Appendix I: Climate Change Vulnerability Assessment

Section 5: Climate Change

Climate change refers to significant changes in temperature, precipitation, wind patterns and other weather that occur over several decades and beyond. Climatic changes observed in recent decades are occurring due to rising average global temperatures that are the result of elevated levels of gases released primarily by human activities, which trap heat in the atmosphere in a process known as the greenhouse effect. These so-called greenhouse gases include, among others, water vapor, carbon dioxide (CO_2) and methane (CH_4).

Climate change is impacting California water resources in many ways, including through rising sea levels, reduced snowpack, and more frequent and severe droughts. Impacts and vulnerabilities vary by region resulting in the need for tailored actions to ensure the viability of regional watersheds, including the Upper Santa Clara River Watershed. These actions focus on reducing the intensity of climate change through mitigation measures and adapting to climate change effects.

5.1 Climate Change

This climate change section was developed to be consistent with the following Proposition 84 IRWMP Guidelines (October 2012):

- Describe, consider, and address the effects of climate change on the region and disclose, consider, and reduce where possible greenhouse gas (GHG) emissions when developing and implementing projects
- Identify climate change impacts and address adapting to changes in the amount, intensity, duration, timing, and quality of runoff and recharge
- Consider the effects of sea level rise on water supply conditions and identify suitable adaptation measures
- Describe policies and procedures that promote adaptive management

This section is intended to focus on climate change adaptation and instill climate change adaptation as an overarching theme throughout the Plan. Climate change mitigation measures are included in future actions discussed in this section, are integrated in IRWMP objectives, and are an important consideration when prioritizing projects to implement this IRWMP. The recently issued *Climate Change Handbook for Regional Water Planning* dated November 2011 (Schwarz et al 2011) was used for guidance in developing this Plan section.

5.1.1 Legislative and Policy Context

5.1.1.1 Current Regulatory Constraints

5.1.1.1.1 US EPA Mandatory Reporting of Greenhouse Gases Rule

The US EPA Reporting Rule, which started in 2011, requires reporting for 2010 emissions for sources or single facilities with more than 25,000 metric tons carbon dioxide equivalent

($MTCO_2e$) annually. The rule can be found at: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

5.1.1.1.2 Title V of the Clean Air Act

Title V of the federal Clean Air Act reauthorization (1990) requires each state to develop a permit-to-operate system and emission fee program for major sources of air pollution. Title V only applies to “major sources.” US EPA defines a major source as a facility that emits, or has the potential to emit (PTE) any criteria pollutant or hazardous air pollutant (HAP) at levels equal to or greater than the Major Source Thresholds (MST). The MST for criteria pollutants may vary depending on the attainment status (e.g., marginal, serious, extreme) of the geographic area and the criteria pollutant or HAP in which the facility is located.

Title V permit holders must incorporate GHG requirements when renewing or revising a permit. EPA has continued to pursue regulations to address issues related to climate change. The EPA already requires large emissions sources (greater than 25,000 MTCO2e) to annually report their emissions. As well, the EPA has published rules to start directly regulating GHG emissions under the Clean Air Act. Under the EPA’s Tailoring Rule, facilities responsible for nearly 70 percent of the nation’s GHG emissions will be subject to GHG emissions permits.

None of the water utilities in the Region are currently subject to these federal regulations because none own or operate a single facility that meets the current emissions threshold of 25,000 $MTCO_2e$ per year.

5.1.1.1.3 AB 32 Global Warming Solutions Act and Executive Order S-3-05

California continues to lead the nation in developing public policy responses to address issues related to climate change and GHG emissions — most notably through the implementation of Assembly Bill 32 (AB 32). AB 32 established GHG reduction targets for California and put the California Air Resources Board (ARB) in charge of implementation and rulemaking through the development of the “Scoping Plan.” AB 32 aims to reduce statewide GHG emissions to 1990 levels (427 million $MTCO_2e$) by 2020. California is currently at about 469 million $MTCO_2e$, and under the business-as-usual case, most recently updated in 2010, 2020 emissions are expected to be about 507 million $MTCO_2e$. In order to meet the 2020 target, California will need to reduce GHG emissions by about 80 million $MTCO_2e$, an approximate 16 percent reduction from the state’s projected 2020 emissions, by 2020. To meet these targets a two percent reduction is needed each year for the next ten years. To accomplish the goal the state is pursuing a number of direct regulations and market-based mechanisms that have been laid out in a Scoping Plan. The core measures of the Scoping Plan are tailpipe standards, transportation and land-use changes, low carbon fuel standard, enhanced energy efficiency, a Renewables Portfolio Standard (RPS) of 20 percent by 2010 and 33 percent by 2020, and a Cap & Trade program. More information about the Scoping Plan can be found at: http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

5.1.1.1.4 California ARB’s Mandatory Greenhouse Gas Reporting Regulation

ARB’s Mandatory Reporting Rule requires the state’s largest emitters (single sources with GHG emissions greater than 25,000 $MTCO_2e$ per year) to annually report and verify their GHG emissions. The rules were revised to harmonize the state’s reporting rules with the US EPA’s

Mandatory Reporting Rule and streamline the reporting and verification process for sources with GHG emissions between 10,000 and 25,000 $MTCO_2e$. ARB finalized the proposed changes in 2011. The rule can be found at: http://www.arb.ca.gov/cc/ccei.htm.

5.1.1.1.5 Cap-and-Trade Rule and Compliance Offsets

The most far-reaching regulatory action to emerge from AB 32 is the development of rules implementing a cap-and-trade program for California. Under cap-and-trade, an overall limit on GHG emissions from capped sectors will be established and lowered every year until 2020. Facilities subject to the cap will be able to trade permits to emit GHGs or acquire offsets from uncapped sectors. Starting in 2012, entities with GHG emissions greater than 25,000 $MTCO_2e$ in process and combustion emissions (not indirect electricity emissions) will be subject to cap. Water utility facilities in the Upper SCR are below this threshold for their facilities and will not be included in the Cap and Trade regulation. More information about the Cap and Trade regulation can be found at: http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

The cap-and-trade program will effectively put a price on GHG emissions and implicitly on energy (transportation fuel and electricity) prices. While water utilities in the Region may not be directly subject to a cap on emissions they may be subject to higher prices for fossil fuels and electricity. Water utilities may also see carbon prices manifested in its supply chain as suppliers pass their compliance and higher energy costs onto their customers.

“The regulation will cover 360 businesses representing 600 facilities and is divided into two broad phases: an initial phase beginning in 2012 that will include all major industrial sources along with utilities; and, a second phase that starts in 2015 and brings in distributors of transportation fuels, natural gas and other fuels.

Companies are not given a specific limit on their greenhouse gas emissions but must supply a sufficient number of allowances (each covering the equivalent of one ton of carbon dioxide) to cover their annual emissions. Each year, the total number of allowances issued in the state drops, requiring companies to find the most cost-effective and efficient approaches to reducing their emissions. By the end of the program in 2020 there will be a 15 percent reduction in greenhouse gas emissions compared to today, reaching the same level of emissions as the state experienced in 1990, as required under AB 32.

To ensure a gradual transition, ARB will provide significant free allowances to all industrial sources during the initial period (2012-2014). Companies that need additional allowances to cover their emissions can purchase them at regular quarterly ARB auctions, or buy them on the market. Electric utilities will also be given allowances and they will be required to sell those allowances and dedicate the revenue generated for the benefit of their ratepayers and to help achieve AB 32 goals.

Eight percent of a company’s emissions can be covered using credits from compliance-grade offset projects, promoting the development of beneficial environmental projects in the forestry and agriculture sectors. Included in the regulation are four protocols, or systems of rules, covering carbon accounting rules for offset credits in forestry management, urban forestry, dairy methane digesters, and the destruction of existing banks of ozone-depleting substances in the U.S. (mostly in the form of refrigerants in older refrigeration and air-conditioning equipment)."[4]

California is coordinating the development of its program with the Western Climate Initiative (WCI). WCI is a multi-jurisdictional initiative to develop regional market-based mechanisms (i.e., cap-and-trade program) to reduce GHGs. The rationale for a broader regional approach is that it could provide greater flexibility for emitters in how, when and where to achieve emissions reductions; and create a more fluid and robust marketplace for trading.

5.1.1.1.6 South Coast Air Quality Management District (SCAQMD) Guidance for CEQA Greenhouse Gas Significance Thresholds

Consistent with Senate Bill (SB) 97, projects subject to CEQA review must estimate GHG emissions and consider potential impacts, and projects with potential significant impacts must consider mitigating project related emissions.

In 2007, the California Legislature directed the Natural Resources Agency to develop specific guidelines for lead agencies on how to quantify, evaluate and mitigate a project's potential GHG emissions and climate change impacts. Under the guidelines, finalized in February 2010, a lead agency must calculate GHG emissions from a project, assess the impacts of these emissions, make a significance determination, and if necessary consider mitigation measures. The definitions of significant impacts and determination of significance thresholds are subject to interpretation of pre-existing CEQA guidelines and jurisprudence.

SCAQMD has developed interim draft guidance establishing a process for evaluating whether or not GHG emissions from an industrial project (i.e., stationary source) are significant where SCAQMD is the lead agency. SCAQMD is currently considering expanding its guidelines for use by other local lead agencies. The proposal includes a significance threshold for commercial and institutional land use projects (e.g., new construction).

SCAQMD draft interim guidance significance thresholds are: 10,000 $MTCO_2e$/year for industrial projects (SCAQMD lead agency), and 3,000 $MTCO_2e$/year (proposed) for commercial/institutional projects. SCAQMD guidance does not distinguish between biogenic (naturally occurring) and anthropogenic (human caused) emissions. Wastewater plant emissions are considered biogenic. More information about the Guidance can be found at: http://www.aqmd.gov/ceqa/handbook/GHG/GHG.html, http://www.water.ca.gov/climatechange/docs/CEQA□GHG□Guidance.pdf and http://www.ceres.ca.gov/ceqa/docs/Final□Statement□of□Reasons.pdf.

5.1.1.1.7 Executive Order S-13-08

By Executive Order S-13-08, the California Governor directed the California Natural Resources Agency, DWR, the Office of Planning and Research, the California Energy Commission, State Water Resources Control Board, and other State agencies to research and advance California's ability to adapt to the impacts of climate change. Results of this work include the California Sea Level Rise Assessment and the California Climate Change Adaptation Strategy.

[4] ARB press release dated December 16, 2010. The full press release can be found at: http://www.arb.ca.gov/newsrel/newsrelease.php□id□170.

5.1.1.1.8 California Ocean Protection Council Resolution

The California Ocean Protection Council Resolution adopted March 11, 2011 requires that projects or programs funded by the State of California consider sea level rise.

5.1.1.2 Future Regulatory Constraints

5.1.1.2.1 US EPA Greenhouse Gas Tailoring Rule

US EPA is considering rules targeting sources below 50,000 short tons CO_2e (about 45,000 $MTCO_2e$) by 2016. The current rule applies to sources greater than 75,000 short tons CO_2e (about 68,000 $MTCO_2e$). US EPA is also reviewing an accounting approach for biogenic emissions sources.

In its final Tailoring Rule, US EPA committed to exclude sources with GHG emissions below 50,000 short tons CO_2e (about 45,000 $MTCO_2e$) per year from new permitting requirements through at least 2016. During this period, US EPA plans to conduct a study of the permitting burdens that would exist if the Tailoring Rule were to be applied to smaller sources. Based on the outcome of the study US EPA may expand the tailoring rule to include additional small sources or permanently exclude them from a GHG permitting system. Given the political constraints facing the agency, including efforts in the U.S. Congress to repeal or delay US EPA's authority to enact the rules, it is unlikely that the agency will pursue aggressive regulation of small sources such as those operated by CLWA.

As currently adopted, the Tailoring Rule does not distinguish between GHG emissions from fossil and biologically derived fuels. US EPA concluded a public comment period in September 2010 seeking information on approaches to account for GHG emissions from bioenergy and other biogenic sources. US EPA is under considerable political pressure to revisit the decision to treat emissions from biomass the same as emissions from fossil fuels. No decision has yet been made on this issue.

5.1.1.2.2 Federal Cap-and-Trade Program or other Market-Based Mechanism to Create a Price for GHGs or Carbon

While the Clean Air Act allows US EPA to use economic incentives, including emissions trading programs, to control emissions; the prospects for legislation establishing a national economy wide cap-and–trade program, or alternative carbon pricing policies such as a carbon tax, are highly unlikely in the near-term. Congress may act to increase incentives for energy efficiency and renewable energy production. The most likely mechanism for renewable resources incentives is through a federal clean energy standard that would include nuclear energy resources. Enactment of a federal clean energy standard is unlikely to impact the Region as none of the current federal policy proposals would preempt California's far more ambitious renewable energy portfolio standard.

5.1.1.2.3 AB 32 Scoping Plan Water Sector Recommendations

In addition to regulatory approaches to meet the state GHG emissions reduction goals; the ARB Scoping Plan calls for the "water sector" to implement six voluntary measures to achieve 4.8 million $MTCO_2e$ in emissions reductions by the year 2020. The measures include: increased water use efficiency, broader implementation of water recycling, improvements to the energy efficiency of the state's water and wastewater infrastructure, low impact development techniques, development of in-conduit hydroelectric and wastewater treatment renewable energy resources, and instituting a public goods charge to finance investments in water conservation and water sector energy efficiency. More information about these measures can be found at: http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf.

Both the Association of California Water Agencies and the California Association of Sanitation Agencies have active programs to track and monitor the development of any legislation or regulatory initiatives to mandate these measures.

The ARB Scoping Plan will be updated in 2013, which will allow past performance to be evaluated and policies to be re-assessed.

5.1.1.2.4 City of Santa Clarita Climate Action Plan

Consistent with requirements by the State of California, the City of Santa Clarita completed a CAP, outlining how emissions reduction goals required under AB 32 will be achieved (see also Section 2.3.1.1). The CAP will serve as a component of the general plan document for the City to address GHG Emissions. Based on the goals, objectives, and policies of the recently adopted General Plan, the CAP identified measurable mitigation strategies that will enable the City of Santa Clarita to meet and even exceed the 2020 GHG emissions targets. Mitigation measures included in the CAP focus actions in four categories.

