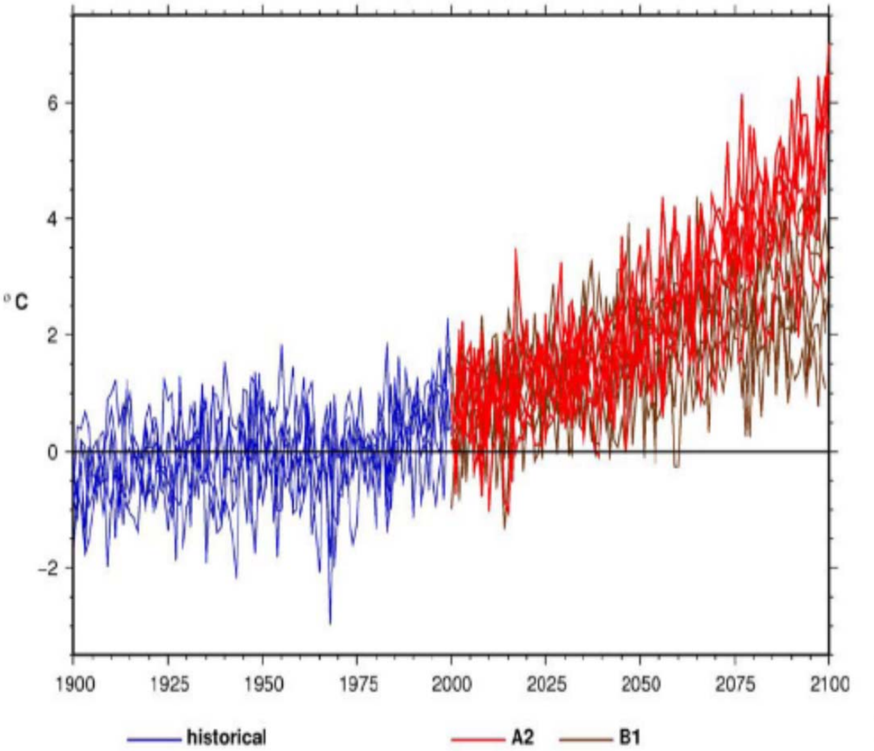

Figure 6.1. Projections of Mean Temperature Increase for Sacramento Area from 12 CAT Scenarios (Cayan et al., 2008).

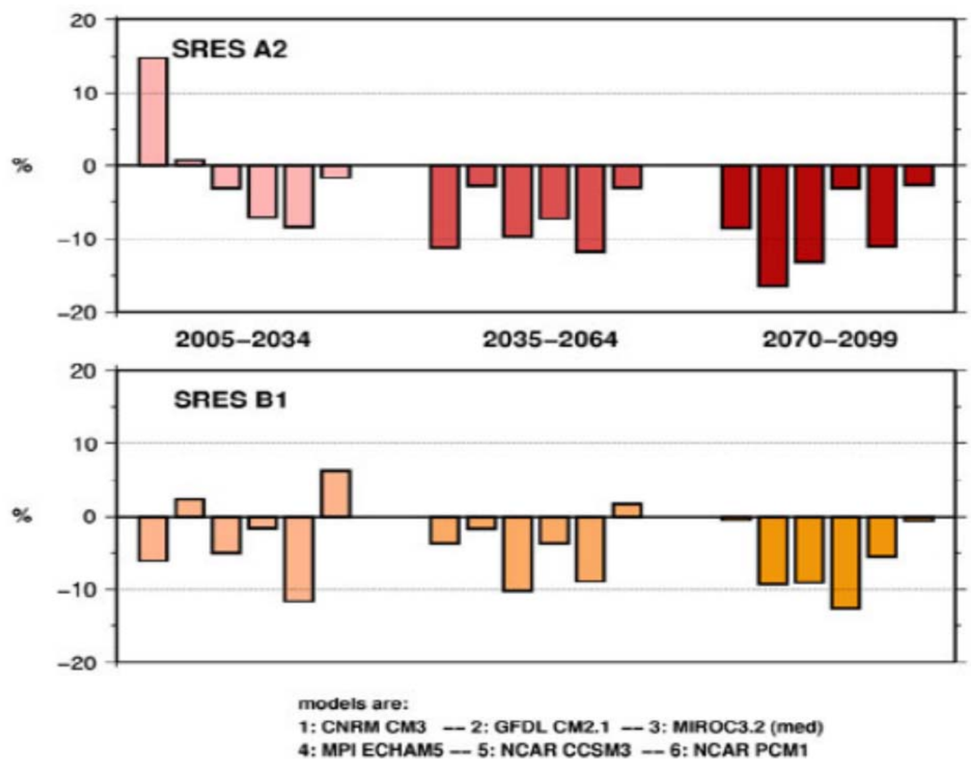

Figure 6.2. Projected Changes in Precipitation Relative to 1961-1990 Average for Northern California from 12 CAT Scenarios (Cayan et al., 2008).