- Energy
    - Installation of higher efficiency public street and area lighting
    - Replacement of traffic lights with LED traffic lights
    - Establishment of onsite renewable energy systems – Solar Power
- Transportation
    - Overall land use/locations measures, which include reducing total vehicle miles travelled and improving traffic flow by increasing density of in-City development and diversity of mixed use developments, increasing location efficiency, destination and transit accessibility, integrating affordable and below market rate housing, improving the transit system, and improving the pedestrian network.
- Water
    - Use of reclaimed water
    - Installation of low-flow water fixtures
    - Use of water-efficient landscape irrigation systems
- Vegetation
    - Urban tree planting
    - Creation of new vegetated open space

Implementation of these CAP measures is anticipated to reduce GHG emissions in the City of Santa Clarita by 193,000 $MTCO_2e$ per year.

5.1.2 Vulnerability to Climate Change

This section identifies the potential climate change vulnerabilities of the Region's water resources. The climate change assessment presented in this section is at least equivalent to the checklist assessment in DWR's *Climate Change Handbook for Regional Water Planning* and consistent with climate change requirements in the Proposition 84 IRWMP Guidelines (October 2012).

5.1.2.1 Climate Change Scenarios

Climate change assessment is performed using the output of computer models that project future conditions from inputs on GHG emissions. These models are not predictive, but provide projections of potential future climate scenarios that can be used for planning purposes.

The primary climate variables projected by global climate models (GCMs) that are important for water resources planning in California are changes in air temperature, changes in precipitation patterns, and sea level rise. The State of California 2009 Climate Change Impacts Assessment (California Climate Change Center 2009) provides the scientific basis for developing statewide climate change impact projections. The 2009 assessment provided future climate projections to support water resources decision making in California. A set of six GCMs were run for two GHG emissions scenarios, A2 and B1, selected from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). The IPCC report provides a family of common scenarios that cover a range of plausible trends in GHG emissions over the 21st century as a result of economic, technological, and population change (IPCC 2007). Scenario A2 assumes higher GHG emissions and high growth in population and represents a more competitive world that lacks cooperation in development (similar to business as usual), while B1 is a lower GHG emission scenario that represents social consensus for sustainable development. Each GCM was used to simulate a historical period from 1950-1999 and a future projection period from 2000 to 2100. The 1950-1999 period serves as a baseline or "present condition" for the models so that future conditions can be projected. Table 5.1-1 lists the six GCM models and their sponsoring organization.

TABLE 5.1-1
SUMMARY OF GLOBAL CLIMATE MODELS

GCM	Sponsoring Organi□ation and Model Name
NCAR-PCM1[(a)]	National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM)
GFDL-CM21[(a)]	National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluids Dynamics Laboratory (GFDL) model, version 2.1
NCAR-CCSM3[(a)]	NCAR Community Climate System Model (CCSM)
MPI-ECHAM5	Max Plank Institute ECHAM5/MPI-OM Used by DWR for its climate change analysis for the 2009 Reliability Report and 2011 update.

MIROC32	MIROC 3.2 medium-resolution model from the Center for Climate System Research of the University of Tokyo and collaborators
CNRM-CM3[a]	French Centre National de Recherches Météorologiques (CNRM) models
Four Model Average[a]	Cal-Adapt website. Average of the following four GCMs: NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3. Used in this analysis for Upper Santa Clara River Region

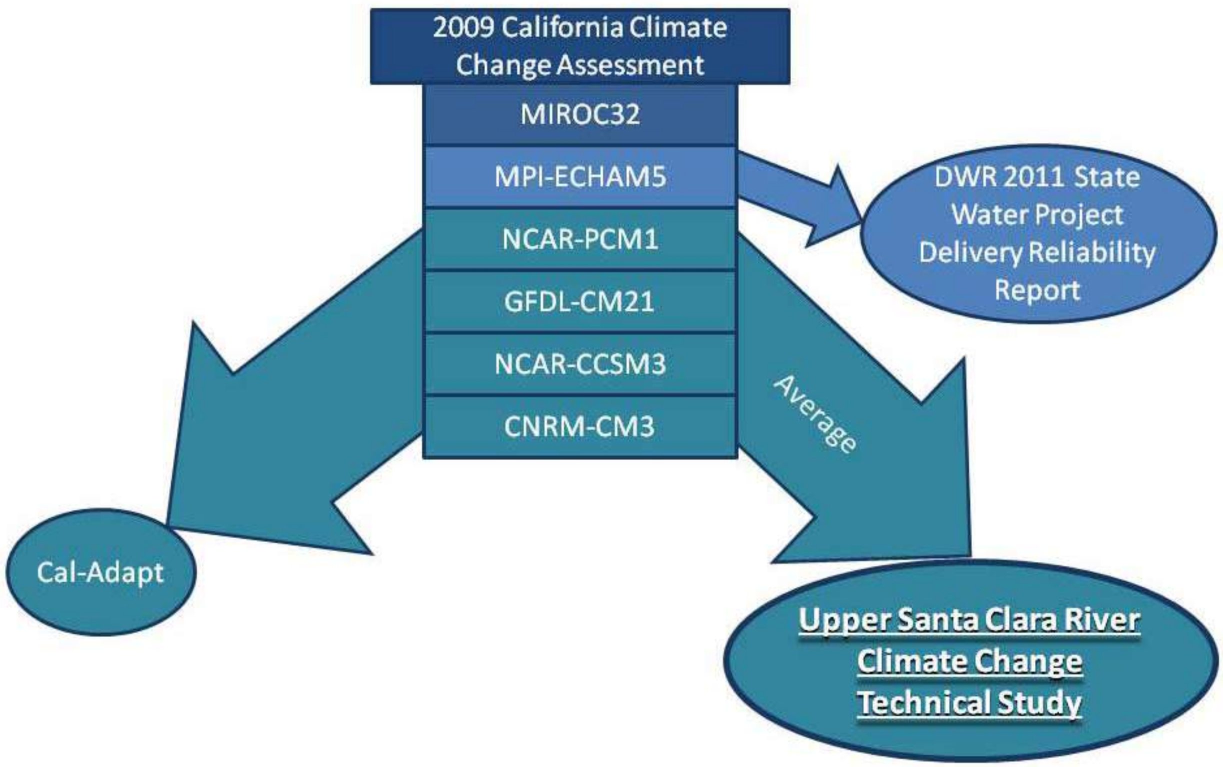
Note: (a) Model used by Cal-Adapt.

DWR used the MPI-ECHAM5 model with the A2 emissions scenario when preparing the 2011 *State Water Project Delivery Reliability Report*. MPI-ECHAM5 represents the median of the six GCMs listed in Table 5.1-1.

The California Energy Commission's Public Interest Energy Research Program (PIER) recently established the Cal-Adapt website (http://cal-adapt.org/), whose purpose is to explore California's climate change research. In part, the website provides output from four climate models (NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3) and two GHG emission scenarios (A2 and B1) downscaled to any location in California. The four GCMs are a subset of the six GCMs used in DWR's climate change assessments. Because the MPI-ECHAMP5 GCM is not included in Cal-Adapt, an average of the four GCMs (also provided by Cal-Adapt) with the A2 emission scenario was used in this analysis for Upper Santa Clara River Region to be consistent with the DWR analysis.

Figure 5.1-1 provides a visualization of which global climate change models were used in the above-mentioned climate change assessments and assessment tools.

FIGURE 5.1-1
GLOBAL CLIMATE CHANGE MODELS USED IN ASSESSMENT OF WATER RESOURCES



5.1.2.1.1 Statewide Climate Change Projections

Statewide climate change projections, based on the 2009 Scenarios Project assessment, were used to assess Regional vulnerabilities described in Table 5.1-2. All of the models show increased warming throughout the 21st century, with average annual air temperature increasing about 2°F to 5°F by 2050. The Mediterranean seasonal precipitation pattern is expected to continue during the 21st century, with most of the precipitation occurring during winter from North Pacific storms. The hydro-climate is expected to be influenced by the El Ni□o-Southern Oscillation (ENSO) with alternating periods of wet and dry water years. In the Sierra Nevada Mountains, there will be some shift to more winter precipitation occurring as rain instead of snow, with a reduction in snowpack accumulation and shifts in runoff patterns, especially during the summer and fall.

5.1.2.1.2 USCR Region Climate Change Projections

Locally, overall air temperatures are expected to rise from 1°F to 2.3°F over the next few decades. The historical average annual temperature in the Upper Santa Clara River region is 61.9°F; the A2 and B1 scenarios project increases of 6.9°F and 4.3°F by the end of the 21st century. Figure 5.1-2 shows the projected air temperature change for the four GCMs averaged from 2000 through 2100, compared with the historical baseline from 1950-2000 used for the initial conditions for the models (see Section 5.1.2.1) The temperature projections begin to deviate between the A2 and B1 scenarios around mid-century, with the A2 scenario increase about twice the B1 scenario by 2100. For purposes of this analysis, an air temperature increase of 4°F has been assumed.

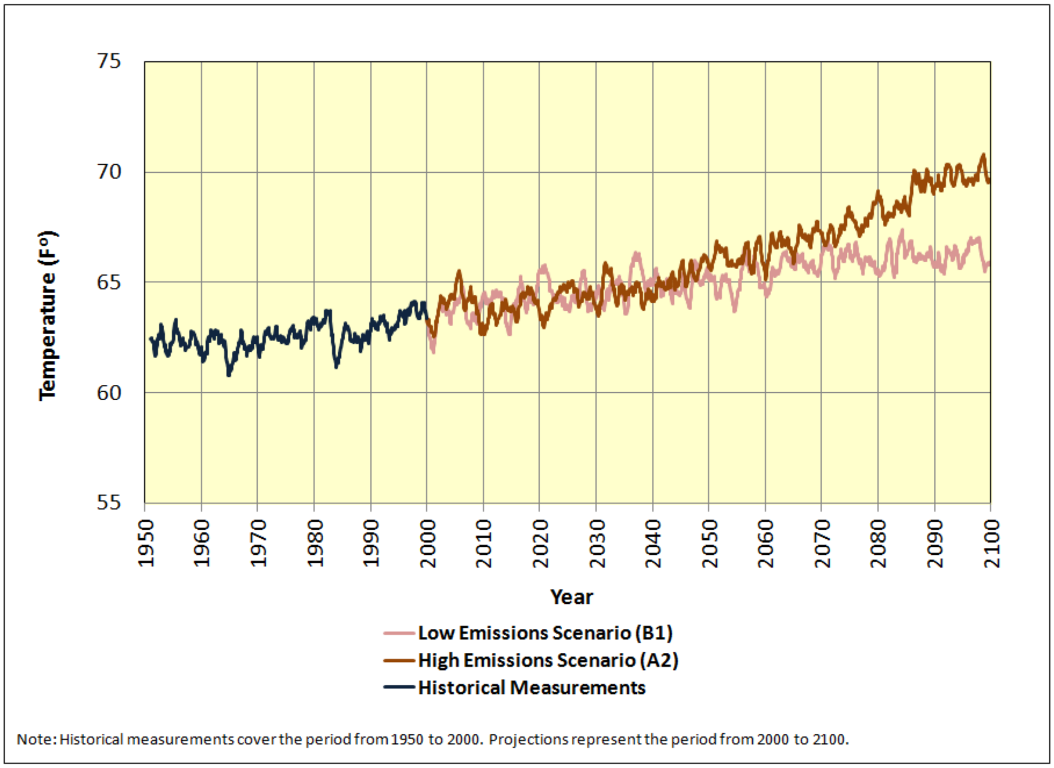
Precipitation in the Region is essentially all due to rain, and significant shifts in the timing of precipitation are not expected to occur. One of the four climate models projects slightly wetter winters, and others project slightly drier winters with a 10 to 20 percent decrease in total annual precipitation. The drier conditions projected may result in a higher wildfire risk in the Region. Figure 5.1-3 shows the decadal precipitation projections from 1960 through 2100. There appears to be continued variable precipitation over the next century, with overall decrease. For purposes of this analysis, a 10 percent decrease in annual precipitation has been assumed.

5.1.2.2 Vulnerable Watershed Characteristics

Identification of watershed characteristics that could potentially be vulnerable to future climate change is the first step in assessing the climate change vulnerabilities in the Region. In the context of this analysis, vulnerability is defined as the degree to which a system is exposed to, susceptible to, and able to cope with and adapt to, the adverse effects of climate change, consistent with the definition in the recently issued *Climate Change Handbook for Regional Water Planning*.

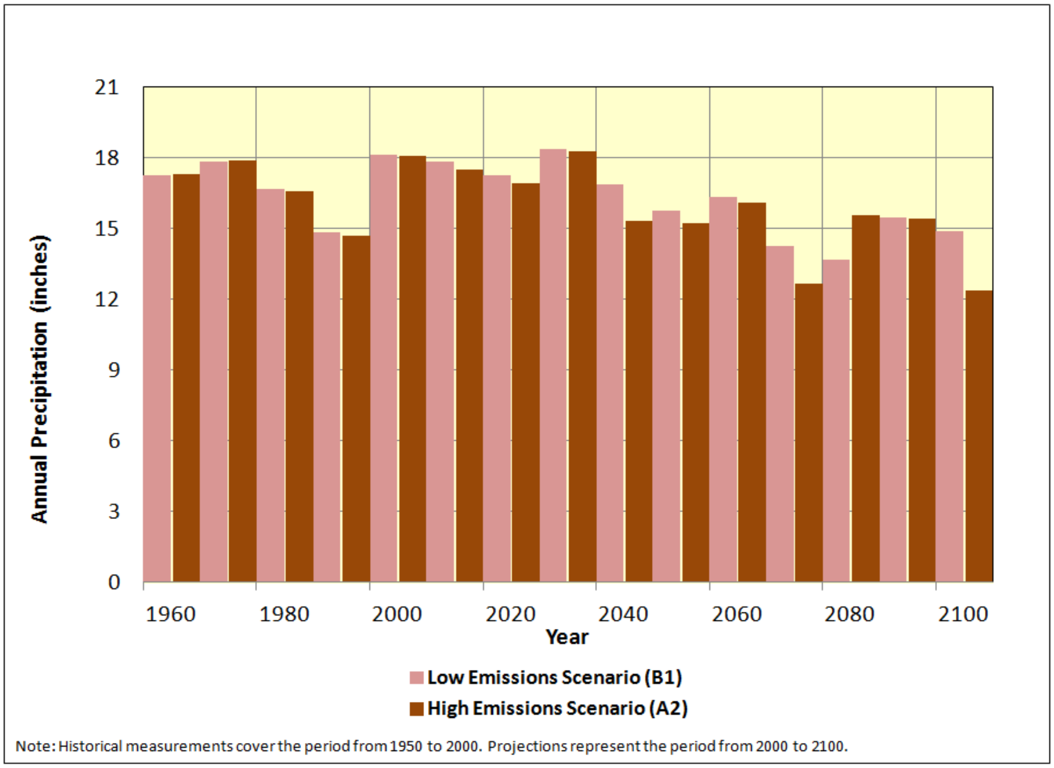
Table 5.1-2 provides a summary list of water-related resources that are considered important in the Region and potentially sensitive to future climate change. The summary table provides the main categories applicable to water planning in the Region with a general overview of the qualitative assessment of each category with respect to anticipated climate change impacts. The main categories follow the climate change vulnerability checklist assessment as defined in the *Climate Change Handbook for Regional Water Planning*. These categories also reflect a combination of the IRWMP requirements and are consistent with Proposition 84 requirements.

FIGURE 5.1-2
HISTORICAL AND PROJECTED ANNUAL AVERAGE AIR TEMPERATURE FOR THE USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

FIGURE 5.1-
PROJECTED ANNUAL PRECIPITATION FOR USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



(a) Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

Table 5.1-2 identifies the anticipated climate change impacts on these identified resources only qualitatively. It should be noted that resources that are likely to be vulnerable to climate change are considered for further analysis in the following subsections. Table 5.1-2 also highlights those resources in the Region that are unlikely to be affected by climate change and therefore they do not warrant further analysis and consideration at this time.

5.1.2. Vulnerability Sector Assessment

Climate change processes are supported by extensive scientific research and are based on a vast number of peer-reviewed and published technical literature. Much of the available literature presents general information, but there is relatively little information that presents specific tools on how to apply impacts in the context of addressing climate change impacts on water resources. In addition, far less information is available on smaller geographic areas and the spatial resolution of the existing climate change models is still quite low. One additional challenge is that precipitation projections cannot be easily converted directly into surface runoff and groundwater recharge to connect with the local water resources planning activities.

TABLE 5.1-2
CLIMATE CHANGE VULNERABILITY ASSESSMENT OVERVIEW

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	**Urban and Agricultural Water Demand** – Changes of hydrology in the Region as a result of climate change could lead to changes in water demand, both in quantities and patterns. Increased irrigation (outdoor landscape or agricultural) is anticipated to occur with temperature rise, increased evaporation losses with warmer temperature, and longer growing season.
Water Supply	**SWP Imported Water** – SWP water is an important portion of the water resources available to the Region. Potential impacts on SWP water availability resulting from climate change directly affect the amount of imported water supply delivered to the Region. **Groundwater** – Changes in local hydrology could affect natural recharge to the local groundwater aquifers and the quantity of groundwater that could be pumped sustainably over the long-term. Decreased inflow from runoff, increased evaporative losses, warmer and shorter winter seasons can alter natural recharge of groundwater. In addition, additional reductions in the SWP imported water imposed by climate change would lead to more reliance on local groundwater.
Water Quality	**SWP Imported Water** – Sea level rise could result in increases in chloride and bromide (a disinfection by product precursor), potentially requiring changes in drinking water treatment. Increased temperature could result in increase in algal blooms and taste and odor events. **Regional Surface Water** – Increased temperature could result in lower dissolved oxygen in streams. Decrease in annual precipitation could result in higher concentrations of contaminants in streams during droughts. Increased wildfire risk and flashier storms could increase turbidity loads for water treatment.
Sea Level Rise	The Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect SWP water supply conditions. As discussed above, the principal concern is the potential for sea water intrusion to increase Delta salinity. As sea level rise is not a direct regional concern, it is not discussed further in this vulnerability assessment.
Flooding	Local surface flows could change as a result of more frequent and intense storm events, leading to more areas susceptible to flooding, and increasing risk of direct flood damage in the Region.
Ecosystem and Habitat	Increased temperature and potential decreases in annual precipitation could put stress on sensitive ecosystems and alter habitats. Water-dependent recreation could also be affected by water quality impacts. In addition, the Region may be subject to increased wildfire risk, which could alter habitat.

Watershed Characteristics	General Overview of Vulnerabilities
Hydropower	Currently, the Region produces only minimal hydropower; thus, climate change effects on hydropower are not likely to be considerable and were not considered further in the analysis at the time of this IRWMP update.

This section presents the vulnerability of each sector identified in Table 5.1-2 with respect to climate change projections given the existing tools and available data. This is an initial attempt using projections specific to the Region for the vulnerability assessment in support of the IRWMP. The outcome of this initial assessment is intended to help understand the potential impacts, to integrate climate change into long-term planning, and to improve understanding of the uncertainties associated with climate change effects. Consistent with the water resources planning horizon in the Region through 2050, the vulnerability analysis considers projections for mid-21st century (2050), consistent with DWR's modeling approach to climate change.

5.1.2.3.1 Water Demand

Demand management is an important adaptation given decreased water supply as a result of climate change. A simple methodology was used to relate historical water demand with temperature. Reasonable projections were made for potential variations in water demand, based on anticipated temperature increase as a result of climate change.

The Cal-Adapt A2 emissions scenario used to project temperature and precipitation with climate change and the MPI-ECHAM5-MPI model used by DWR for SWP reliability analysis are similar with respect to the level of future projected emissions. The Cal-Adapt A2 emissions scenario projects a temperature increase for the Region of about 4°F by the mid-century (2050) and increase of about 7°F by the end of century. The projected average annual air temperature rise of 4°F by 2050 appears small against the background historical annual variability and characterizing the impacts of temperature rise on water demand is a difficult task and discussed on a qualitative basis. While water use varies considerably depending on other factors such as regional economy, population, and land use, a qualitative assessment of water demand increase can be noted based on the projected temperature increase from the Cal-Adapt A2 emission scenario.

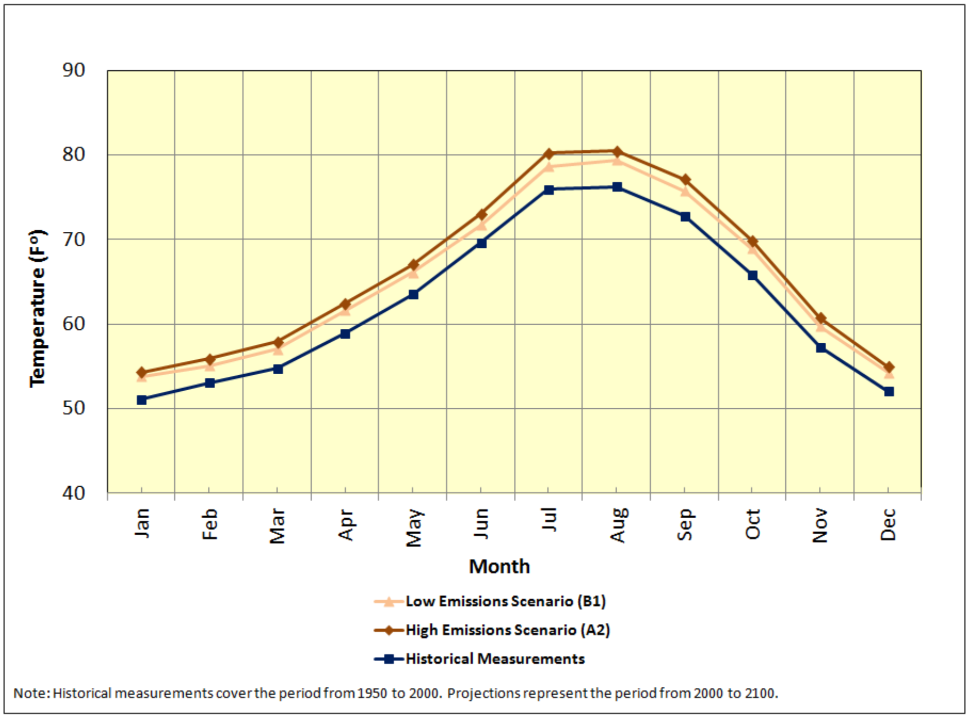
Limited historical temperature data are available for the Region from the Castaic Dam Evaporation Station (Site 252CE), provided by the LADPW. Based on 20 years of limited data between 1991 and 2011, the average of the maximum temperature varied from 62.9°F in February to 95.1°F in August, with the highest temperature of 98.4°F measured in August 1998. The average of the minimum temperature over the same historical period varied from 43.8°F in February to 62.6°F in August, with the lowest temperature of 39.1°F measured in March 2006. Although data records are limited covering a relatively short period of time, significant seasonal and annual variations are noted.

Historical water demand shows an increasing trend since 1995 with a downturn in recent years, likely due to response by customers to conservation efforts and the economic downturn. Water use to meet municipal water needs increased from approximately 45,700 AF in 1995 to nearly 77,500 AF in 2007, and was about 70,000 AF in 2009. Water demand is projected to gradually increase from almost 95,000 AF in 2015 to nearly 141,000 AF in 2050 (Section 3.3.1). This projection accounts for projected land use changes and conservation to comply with SBX7-7.

Weather affects water demand in the Region. The largest water use occurs during the end of summer and the beginning of fall months (July, August, and September) and water is used least in cooler months leading into spring (February and March). Total water use can vary more than 50 percent seasonally, indicating a significant monthly and seasonal variation in water use with weather conditions.

Higher temperature is likely to increase water demands. While the ten percent increase of water demand per capita has been assumed to account for dry years in the *2010 Santa Clarita Valley UWMP*, there are not sufficient data available to quantify the effect from increasing temperature resulting from climate change. For a qualitative discussion, the projected increases in temperature and evapotranspiration (ET) have been evaluated to show seasonal changes in projections with climate changes compared with historical trends. Figure 5.1-4 shows the projected average monthly air temperature change for the four GCMs averaged from the present (1950-2000) through 2100 for the Region. The temperature projections are higher for the A2 and B1 emissions scenarios than the historical observed data and the A2 scenario projections are consistently higher than the B1 scenario projections. Based on the monthly average temperature, the projections with climate change show increase in temperature throughout the year with higher temperature increase in dry or summer months than wet or winter months. Under the A2 scenario, the projected temperature increase would be about 4°F during summer months compared with about 3°F during winter months. Qualitatively, these projections suggest water demand in the Region is likely to increase as a result of the projected higher temperature with a higher temperature increase anticipated during dry months compared to wet months.

FIGURE 5.1-4
PROJECTED AVERAGE MONTHLY TEMPERATURE FOR USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS

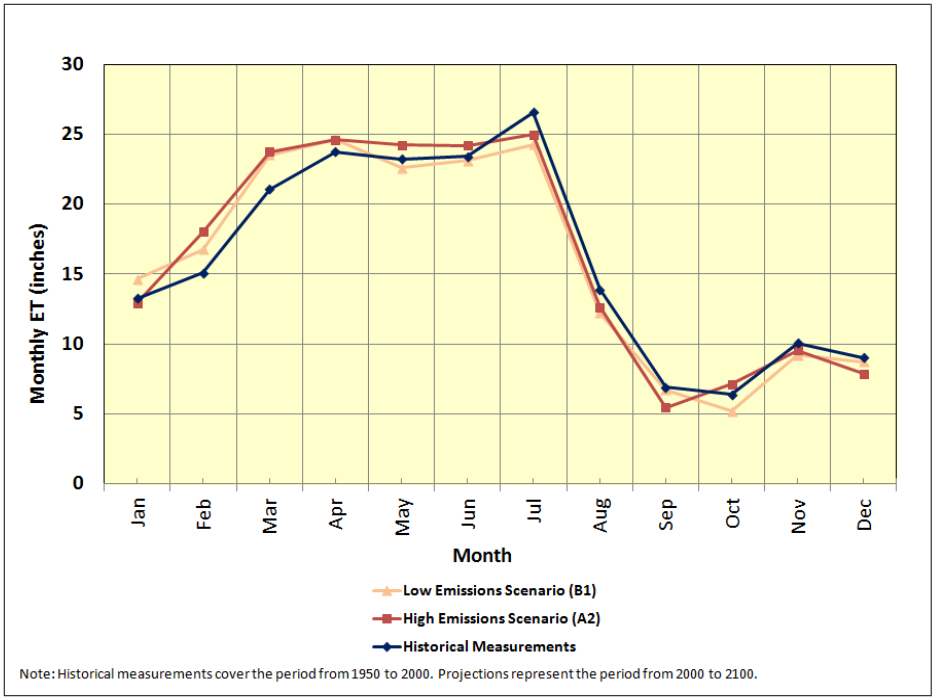


Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

The most important effect of changing weather conditions is likely to be on agricultural demand. Higher temperature generally increases ET rates, but some research studies also suggest higher CO_2 levels and higher temperature increase rates of plant growth and can shorten the time to plant maturity (Hanak and Lund, 2008). This would reduce the overall plant water uptake, partially compensating for potential reductions in agricultural water supply. Thus, the net effect on agricultural crops is still uncertain (Kiparsky and Gleick, 2005) and remains an important area of ongoing research. Figure 5.1-5 shows the projected average monthly ET change for the four GCMs averaged from the present (1950-2000) through 2100 for the Region. In general, both the background historical and projections with climate change show higher ET during dry months (March through July) with a sharp decline in ET during August and September. The ET projections are generally higher for the A2 and B1 emissions scenarios than the historical observed data during months of the year where ET tends to be higher (January through June months). For months where ET is generally lower, a shift is anticipated between the background historical data and projections, where the historical data become slightly higher than the A2 and B2 scenario projections.

Qualitatively, the ET projections with climate change suggest water demand for agriculture in the Region is anticipated to increase during months where ET is high and decrease in months where ET is low. As a result of increased ET, urban water demand is anticipated to increase with greater outdoor water use for landscape irrigation. The temperature and ET projections with climate change as shown in Figures 5.1-4 and 5.1-5 demonstrate the effects of climate change on the future water demand based on seasonal variations; however, the projected water demand increase with population growth and land use changes is large in the Region and these factors are likely to be more significant drivers of outdoor water use than the effect of climate change alone.

FIGURE 5.1-5
PROJECTED AVERAGE MONTHLY EVAPOTRANSPIRATION FOR USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

5.1.2.3.2 Water Supply

For long-term water supply planning, coping with variability is a challenge. With potential additional changes imposed by climate change, there will be a heightened need to evaluate and respond to increased water supply variability.