6.1.4. Selected Climate Change Scenarios

To evaluate potential impacts of climate change, two climate change scenarios have been selected from the Governor's 2008 Climate Action Team (CAT) recommended scenarios for evaluating water management in California using an ensemble based approach. The CAT identified 12 scenarios as part of its evaluation that can be used to project future temperature; precipitation timing and amounts; snowfall, snowmelt, and runoff, etc. By mid-century (2035-2065), the scenarios generally agree in an increase in average air temperature, as shown in Figure 6.3. In the figure, scenarios are divided into four quadrants corresponding to (1) hotter, drier; (2) hotter, wetter; (3) warmer, drier; and (4) warmer, wetter based on average results. Results are more mixed regarding changes in precipitation, but on average a slight reduction in precipitation is suggested. The two scenarios selected and highlighted in Figure 6.3 are as follows:

- Central tendency ("consensus" among scenarios)[2]. This scenario predicts (1) a 2.4 F increase in mean annual temperature, (2) a 2 percent decrease in valley floor precipitation, (3) a 2 percent decrease in Feather River water year full natural flow, and (4) a 27 percent decrease in Feather River April to July runoff by mid-century.
- Hotter-Drier (more extreme heating and drying)[3]. This scenario predicts (1) a 3.2 F increase in mean annual temperature, (2) an 11 percent decrease in valley floor precipitation, (3) a 19 percent decrease in Feather River water year full natural flow, and (4) a 46 percent decrease in Feather River April to July runoff by mid-century.

For comparison, the climate change scenario selected for the 2011 State Water Project (SWP) Delivery Reliability Report (DWR 2011) is shown. This scenario predicts (1) a 2.4 F increase in mean annual temperature, (2) a 3 percent increase in valley floor precipitation, (3) a 3 percent increase in Feather River water year full natural flow, and (4) a 25 percent decrease in Feather River April to July runoff by mid-century.

Based on the scenarios selected, magnitudes of historical precipitation, streamflows, and diversions are in the process of being adjusted using a perturbation ratio approach to develop BBGM inputs. One set of inputs will be developed for each scenario.

[2] NCAR CCSM3, b1 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/CCSM3.htm).
[3] MIROC3.2, a2 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/MIROC3.2_medres.htm).

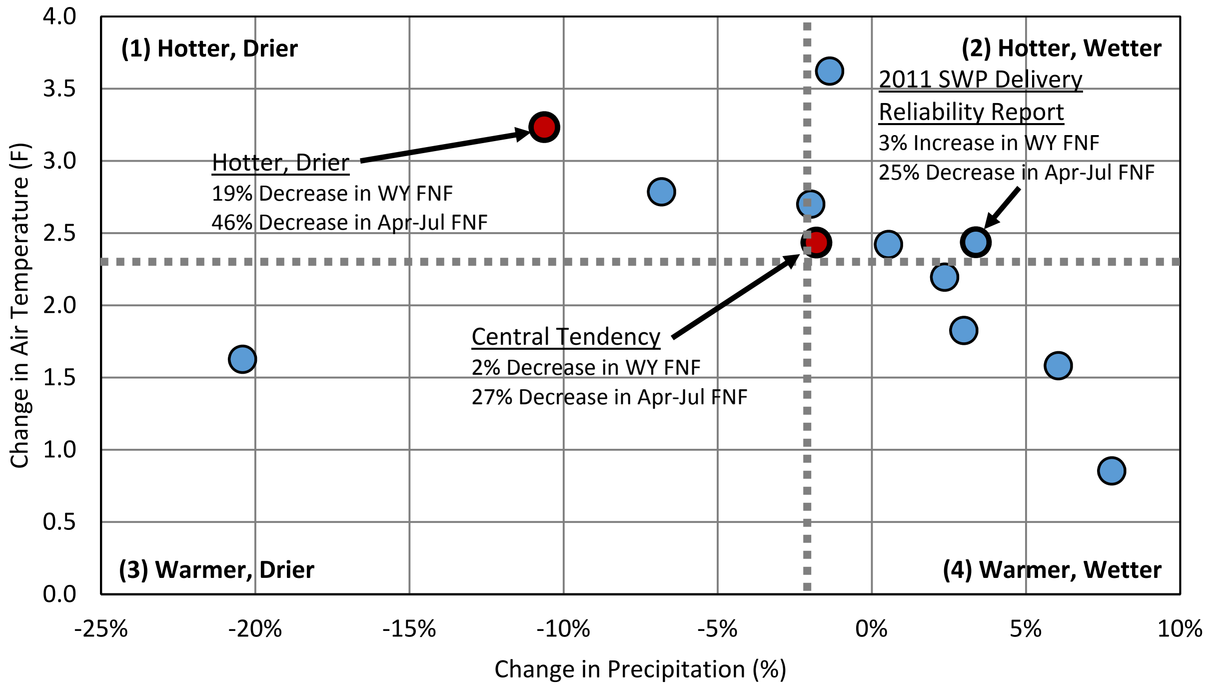

Figure 6.3. Comparison of Mid-Century (2035-2065) Changes in Butte Basin Mean Annual Precipitation and Air Temperature for 2008 CAT Scenarios. Corresponding Changes in Feather River Water Year Full Natural Flow (WY FNF) and April to July FNF Shown for Selected Scenarios.

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