A broad range of impacts could be produced by climate change in the Region, yet some of the most significant impacts of climate change are anticipated to occur on water resources. An analytical approach was used to identify and describe water supply availability under climate change, and includes DWR's modeling analysis of SWP imported water reliability.

SWP delivery to the Region comprises about 54 percent of total existing water supplies projected through 2050 in the Region in normal/average years (Table 3.1-1). Groundwater pumping from local aquifers and additional sources from groundwater banking activities make up the remaining major water sources used to meet the Region's municipal and agricultural water demand. The Region relies on imported SWP supplies and any reduction or change in the timing or availability of those supplies could have negative impacts on the Region. Reductions in the SWP imported water would lead to increased reliance on local groundwater or other sources of supplies. Changes in local hydrology could affect natural recharge to the local groundwater and the quantity of groundwater that could be pumped in a sustainable manner. Reductions in SWP imported water as a result of climate change could lead to increased groundwater production.

Although SWP supply is mainly controlled by hydrologic conditions in the northern part of the state, the groundwater resources would be affected by local conditions, whereby climate change effects on these resources could occur at the same time. Therefore, the combined effects on SWP imported water and groundwater resources can exert more magnified stress on the Region's water supply planning than the effects on individual resources.

The following is an assessment of climate change on SWP imported water and groundwater resources. The SWP imported water assessment is presented first to identify potential reductions in SWP deliveries. The outcome of the SWP assessment is tied to the groundwater assessment as SWP reductions may lead to increased reliance on local groundwater.

5.1.2.3.2.1 SWP Imported Water

Availability of future SWP imported water supplies to the Region was assessed within the context of climate change impacts. The methodology used for the vulnerability assessment includes a comparison of estimated future SWP deliveries with and without climate change to evaluate the potential vulnerability of the SWP imported water. Future projections of SWP deliveries are based on the modeling analysis performed by DWR, as reported in the recently issued *2011 Reliability Report* (DWR 2012). DWR conducted an assessment of the impacts of climate change on the state's water supply using MPI-ECHAMPS Global Climate Model. As described earlier, the model output is based on the A2 emission scenario with mid-century (2050) projections. The assumption used for the emissions level in the DWR modeling analysis is consistent with the Cal-Adapt A2 emissions scenario used for forecasting temperature, precipitation, ET, and runoff projections with climate change.

DWR's modeling analysis is based on the 82 years of hydrologic data (water years 1922-2003) and uses projected levels of climate change through year 2050, with 2020 land use levels. The analysis accounts for potential hydrologic changes that could result from climate change and the effects of sea level rise on water quality, but does not incorporate the probability of catastrophic levee failure (DWR 2012).

On a qualitative basis, DWR's climate change modeling analysis indicates increased temperature, decreased water availability with reduced Sierra Nevada snowpack, early snow melt, and a rise in sea level (DWR 2012). DWR's *2011 Reliability Report* provides SWP system-wide deliveries expressed as a percentage of total maximum Table A amounts for future conditions with climate change. These percentages do not reflect the differing allocations to individual contractors. In the absence of detailed results for each contractor, this vulnerability assessment assumed that changes in total SWP Table A deliveries resulting from climate change are a reasonable representation of future SWP imported water supply to the Region. The underlying assumption is that future reductions in SWP imported water to the Region would be proportional to projected reductions in total SWP deliveries.

DWR's modeling analysis provides future projections of SWP deliveries both with and without climate change, each using the 82 years of hydrologic data. Using DWR's modeling analysis for the assessment of climate change is consistent with the ongoing long-term water planning in the Region. In addition, results from DWR's climate change analysis allows for a direct comparison of SWP supply vulnerability of future conditions with and without climate change on a quantitative basis.

As described above, the climate change model MPI-ECHAMPS with the A2 emission scenario was used by DWR in the *2011 Reliability Report* for the future SWP delivery projections with climate change. The maximum SWP Table A demands for deliveries to SWP contractors from the Delta is 4,133 thousand acre feet (TAF) based on the current demands developed by DWR. In the *2011 Reliability Report*, the maximum SWP Table A demands for deliveries from the Delta are assumed to be the same as 4,133 TAF under future conditions, both with and without climate change effects. In other words, the maximum annual SWP Table A demand of 4,133 TAF is assumed in all 82 years of the simulation (note there is no variation in demand due to different annual hydrologic conditions). In the context of evaluating the climate change effects in this study, reductions in SWP deliveries with and without climate change are presented as percentages of the maximum SWP Table A delivery amount of 4,133 TAF annually.

It should be noted that SWP supplies to CLWA, as reported in the *2010 Santa Clarita Valley UWMP*, are based on DWR's more detailed, contractor-specific delivery data from its analyses for the *2009 Reliability Report*. In the *2010 UWMP*, DWR's analysis of current (2009) conditions was used to estimate 2010 SWP supplies and its analysis of future (2029) conditions was used to estimate 2030-2050 SWP supplies. SWP supply to CLWA by 2050 is projected to be at 57,400 AF□ (60 percent of CLWA's 95,200 AF□ Table A amount) in average/normal years, 9,100 AF□ (10 percent of Table A amount) in a single dry year and 33,000 AF□ over a multi-year dry period.

<u>Average, Maximum, and Minimum Annual SWP Table A Deliveries</u>

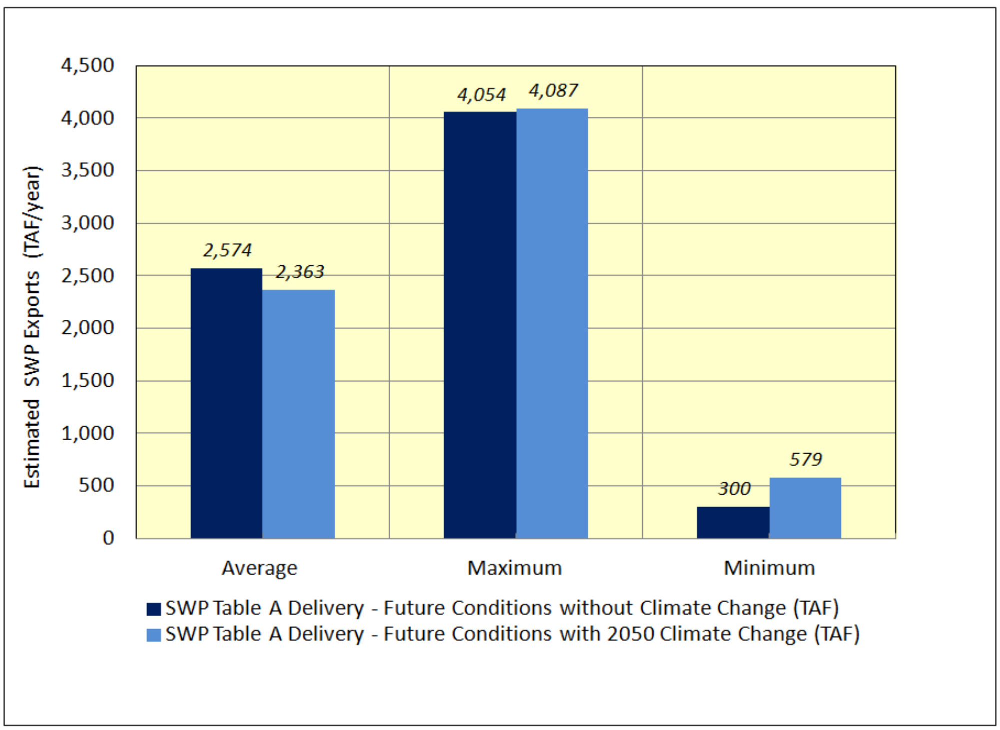
Figure 5.1-6 presents the estimated long-term average, maximum, and minimum annual SWP Table A deliveries for the future conditions with and without climate change. The long-term average is based on the projections for the 82 years of hydrologic period (1922 to 2003) modified to reflect climate change. Based on the future conditions with climate change, SWP Table A deliveries range from an annual minimum of 579 TAF to a maximum of 4,087 TAF, with the long-term average of 2,363 TAF. These estimates show that the maximum annual delivery increases by 33 TAF per year (1 percent) under the future conditions with 2050 climate change, relative to the future conditions with no climate change effects.

Estimated minimum annual delivery is 279 TAF (48%) higher with climate change than without climate change. However, the average annual deliveries decrease from 2,574 TAF under the future conditions without climate change to 2,363 TAF under the future conditions with climate change. This is a reduction of 211 TAF annually at the system-wide level.

In assessing the future SWP delivery reliability, the long-term average SWP delivery from the *2011 Reliability Report* is directly applicable to individual contractors. The long-term average of future SWP deliveries with climate change is lower than the long-term average without climate change, as depicted in Figure 5.1-6. The average value represents the long-term trend over the entire 82 years of the hydrologic data. This decreasing trend in the average SWP delivery projections with climate change is consistent with the expected reduction in the reliability of the

SWP water supply system due to climate change impact (DWR 2009). SWP future projections associated with any particular year (i.e., the minimum and maximum values) or over a short period of time (i.e., a single dry period or single wet period) should be viewed carefully because these results are dependent upon the rainfall that has occurred in previous years. In addition, reservoir storage for the beginning of any year varies depending upon the weather conditions in the previous year. Therefore, the results for any single year, such as the minimum and maximum values as shown in Figure 5.1-6, should be interpreted with caution as they may be affected by the amount of water assumed to be available from the previous year. While the long-term SWP future projections with climate change indicate reduction in deliveries, SWP projections for a single year (or over a short period of time) does not follow the decreasing trend. As described above and shown in Figure 5.1-6, the minimum and maximum values are projected to be higher with climate change. Since they represent projected deliveries in a single year, the increasing trend with climate change could be attributed to the factors that occur in the previous years, such as weather and or reservoir storage conditions, that affect deliveries.

FIGURE 5.1-□
ESTIMATED AVERAGE, MAXIMUM, AND MINIMUM ANNUAL SWP EXPORTS – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Figure based on Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12.

Long-term average SWP Table A deliveries are estimated to be 57 percent of Table A amount for the future conditions with climate change; without climate change long-term deliveries are expected to be 62 percent of Table A amounts. Assuming available SWP supply to the Region would be proportional to the SWP system-wide supply conditions, projected SWP imported water delivery to CLWA with climate change corresponds to about 54,500 AF (or 57 percent of Table A amount based on CLWA's annual contract amount of 95,200 AF of SWP water) and 59,300 AF (or 62 percent of Table A amount) without climate change.

The *2010 Santa Clarita Valley UWMP,* based on the *2009 Reliability Report,* assumed SWP supply of 57,400 AF□. The new modeling in the *2011 Reliability Report* suggests that CLWA SWP average supply could be 2,900 AF□ less (about 3%) than assumed in the *2010 Santa Clarita Valley UWMP*. For the purpose of this analysis, results from the *2011 Reliability Report* were used consistently for future projections with and without climate change. In light of the long-term water supply availability, this reduction appears small and comprises a relatively small portion of the Region's total water supply.

It should also be noted that the current assumptions used in DWR's *2009* and *2011 Reliability Report* present a conservative projection of SWP delivery reliability. Several emerging factors related to the biological opinions on the Delta operations, issued by US FWS and the National Marine Fishery Service (NMFS), have the potential to affect the availability of SWP supplies. Therefore, the projections presented herein also present conservative estimates concerning the long-term delivery reliability of SWP supplies. These projections should be revisited during future IRWMP updates.

<u>SWP Table A Deliveries by Water □ear Types</u>

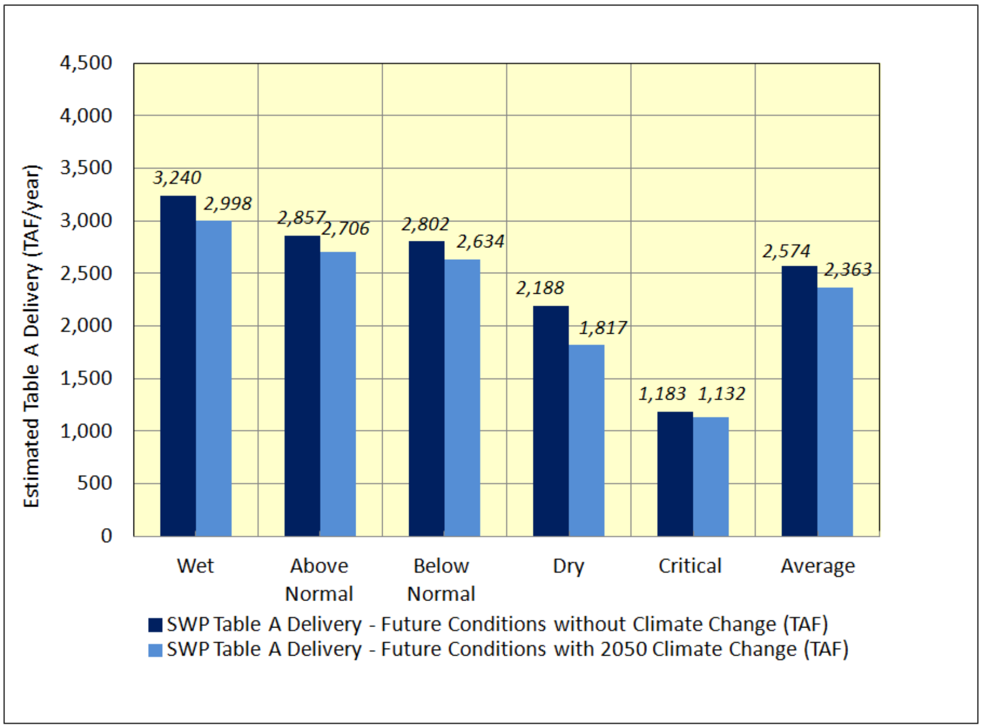
Figure 5.1-7 and Table 5.1-3 show estimated SWP Table A deliveries by water year type under future conditions with and without climate change. In Figure 5.1-7 and Table 5.1-3, estimated SWP exports reported by DWR for the 82 years of hydrologic data (water years 1922 to 2003) were averaged according to water year type. This representation shows how the estimated SWP exports would vary by hydrologic year types over the entire 82 years of the modeling analysis. Overall, the future conditions with climate change forecast lower deliveries under all water year types, with the largest difference for dry years. Deliveries decrease by as little as 51 TAF (5%) during critical years to as much as 371 TAF (20%) during dry years under the future conditions with climate change relative to no climate change.

TABLE 5.1-□
ESTIMATED SWP EXPORTS BY WATER YEAR TYPE – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE

Water Year Type	Future Conditions (2050) with Climate Change (TAF)	Future Conditions (2050) without Climate Change (TAF)	Difference, Future with and without Climate Change	
			TAF	□
Wet	2,998	3,240	-242	-8
Above Normal	2,706	2,857	-152	-6
Below Normal	2,634	2,802	-168	-6
Dry	1,817	2,188	-371	-20
Critical	1,132	1,183	-51	-5
Average	2,363	2,574	-211	-9

Source: Estimated SWP exports are based on the 82 years of hydrologic data (water years 1922-2003) from Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions. Hydrologic data were averaged according to water year types based on DWR's Sacramento Valley water year index (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST).

FIGURE 5.1-7
ESTIMATED SWP TABLE A DELIVERY BY WATER YEAR TYPE – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Estimated SWP exports are based on the 82 years of hydrologic data (water years 1922-2003) from Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions. Hydrologic data were averaged according to water year types based on DWR's Sacramento Valley water year index (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST).

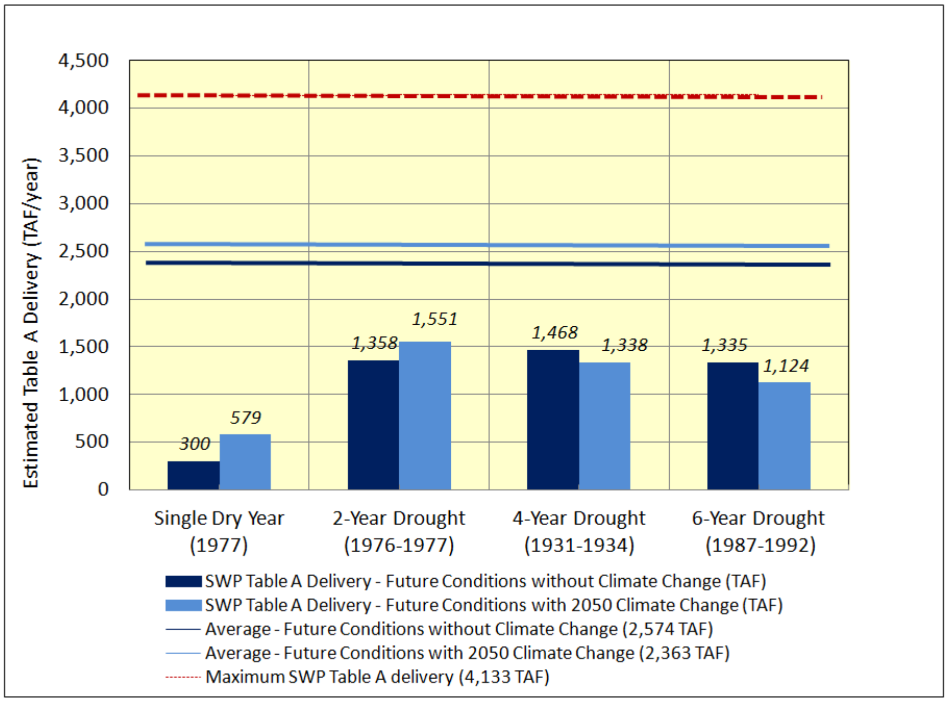
Dry-□ear SWP Table A Deliveries

Figure 5.1-8 shows a comparison of estimated SWP Table A deliveries under future conditions with and without climate change during possible drought conditions. Unlike Figure 5.1-7 that shows the average of dry and critical years over the entire 82 years of hydrologic period, Figure 5.1-8 shows estimates of SWP exports for a single dry year, or the average of the consecutive dry years. Droughts are analyzed using historical drought-period precipitation and runoff patterns from 1922 through 2003. Future conditions with land use and climate change are also accounted for. As shown in Figure 5.1-8, estimated annual SWP deliveries can be expected to range from 579 TAF to 1,551 TAF under the future conditions with climate change, relative to 300 TAF to 1,468 TAF without climate change effects. This indicates a 12% to 48% increase for the single dry year and 2-year drought, respectively, with climate change. Under both future conditions, the single year drought (1977) is the most intense dry period, with the lowest delivery. As shown in Figure 5.1-8, the increasing trend for the single dry and 2-year drought with climate change is different than the overall decreasing trend seen in SWP projections with climate change. As discussed above, the long-term average SWP delivery is projected to be lower with climate change (Figure 5.1-6). Similarly, a decreasing trend is seen for the average deliveries by water year types where the future conditions with climate change forecast lower deliveries under all water year types (Figure 5.1-7). However, as discussed above, the minimum and maximum values are projected to be higher with climate change (Figure 5.1-6), similar to the increasing trend seen for the single-dry year and 2-year drought projections with climate change (Figure 5.1-8). As discussed earlier, the projections over a single year (i.e., minimum, maximum, or a single dry period) or over a short period of time (i.e., 2-year drought) should be interpreted carefully because the results for the beginning of any year are dependent upon the rainfall and reservoir storage conditions in the previous year. While the increasing trend with climate change does not follow the overall expected trend for decreasing SWP deliveries with climate change, it could be attributed to the factors that occur in the previous years, such as weather and or reservoir storage conditions that affect deliveries.

While SWP supplies are anticipated to increase during short period drought conditions, as depicted in Figure 5.1-8 for the single dry year and 2-year drought, during the multi-year (4-year and 6-year) drought projections under future conditions are lower with climate change than without climate change. This is consistent with the decreasing trend seen with climate change for the long-term average and the average deliveries during different water year types. For the 4-year and 6-year drought, SWP Table A deliveries with climate change decrease by 10% to 19%, respectively, compared with future conditions without climate change. For the 6-year drought, SWP supply to the Region is anticipated to be reduced by 4,900 AF per year, as a result of decrease in SWP Table A delivery from 36% of Table A amount without climate change to 32% of Table A amount with climate change.

Assuming that the Region's SWP supply reliability would be proportional to SWP system-wide supply reliability, there is potential for slightly increased SWP supply to the Region during a single year and 2-year drought with climate change assumptions compared with no climate change effects. In the worst-case single critically dry year (1977), estimated SWP Table A delivery increases from 7% of total maximum Table A amount without climate change to 14% of Table A amount with climate change. This represents a 7% increase and corresponds to about 6,500 AF additional SWP supply to the Region (based on the annual contract amount of 95,200 AF of SWP water). During the 2-year drought, the projected increase in SWP supply is about 5% of total Table A amount or 4,500 AF more of SWP supply.

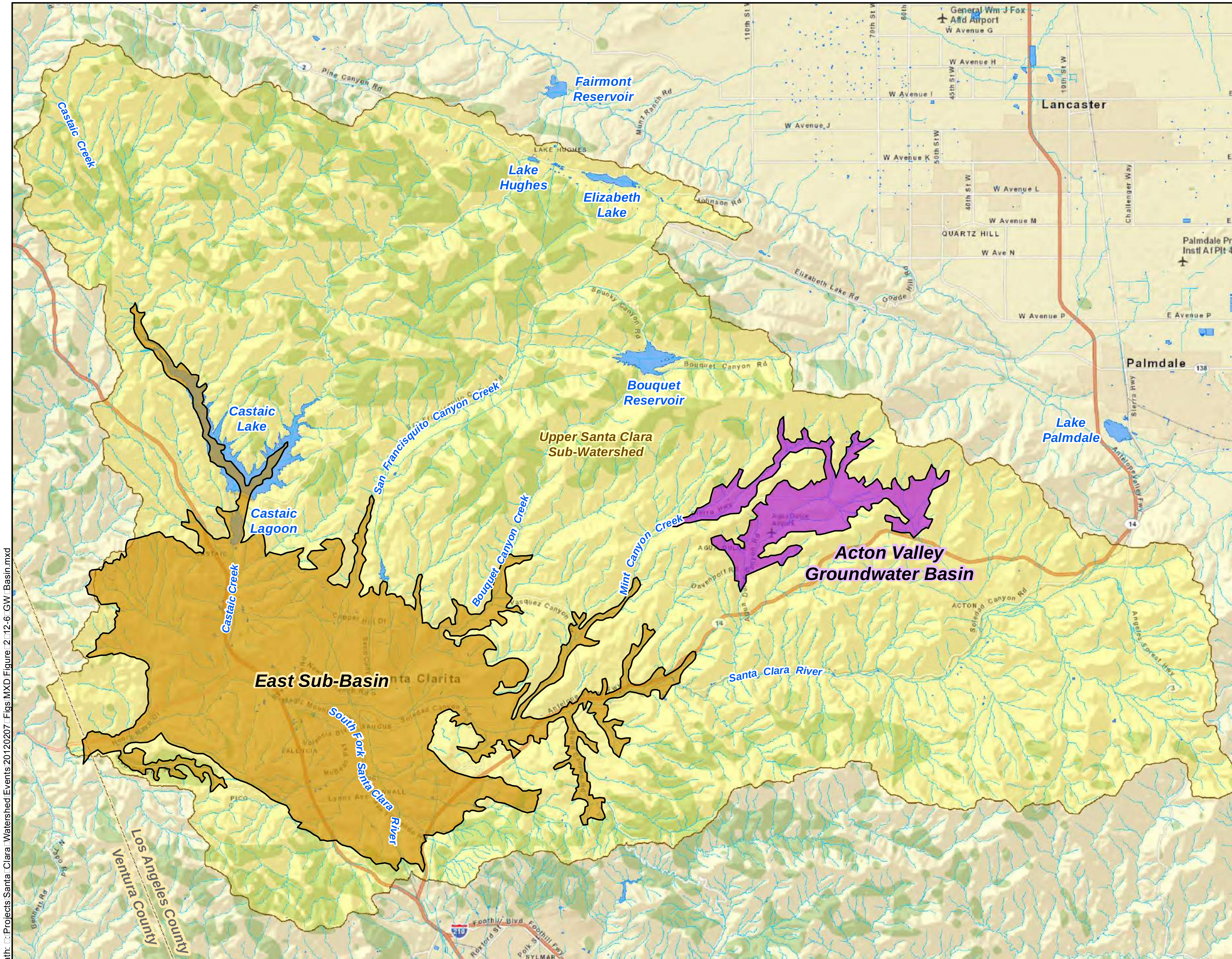
FIGURE 5.1-8
ESTIMATED SWP TABLE A DELIVERY DURING DRY PERIODS – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Figure based on Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions.

5.1.2.3.2.2 Groundwater

As discussed in the Water Supplies and Water Demand Section (see Section 3.1-1 and Table 3.1-1), the Region relies on groundwater mainly in two groundwater basins: Acton Valley Basin and Santa Clara River Valley Basin, East Subbasin. The boundaries of the basins are shown in Figure 5.1-9, as defined by DWR Bulletin 118 (DWR, 2003). There are also groundwater areas that are recognized locally (Agua Dulce Basin and Soledad Canyon Alluvial Channel) and used for pumping, but they are not designated as a groundwater basin by DWR. Groundwater extraction data, groundwater storage, and yield data for these locally recognized basins are not currently available. A detailed description of the hydrogeologic characteristics of the basins, groundwater flow and water quality conditions, and storage capacity of the aquifers is presented in the previous sections and additional details can be found in other existing reports (CH2MHill 2005; LSCE 2011).



Legend

- Acton Valley Groundwater Basin
- East Sub-Basin (Santa Clara River GW Basin)
- Upper Santa Clara Sub-Watershed
- Water Body
- Streams

N

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Miles

Kennedy/Jenks Consultants

CLWA IRWMP Grant Application
Los Angeles County, California

Groundwater Basin Boundaries in the Region

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February 2012

Figure 5.1-9

Path: Projects Santa Clara Watershed Events 20120207 Figs MXD Figure 2 12-6 GW Basin.mxd

Groundwater basins in the Region are recharged largely by infiltration of surface water flows in the Santa Clara River channel and deep percolation of precipitation and runoff in its tributaries. Surface water flows percolate through the alluvial deposits along the stream channels, recharging the Alluvium, and the underlying Saugus Formation. Groundwater in the Santa Clara River Valley Basin is produced from the Alluvium and Saugus Formation.

Based on the groundwater operating plan for the Santa Clara River Valley East Subbasin, total groundwater production in a given year varies depending on the hydrologic conditions. Based on the existing and planned pumping, groundwater is anticipated to provide about 43,600 AF through year 2050 (35,225 AF existing and 8,375 AF planned) (see Table 3.1-1). In some years groundwater supplies could be supplemented with banked groundwater. With the existing (24,950 AF) and planned (20,000 AF) banking programs, total (maximum) capacity of the banking program withdrawals would reach 44,950 AF annually through 2050, but this banking water is typically used only in dry years. The projections of pumping are well within the available groundwater supply for the Region. Total combined groundwater available from the Alluvium, Saugus Formation, and Acton Basin ranges from 71,900 AF□ to 89,000 AF□ during normal and above normal years and reduces to 60,400 AF□ to 74,900 AF□ during dry years (see Table 3.1-2).

While the basins have supply exceeding the future projected pumping levels, in light of the basin characteristics and natural recharge processes in the basins, changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage. Warmer winters would increase the amount of runoff available for groundwater recharge, but reductions in inflow from runoff and increased evaporative losses could reduce the amount of natural recharge. While the extent to which climate change will change the natural recharge processes and the impact of that change are not exactly known and are difficult to quantify, simplifying assumptions were applied to provide initial estimates.

For this analysis, precipitation reduction of 10 percent was assumed to occur in the Region on a long-term basis. Assessment of climate change impacts on groundwater resources is presented in two parts. The first part of the analysis uses a “what if” scenario to evaluate if groundwater aquifers could make up for SWP supplies impacted by climate change while staying within a safe operating range. The underlying assumption was that reduced SWP supplies would be solely made up by groundwater pumping and that future pumping levels could be potentially higher than the future pumping projections reported in the *2010 Santa Clarita Valley UWMP*. The second part of the analysis is based on a “what if” scenario to evaluate the combined effects of climate change on SWP supplies, in conjunction with potential climate change effects on groundwater resources. In this scenario, it was assumed that 10 percent precipitation reduction would result in 10 percent reduction in the current safe groundwater pumping operational range. This is considered as an initial assessment of climate change effect on groundwater resources and further analysis may be warranted.

Following is a brief discussion of historical and operational range of pumping from the Alluvium, Saugus Formation, and Acton Basin, as this information is pertinent to the assessment of future pumping projections with climate change effects.

Santa Clara River Valley East Subbasin – Alluvium

Pumping from the Alluvium in a given year is governed by local hydrologic conditions in the eastern Santa Clara River watershed. Therefore, changes in local hydrologic conditions resulting from climate change are anticipated to directly affect the available supply in the Alluvium.

Groundwater production from the Alluvium is projected to range from 38,100 AF□ to 38,600 AF□ through year 2050 under normal years (CLWA, et al. 2011). Future projections of pumping account for land-use changes including a decrease in agricultural land use and decrease in agricultural pumping and the equivalent amount of increased pumping for municipal water supply. Future pumping projections are consistent with the long-term sustainable pumping operations and are within pumping capacity and historical ranges of pumping in the Alluvium. The Alluvium can supply groundwater on a long-term sustainable basis in the overall range of 30,000 to 40,000 AF□ during normal and above-normal years, with a probable reduction in dry years to 30,000 to 35,000 AF□. In terms of pumping capacity, the combined maximum pumping capacity of the three retail water purveyors with Alluvium wells (NCWD, SCWD, and VWC) is approximately 67,000 AF□ (CLWA, et al. 2011), which is more than sufficient to meet the potential future groundwater supply from the Alluvium. However, as a result of the groundwater operating plan, pumping to full capacity is not permitted. Historical pumping data show that since the beginning of SWP deliveries to the Region in 1980, total pumping from the Alluvium ranged from 20,000 AF□ (in 1983) to slightly more than 43,000 AF□ (in 1999). During recent years between 2005 and 2009, pumping from the Alluvium was at the upper end of the operating plan range, from nearly 38,700 AF (in 2005) to slightly over 43,000 AF (in 2006).

The groundwater modeling analysis, prepared by CH2M Hill and LSCE (2005), was used to examine the yield and sustainability of the Alluvium in response to pumping in the 30,000 to 40,000 AF□ range under average/normal and wet conditions, and in the 30,000 to 35,000 AF□ range under locally dry conditions. The model was based on a 78-year hydrologic period from historical precipitation and considered a number of hydrologic conditions expected to affect groundwater pumping and recharge. The modeling analysis showed no evidence of long-term decline in groundwater levels or storage. The updated basin yield analysis (LSCE & GSI 2009) resulted in similar findings as the original modeling analysis, providing further evidence that the operating plan reflects the ongoing sustainable groundwater supply rates. On an overall basis, projected groundwater production from the Alluvium is intended to remain within the sustainable ranges in the groundwater operating plan (CLWA, et al. 2011).

Santa Clara River Valley Basin - Saugus Formation

Pumping from the Saugus Formation in a given year is tied directly to the availability of other water supplies, particularly from SWP. Therefore, reductions in the SWP imported water from climate change impacts would lead to more reliance on the Saugus Formation.

Based on the future projections of groundwater pumping through year 2050, the Saugus Formation would supply water from 11,500 AF□ to 12,500 AF□ in normal years (CLWA, et al. 2011). On an overall basis, projected groundwater production from the Saugus Formation remains well within the sustainable ranges defined in the groundwater operating plan (CLWA, et al. 2011). Based on the historical operating ranges and recent modeling analyses (2005 and 2009), the Saugus Formation can supply groundwater on a long-term sustainable basis in the overall range of 7,500 to 15,000 AF□ during normal years, but has the capacity to produce more in dry years. As presented earlier in Table 3.1-2, planned dry-year pumping from the Saugus Formation ranges between 15,000 and 25,000 AF□ during a drought year and can increase to between 21,000 and 25,000 AF□ if SWP deliveries are reduced for two consecutive years and between 21,000 and 35,000 AF□ if SWP deliveries are reduced for three consecutive years.

Based on a combination of historical operating experience and recent groundwater modeling analysis in 2005 and 2009, the Saugus Aquifer can be considered a sustainable water supply source to meet the Saugus portion of the operating plan for the groundwater subbasin. The operating plan for the Saugus, with fairly low pumping in wet/normal years and increased pumping through dry periods, reflects sustainable groundwater supply rates. Limited data exists regarding groundwater levels in the Saugus Formation; however, the existing data indicate no trend toward a sustained decline in water levels or storage indicative of overdraft.

<u>Acton Groundwater Basin</u>

The Acton Basin consists of alluvial and stream terrace deposits and is under unconfined conditions. The basin is drained by the Santa Clara River and recharged largely by deep percolation of direct rainfall runoff captured in the valley floor, and Santa Clara River and tributaries. As seen in Table 3.1-2, availability of groundwater from the Acton Basin is estimated to range from 14,900 AF for a relatively dry period to 34,400 AF for a relatively wet period. Based on the historical data, groundwater levels declined during the 1950s through the mid-1970s, rose during the late 1970s to the mid-1980s, and continued to decline after the 1980s (Slade 1990).

<u>"What If" Scenario 1: Projected Future Groundwater Pumping with Reduced SWP Supplies</u>

This scenario assumes (1) SWP supplies with climate change as reported in the 2011 Reliability Report and (2) groundwater supplies consistent with the 2010 Santa Clarita Valley UWMP.

This section presents the first part of the analysis where future groundwater pumping volumes are projected to accommodate the reduced SWP supplies as a result of climate change effects on SWP supplies. The future projections of pumping from the Alluvium, Saugus Formation, and Acton Basin, as reported in the *2010 Santa Clarita Valley UWMP*, were evaluated in light of the operating plan pumping range and reduced SWP supplies resulting from climate change based on the vulnerability assessment of SWP supplies presented above. This is a qualitative analysis to evaluate if the basins have the potential to make up for reduced SWP supplies resulting from climate change without long-term effects on groundwater levels and storage. The current analysis is mainly based on the long-term average trends to capture the long-term response from climate change. Conditions during a multi-year (6-year) drought were also assessed as a conservative approach.

Based on DWR's modeling analysis of climate change effects on SWP supplies, CLWA's SWP imported water supply is estimated to decrease by 4,900 AF□ both on the long-term average basis and during the multi-year (6-year) drought, relative to future projections without climate change. In average/normal years, the future pumping projections of 38,100 AF□ to 38,600 AF□ in the Alluvium, as described in the *2010 Santa Clarita Valley UWMP* (CLWA, et al. 2011), would be in the upper range of the operating plan (up to 40,000 AF□, Table 3.1-2). Additional pumping from the Alluvium to accommodate the reduced SWP delivery of 4,900 AF□ would exceed the sustainable yield. In addition, pumping higher than the estimated sustainable Alluvium yield at 38,600 AF□ could potentially result in both short-term and long-term groundwater levels and storage depletion in this basin. For the purpose of this assessment, it was assumed that the Alluvium could potentially produce 38,600 AF□ on the long-term average. During a multi-year drought, the potential for the basin to support additional pumping of 4,900 AF□ is low, given that the basin operating yield decreases to 34,850 AF□ (CLWA, et al. 2011).

Historical pumping in the Saugus Formation, on the other hand, has been fairly low and increased pumping up to about 15,000 AF□ over a four-year period showed short-term water level impacts but produced no long-term depletion of the substantial groundwater storage. While the future projection of pumping from the Saugus Formation ranges from 11,500 AF□ to 12,500 AF□, the basin has the potential to pump additional amounts in the short-term, as high as 35,000 AF□ during a single dry year and up to 32,550 AF□ during a multi-year drought in the case of reduced SWP deliveries. For the purposes of this assessment, it was assumed that, both on the long-term basis, and multi-year drought conditions, the entire amount of reduced SWP supplies could be potentially made up by pumping in the Saugus Formation. If the reduced SWP supply was made up solely by groundwater pumping in the Saugus Formation, pumping would increase by an equivalent amount of reduced SWP delivery, or 4,900 AF□. This would result in pumping in the range of 16,400 AF□ to 17,400 AF□ on the long-term average. This range is slightly higher than the upper end of the planned use of the aquifer in normal years, but lower than the upper range of pumping in dry years when reduced SWP deliveries occur during consecutive years (up to 35,000 AF□). As discussed earlier, the full Saugus Formation supply of 35,000 AF□ in certain dry years would require restoration of perchlorate impacted wells with additional wells, but pumping in the range of 16,400 AF□ to 17,400 AF□ is not anticipated to be affected by well capacity. Overall, additional pumping from the Saugus to make up for reduced SWP supplies is within the range of pumping identified in the recent basin analysis found to protect long-term groundwater sustainability. Groundwater levels could potentially go below historical levels in response to greater long-term use of the aquifer, but the basin is anticipated to show recovery of groundwater levels and storage after cessation of higher pumping.

Given that the Acton Basin is under unconfined conditions and shows historical groundwater level declines, the basin is anticipated to be most vulnerable to local changes in hydrology and reduced natural recharge. For the purpose of this assessment, no additional pumping from the Action Basin was assumed to occur to respond to reduced SWP deliveries resulting from climate change.

<u>"What If" Scenario 2: Projected Future Groundwater Pumping with Reduced SWP Supplies and Reduced Precipitation</u>

This scenario assumes (1) SWP supplies with climate change as reported in the 2011 Reliability Report and (2) groundwater supplies reduced to reflect anticipated reductions in recharge with climate change.

For the purpose of this part of the analysis, SWP projections with climate change remain the same as discussed in the "What If" Scenario 1. However, the groundwater operating range was modified based on the simplifying assumption that a 10 percent reduction in precipitation would lead to a 10 percent reduction in the operational range. This is done on a long-term basis and does not account for year-to-year variations in precipitation change or any resulting annual changes in groundwater resources. The intent is to evaluate if the basins can still support the additional pumping in the long-term without adverse long-term effects in groundwater storage and levels when SWP deliveries are reduced because of climate change effects on SWP supplies.

Given a 10 percent reduction in the operational yield, available pumping from the Alluvium is assumed to decline to 27,000 AF□ to 36,000 AF□, less than the current operating range of 30,000 AF□ to 40,000 AF□. Future projected groundwater production from the Alluvium (without climate change) ranges from 38,100 AF□ to 38,600 AF□, which exceeds the modified operational yield. While the 10 percent reduction assumption is very broad and conservative, this suggests that, the Alluvium may not have the capacity to support future projections of pumping in the long-term, and may not support additional pumping that may be required when SWP supplies are reduced. In addition, future pumping of 38,100 AF□ to 38,600 AF□ may require further analysis of the operational range to maintain the long-term sustainability of the basin.

Assuming a 10 percent reduction in the operational yield, the Saugus Formation could potentially range from 6,750 to 31,500 AF□, compared with the current range of 7,500 AF□ to 35,000 AF□. If the reduced SWP supply of 4,900 AF□ was made up solely by groundwater from the Saugus Formation, pumping would range from 16,400 AF□ to 17,400 AF□ on the long-term average, compared with future pumping projection of 11,500 AF□ to 12,500 AF□ without climate change. This increased pumping is higher than the upper end of the modified operating range in normal years (13,500 AF□), but still lower than the upper range of the modified operating use in consecutive dry years (22,500 AF□ for a dry year 2 and 31,500 AF□ for dry year 3). With the modified (reduced) operating range, it appears that the Saugus Formation could potentially support pumping up to 13,500 AF□ in the long-term without affecting the long-term stability of the basin. Therefore, the Saugus Formation has the potential to make up for a portion of the additional pumping when SWP deliveries are reduced with climate change, but a combination of other sources should be considered to make up the difference and meet the water demand in the Region.

5.1.2.3.3 Water Quality

Improving water quality is a Plan objective that may be impacted by climate change. Studies of potential climate change impacts on water quality exist, but few trends in relationships between hydroclimate (hydrology and weather variables) have been identified. Key climate vulnerabilities potentially important to the Region include increasing temperature and changes in precipitation patterns. Increased wildfire risk is another potential factor that could affect water quality in the Region. Outside the Region, sea level rise in the Sacramento-San Joaquin Delta is expected to impact water quality of imported SWP water.

Surface waters in the Region are expected to be more directly vulnerable to water quality impacts of climate change, while water quality impacts to groundwater sources would be indirect. Key surface water sources include imported SWP water stored in Castaic Lake and flowing water in the Upper Santa Clara River and its tributaries such as Bouquet Creek.

SWP Imported Water

SWP water is vulnerable to potential effects of climate change at the source in the Delta and in storage in Castaic Lake. The effect in the Delta would be due to sea level rise which increases the intrusion of salinity into the exported SWP water. This will increase chloride and bromide (a disinfection byproduct precursor that is also a component of sea water) concentrations in the SWP imported water. In addition, decreased freshwater flows into the Delta could increase organic matter, which contribute to disinfection byproduct formation, in the SWP water. Water stored in Castaic Lake will also be vulnerable to climate change. A prior study of potential climate change impacts on the water quality of Lake Cachuma near Santa Barbara found that water quality parameters related to rainfall-runoff (turbidity and apparent color) during the wet season, winter, and/or spring could be evaluated by looking at total precipitation while water parameters related to taste and odor (increasing water temperature, dissolved oxygen (DO), threshold odor number (TON), pH, and percent DO saturation) during the dry season, spring, and summer could be evaluated by looking at air temperature parameters and/or evaporation (Drago and Brekke 2005).

Extreme storm events, although rare, may be more intense under climate change and may present treatment challenges for source water with increased turbidity. In the past, high turbidity events in Castaic Lake during 1998 and 2005 required modification of the drinking water treatment processes (primarily additional chemical usage) for extended periods. In 2005, an intense winter rainfall event after a wildfire in the watershed the prior year resulted in extremely high turbidities (peak over 80 NTU) in the lake. Although the treatment plants were able to treat the water, the additional sludge production overwhelmed the solids handling equipment and the plants had to be shut down for a brief time. This combination of more intense rainfall events and increased wildfire risk is more likely under projected climate change conditions.

The warmer temperatures could lead to increased taste and odor events triggered by algal blooms, which are characterized by water quality changes such as increases in DO and DO saturation, pH, and TON, during the spring and summer. CLWA's two surface water treatment plants are designed to address taste and odor events through preozonation, although use of higher ozone dosages to control taste and odor events must also consider the need to control bromate formation (from the oxidation of bromide), which could increase due to greater bromide levels in the imported SWP water affected by climate change.

Regional Surface Waters

The primary Regional surface water is the Upper Santa Clara River and its tributaries, including Bouquet Creek. The Upper Santa Clara River is largely defined as ephemeral with highly variable flows, depending on precipitation levels. Water quality impacts to rivers due to climate change include increased temperature, more frequent heavy rainfall events, and longer periods of low natural stream flow due to decreased annual precipitation. A prior study of 43 rivers found that surface water temperatures increased 0.4 to 0.6°F for each 1°F rise in air temperature (Morrill, Bales, and Conklin 2005). Increased water temperature generally reduces dissolved oxygen and can promote algal blooms if nutrients are available in the source. The storm events can transport sediments and other pollutants along the river, while long periods of low flow can increase concentrations of pollutants from wastewater plant and non-point discharges. Increased wildfires may contribute to the turbidity events.

Key water quality considerations are nitrogen concentrations and chlorides in stretches of the river, both of which may be impacted by climate change. Nitrogen concentrations can be influenced by low stream flows and increased temperatures that may promote eutrophication.

Regional Groundwater

Any water quality impacts to groundwater sources due to climate change are expected to be indirect, primarily due to decreased recharge from lower precipitation and increased use of groundwater to make up loss of SWP imported water. Decreased recharge and increased groundwater pumping may allow concentrations of groundwater contaminants such as perchlorate and volatile organic compounds to increase, which may trigger additional treatment requirements and increase groundwater treatment costs.

5.1.2.3.4 Flooding

Flooding is the most costly and destructive natural disaster; thus, a change in flood risk is a potential significant effect of climate change that could have great implications for the Region.

Figure 5.1-10 present the 100-year and 500-year floodplains within the Upper Santa Clara River Watershed, showing areas that would be most vulnerable to flooding, based on data available from FEMA. It should be noted that FEMA does not provide 200-year floodplain maps . In general, the floodplains are primarily located along the Santa Clara River and its major tributaries and correspond to surface water bodies such as Castaic Lake and Bouquet Reservoir. In general, land use within the floodplains typically includes residential, commercial, industrial, and agricultural areas.

While the Cal-Adapt climate change model projects precipitation decrease of 10 percent by 2050 on the long-term basis, research data suggest that there is a risk of increased flooding in California (Kiparsky and Gleick 2005). Flooding depends not only on average precipitation but on the timing and intensity of precipitation. For the purpose of the assessment of future flooding from climate change, Cal-Adapt model results for runoff were used to make a general assessment for the likelihood of future flooding events in the Region. Cal-Adapt provides projections of monthly and annual runoff for the Santa Clarita region for the period 1950 to 2099, based on the four different models. Monthly runoff from the four climate change models were averaged to provide an estimate for the Region. Historical monthly averages were compared with future projections to provide an indication of future changes in runoff due to climate change.

Figure 5.1-11 shows results of the annual runoff for the historical period (1950 to 2000 base period) and projections (2000 through 2099), based on the average of results from the four different climate models under A2 emissions scenario. Overall, future runoff projections are slightly higher than historical trends. On the long-term average, monthly runoff is slightly higher for the future projections (0.26 inches/month from 2000 through 2050) than the historical period (0.24 inches/month for 1950-2000). Similarly, the maximum monthly runoff is also higher for future projections (7.32 inches//month) than historical data (4.62 inches/month). Future projections generally suggest the possibility of increased amount and intensity of runoff than historically observed, in addition to more variable runoff with climate change.

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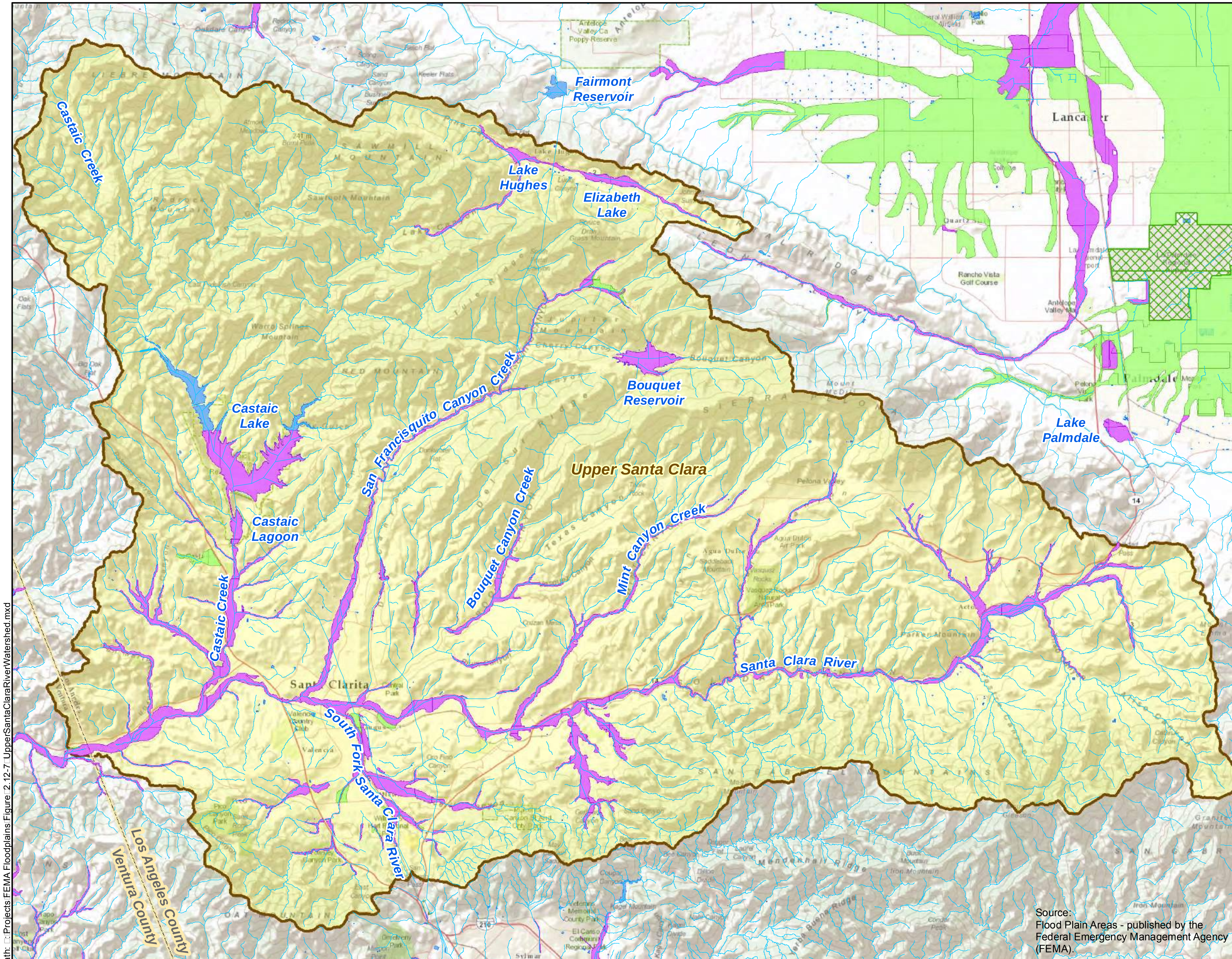


Legend

- 500-Year Flooding (Zone x500)
- 100-Year Flooding (Zone A)
- An area that is located within a community or county that is not mapped on any published FIRM.
- Upper Santa Clara Sub-Watershed
- Streams
- Water Body

Source:
Flood Plain Areas - published by the Federal Emergency Management Agency (FEMA).

Kennedy/Jenks Consultants

CLWA IRWMP Grant Application
Los Angeles County, California

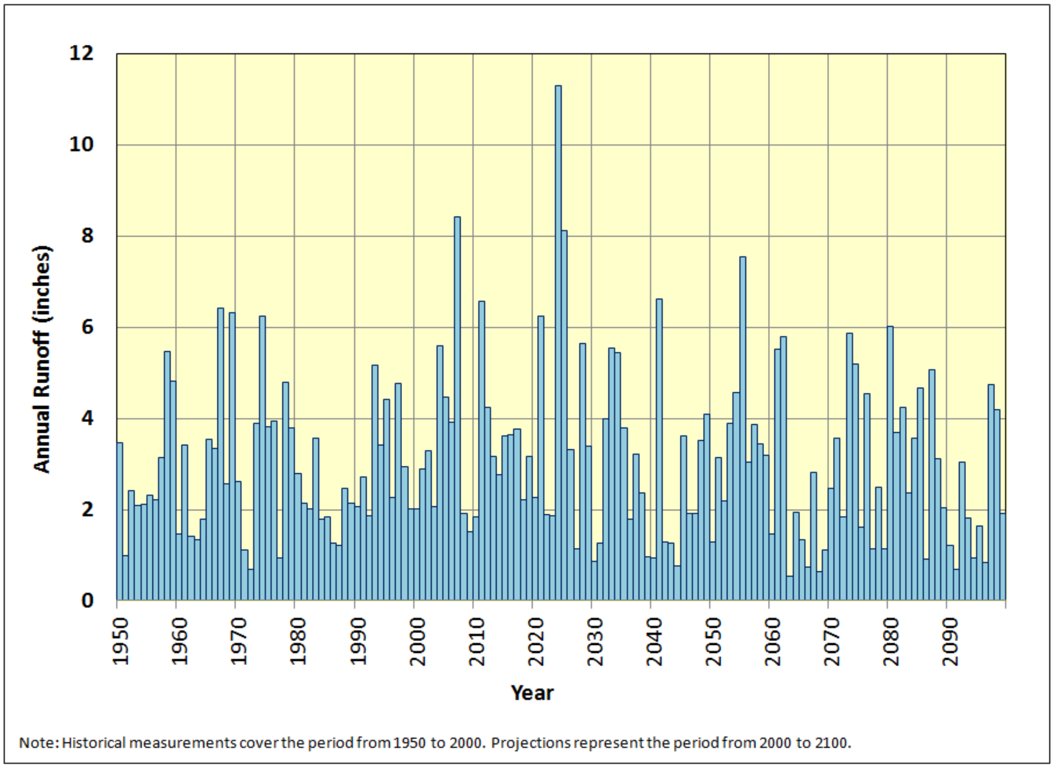
Upper Santa Clara River Sub-Watershed Flood Plain Areas

1189057□00
February 2012

Figure 5.1-10

Path: □:\Projects\FEMA Floodplains\Figure 2.12-7_UpperSantaClaraRiverWatershed.mxd

FIGURE 5.1-11
HISTORICAL AND PROJECTED RUNOFF FOR SANTA CLARITA REGION



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

These projections are intended to provide general trends for future projections and are considered reasonable when compared to historical trends over a long-period of time. However, these are runoff estimates over large areas and considered relatively straightforward evaluations of changes in large scale precipitation patterns. The climate change model results may not capture the timing and intensity of runoff and the model resolution is insufficient to account for small-scale watershed characteristics that play a significant role in flooding events.

Historical runoff data used in the climate change models were analyzed for the periods of historical flooding events in the Region to demonstrate if Cal-Adapt model results are able to capture the site specific trends that occurred historically. As presented earlier (Section 4.1), major floods in the Region occurred during the winters of 1969 (January and February) and 1983 (in February and March). Historical runoff data from Cal-Adapt model are 0.68 inches/month for January 1969 and 3.7 inches/month for February 1969, which are considerably higher than the long-term monthly average runoff of 0.24 inches/month. For the 1983 flood event, runoff of 1.8 inches/month for February and 0.76 inches/month for March predicted by Cal-Adapt are also much greater than the historical long-term averages. While the comparison was done for only limited flood occurrences, Cal-Adapt seems to generally respond to site conditions with anticipated runoff. Therefore, results from Cal-Adapt could be used as a general guidance for potential occurrence of future floods in the Region.

In some ways, risk of flood from climate change could be more problematic than for water supply. Water supply issues usually arise over a period of months to years, allowing time to respond to changes. In contrast, while large floods are relatively rare, they are swift and devastating if preparations are insufficient. There is no window to prepare for a flood once the flood waters arrive; floods must be addressed through advanced preparation and quick response in the course of an event. Various major flood events have occurred within the Region in the past, as described in Section 4.3, resulting in damages to bridges, roads, homes, waterlines and other infrastructure. Increased floods with climate change may increase the risk of, and potentially exacerbate, these types of flood-related damages. Greater flood risk should be considered when evaluating new development in the 500-year floodplain.

5.1.2.3.5 Ecological Health and Habitat

Ecosystem health and habitat protection are important to the Region. Increased temperature, changes in precipitation patterns, and increased wildfire risk projected for potential climate change scenarios are potential stressors to ecosystems and habitat in the Region.

Principal features in the Region include the Upper Santa Clara River and several canyons that provide complex topography that support diverse ecosystems and habitat (see Section 2.4 for a detailed description of ecological processes and environmental resources in the Region). These include at least 26 special status plant species, 45 special status wildlife species, several significant habitats (native grasslands, forests, fresh water marshes, vernal ponds, wetland habitat, and wildlife corridors), and five significant ecological areas (Cruzan Mesa Vernal Ponds SEA, Santa Clara River SEA, Santa Felicia SEA, Santa Susanna Mountains/Simi Hills SEA, and Valley Oak Savannah SEA). All of these species and habitats have acclimated to the historical climate and water resources and may or may not to adapt to potential changes due to future climate change.

Increased air temperature will increase water temperature in rivers, tributary streams, ponds, and lakes, with resulting decreases in DO. This combination may stress fish and biota that depend on higher DO levels and colder water which may impact their sustainability. The increased annual average air temperatures may also alter plant habitat by changing the length and timing of the growing season and/or allowing non-native species to outcompete native species and disrupt ecosystems that depend on the present habitats. Thus, measures to control non-native species may be needed to maintain habitats. Water available for plant habitat could be impacted by potential decreases in annual precipitation and increases in ET due to projected increases in temperature. Decreased precipitation could also directly affect formation of vernal ponds.

Climate change may also affect water-dependent recreation primarily through water quality impacts on recreational lakes in the Region, as described in Section 5.1.2.3.3 Water Quality. Effects may include potential health concerns and aesthetic issues limiting use of these resources.

Fire is an important process in maintaining a diverse ecosystem in the Region. Projected increases in wildfire risk due to climate change are not well understood, but it appears that summer dryness could begin earlier and fires could burn longer and affect more land area. It is unclear at this time whether projected increased fire risk will be beneficial or harmful to long term ecosystem health and habitat maintenance, but will likely negatively impact water quality as discussed in Section 5.1.2.3.3.

5.1.2.4 Vulnerability Prioritization

This section discusses a list of prioritized vulnerabilities based on the vulnerability assessment presented in the earlier subsections and stakeholder input on the importance of these sectors to the Region. The watershed vulnerability assessment (Section 2.12.2.3) identifies the water resources characteristics for each sector most vulnerable to potential climate change projections. The Region can use the assessment results to prioritize the sectors with vulnerabilities and develop adaptive strategies to respond to potential climate change impacts. Based on the inputs from the stakeholders in the Region, the sector vulnerability prioritization is defined as follows (1 being the sector most prioritized and 4 being the sector least prioritized with respect to climate change vulnerability):

5. Water Supply; Water Quality

6. Water Demand; Flooding

7. Ecosystem and Habitat

8. Sea Level Rise; Hydropower

Table 5.1-4 summarizes the climate change vulnerability based on the results of the vulnerability assessment.

With respect to climate change effects, the vulnerability prioritization is intended to identify if existing sectors can handle the impacts that would occur under future climate change, and to evaluate alternative water management options and projects. This also assists IRWMP's decision making process as part of proposed measures for adapting to climate change (see Section 5.1.3).

The vulnerability assessment and prioritization was conducted based on data currently available and inputs from the stakeholders involved in the preparation of this study for the Region. This assessment can be improved in the future with further data gathering and analyzing of the prioritized vulnerabilities.

5.1.3 Adaptation to Climate Change

Adaptation to climate change involves adjustments in natural and human systems that occur in response to projected impacts of climate change. The goal of adaptation is to minimize risks associated with anticipated impacts and take advantage of beneficial opportunities that may arise from climate change. Adaptation strategies are developed in conjunction with GHG mitigation strategies, which may overlap. For example, promoting water and energy efficiency are both GHG mitigation and climate change adaptation strategies. Adaptation strategies discussed in this section provide the Region with guidance related to projects that will enhance the Region's preparedness to plan and react to these potential impacts.

TABLE 5.1-4
CLIMATE CHANGE VULNERABILITY ASSESSMENT

Watershed Characteristics	General Overview of Vulnerabilities
Water Supply	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with a slightly drier climate by mid-century. The overall impact on SWP imported water and groundwater supplies would be significant and can affect the long-term planning. **Sector Response in Context of Regional Planning** **SWP Imported Water** - SWP supply to the Region is projected to be impacted by climate change on a long-term basis, based on DWR's latest analysis of SWP delivery reliability with climate change effects. Based on the future conditions with 2050 climate change, the long-term average SWP system-wide deliveries are projected to be reduced by 5%, from 62% of Table A amount without climate change to 57% of Table A amount with climate change. Assuming the Region's SWP supply would be proportional to SWP's system-wide supply reliability, this represents a reduction of 4,900 AF□, of CLWA's SWP Table A amount. While this appears to be a small impact and comprises a small portion of future water supply in the Region, it should be viewed in light of the cumulative effects of climate change on other water resources, such as the local groundwater availability. **Groundwater** – Natural recharge to the local groundwater aquifers is likely to be affected by projected changes in precipitation pattern and amount (a long-term reduction of about 10% by 2050), increased evaporative losses, and warmer and shorter winter seasons. The overall impact on groundwater resources could be significant. Reduced natural recharge would affect the amount of groundwater available in the long-term. Reductions in the SWP imported water imposed by climate change would lead to more reliance on local groundwater. However, with potential reductions in natural recharge, groundwater may only make up a portion of reduced SWP supply. Future planned projects need to meet the water demand to accommodate the effects of climate change on water demand and water supplies. **IRWMP Objective Impacted** – Increase Water Supply **Performance Metric Development** – Performance metrics should be based on SWP delivery and groundwater operation range limitations and quantities of new supply development (reclaimed water, water baking, etc.).

Watershed Characteristics	General Overview of Vulnerabilities
Water Quality	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. **Sector Response in Context of Regional Planning** **SWP Imported Water** – SWP imported water stored in Castaic Lake is potentially vulnerable to water quality changes from climate change, mainly because of the vulnerability of SWP source water in the Delta, resulting from sea level rise and increased salinity of SWP water. Extreme storm events could also result in increased turbidity. Potential changes in the water quality of Castaic Lake could present challenges at the surface water treatment plants in the Region and may require modifications to treatment processes. **Regional Surface Water** – The Upper Santa Clara River and its tributaries are vulnerable to potential water quality impacts due to climate change as a result of increased temperature, more frequent heavy rainfall events, increased wildfire risk, and longer periods of low natural stream flow from decreased annual precipitation. Key water quality constituents of concern are nitrogen and chloride, in addition to reduced DO and increased algae growth, turbidity and sedimentation. **Regional Groundwater** – Groundwater aquifers in the Region are subject to indirect water quality impacts, primarily due to decreased natural recharge under future conditions of decreased precipitation and increased use of groundwater to make up for reduced SWP supply. Increased groundwater pumping may present challenges with the management of perchlorate in groundwater, leading to additional treatment or treatment cost. **IRWMP Objective Impacted** – Improve Water Quality **Performance Metric Development** – Performance metrics should be based on source water quality exceedances (e.g., consecutive days with turbidity exceeding a trigger value, frequency of algal blooms) and frequency of meeting water quality standards (e.g., chloride, nitrogen).

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	**Potential Climate Change Vulnerability** – Projected increase in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand. **Sector Response in Context of Regional Planning** **Urban Water Demand** – Water demand in the Region is affected by weather and shows large seasonal variations, with the largest water use in the summer months and the least in cooler months. Water demand is likely to increase in the Region as a result of projected increase in annual average air temperature due to climate change (about 4°F by 2050). However, water demand increase resulting from this projected temperature increase appears minor relative to other major factors, such as population growth and land use conversion from agriculture to urban. Urban outdoor landscape is expected to be impacted most from climate change, with temperature rise, increased evaporation losses with warmer temperature, and longer growing season. **Agricultural Water Demand –** Climate change is expected to increase agricultural demand, as a result of projected increased annual average temperature, increased evaporation losses with warmer temperature, and longer growing season. The Region's agricultural demand is projected to decrease over time as a result of land use conversion from agriculture to urban. Thus, any climate change effects on agricultural demand are likely to be outweighed by decrease in agricultural activities. **IRWMP Objective Impacted** – Reduce Water Demand **Performance Metric Development** – To be determined. It is unclear that sufficient information is available to develop a performance metric unless a correlation between air temperature and water demand for the Region can be developed (data gap).
Flooding	**Potential Climate Change Vulnerability** – Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms would occur. **Sector Response in Context of Regional Planning** The Region could be potentially subject to more frequent and intense storm events resulting in increased annual runoff and short-term peak flows with climate change. This could present larger areas susceptible to flooding and increase the risk of direct flood damage in the Region. **IRWMP Objective Impacted** – Promote Resource Stewardship. **Performance Metric Development** – Consider excluding placement of critical infrastructure within the 500 year (or 200 year, if defined) floodplain.

Watershed Characteristics	General Overview of Vulnerabilities
Ecosystem and Habitat	**Potential Climate Change Vulnerability** – Climate change projections of increasing annual average temperature suggest potential environmental stressors. **Sector Response in Context of Regional Planning** The Upper Santa Clara River and several canyons in the Region support diverse ecosystems and habitat that may need to adapt to potential changes due to future climate change. Increased air temperature, increased ET, decreased precipitation and resulting water temperature increases, in addition to decreased DO may impact the sustainable habitat of fish and biota. Increased air temperature, increased ET, and decreased precipitation may also change water available to plant habitat, resulting in habitat alteration. Increased risk of wildfire is projected, but the impact is unclear. **IRWMP Objective Impacted** – Promote Resource Stewardship **Performance Metric Development** – Consider use of metrics such as acres of habitat maintained.
Sea Level Rise	**Potential Climate Change Vulnerability** – Studies project the sea level off most of the California Coast to rise by over half a meter by mid-century and by about one meter by the end of the century (NRC 2012). **Sector Response in Context of Regional Planning** The Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect SWP water supply conditions, mainly because of the potential for sea water intrusion to increase Delta salinities (see water quality above). **IRWMP Objectives Impacted** – Improve Water Quality **Performance Metric Development** – No performance metric is recommended because the climate change response will be undertaken by DWR for SWP deliveries.
Hydropower	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. **Sector Response in Context of Regional Planning** Currently, the Region produces only minimal hydropower; thus, climate change effects on hydropower are not likely to be considerable. However, DWR operates hydropower projects as part of the SWP and any decreases in hydropower production would result in higher energy costs to the Region. **IRWMP Objective Potentially Impacted** – Increase Water Supply **Performance Metric Development** – Performance metrics should be based on energy charges from DWR.

5.1.□.1 Statewide Adaptation Strategies for the Water Sector

The California Natural Resources Agency (CNRA), working through the Climate Action Team, is responsible for leading the effort to develop adaptation strategies for California. Strategies were published as a report to the Governor entitled *2009 California Climate Adaptation Strategy* (CNRA 2009) and will be updated approximately every two years. Additional guidance for regional and local strategies is provided in the 2012 California Adaptation Planning Guide (CNRA 2012), which helps communities address climate change consequences in a proactive manner. Specific adaptive water management strategies for the water sector were developed by DWR. The statewide adaptation strategies target fundamental improvements in water management systems and enhancements in ecosystem sustainability.

DWR (2008) developed the following 10 statewide adaptation strategies for the Water Management Sector:

- Strategy 1: Provide sustainable funding for statewide and integrated regional water management
- Strategy 2: Fully develop the potential of integrated regional water management
- Strategy 3: Aggressively increase water use efficiency
- Strategy 4: Practice and promote integrated flood management
- Strategy 5: Enhance and sustain ecosystems
- Strategy 6: Expand water storage and conjunctive management of surface and groundwater resources
- Strategy 7: Fix Delta water supply, quality, and ecosystem conditions
- Strategy 8: Preserve, upgrade and increase monitoring, data analysis and management
- Strategy 9: Plan for, and adapt to, sea-level rise
- Strategy 10: Identify and fund focused climate change impacts and adaptation research and analysis

These statewide strategies provide guidance specifically aimed at addressing the impacts of climate change. Some of DWR’s strategies can be directly applied to Regional management strategies, while others are supportive of Regional efforts that are discussed in the following section.

5.1.□.2 Regional Adaptation Strategies

In this analysis, potential adaptation strategies have been grouped by watershed characteristics (or sector) and priorities developed in the climate change vulnerability analysis. This approach will allow the Regional Management Group and other stakeholders to incorporate climate change adaptation and GHG mitigation measures in projects developed and evaluated as part of the IRWMP process. While the focus of this discussion is adaptation, some of the adaptation strategies will overlap with and enhance GHG mitigation measures.

5.1.3.2.1 Vulnerability Priority 1 (Highest) Sectors: Water Supply and Water Quality

Water supply and water quality were identified as the highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

5.1.3.2.2 Water Supply

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. The overall impact will include reductions in SWP imported water and greater reliance on groundwater supplies with the potential to affect long-term planning.

Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Expand water storage and conjunctive management of surface and groundwater resources.
- Reduce reliance on imported SWP water, which depends on the Sierra snowpack for water supply.
- Enhance use of recycled water for appropriate uses as a drought-proof water supply.
- Enhance practices of water exchanges and water banking outside the Region to supplement water supply.
- Encourage local agencies to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of the IRWM plan.
- Develop plans for local agencies in the Region to monitor the elevation of their groundwater basins.
- Encourage cities and the county agencies in the Region to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

5.1.3.2.3 Water Quality

Climate change projections suggest increased temperature and continued highly variable annual precipitation with slightly drier climate by mid-century that could degrade water quality.

Suggested Regional adaptation strategies to address potential water quality impacts include the following:

- Support DWR strategies that protect or enhance water quality delivered by the SWP.

- Consider coordination with DWR to improve water quality in Castaic Lake through lake aeration practices.
- Consider water quality improvements associated with water transfers and water banking on Regional water supply.
- Consider riparian forest projects that provide cooling for habitat (see Ecosystem Health and Habitat).
- Encourage projects that improve water quality of contaminated groundwater sources.
- Increase implementation of LID techniques to improve stormwater management
- Comply with NPDES permits to ensure water quality protection

5.1.3.2.4 Vulnerability Priority 2 (Second Highest) Sectors: Water Demand and Flooding

Water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

5.1.3.2.5 Water Demand

Climate change projections suggest increases in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand.

Suggested Regional adaptation strategies to address potential increases in water demand include the following:

- Aggressively increase water use efficiency
- Encourage agricultural users to adopt efficient water management practices
- Encourage landscape water users to adopt efficient water management practices, including xeriscaping

5.1.3.2.6 Flooding

Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms will occur.

Suggested Regional adaptation strategies to address potential increases in flood risk include:

- Improve emergency preparedness and response capacity in anticipation of potential increases in extreme events.
- Practice and promote integrated flood management among water and flood management agencies.

- Flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands

- Avoid significant new development in areas that cannot be adequately protected from flooding.

- Encourage land use policies including low impact development (LID) that maintain or restore historical hydrological characteristics.

- Control invasive species, such as arundo donax, within floodplains that could contribute to floods and related damages.

5.1.3.2.7 Vulnerability Level 3 (Third Highest) Sector: Ecosystem and Habitat

Ecosystem Health and Habitat was identified as the third highest priority sector category that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

Climate change projections of increasing annual average temperature suggest potential environmental stressors that may affect the sustainability of existing ecosystems and habitat. Suggested Regional adaptation strategies to address potential Ecosystem Health and Habitat impacts include the following:

- Promote water resources management strategies that restore and enhance ecosystem services.

- Provide or enhance connected “migration corridors” for animals and plants to promote increased biodiversity and allow the plants and animals to move to more suitable habitats to avoid serious impacts and support increased biodiversity.

- Consider projects that provide seasonal aquatic habitat in streams and support corridors of native riparian forests that create shaded riverine and terrestrial habitat.

5.1.3.2.8 Vulnerability Priority 4 (Lowest) Sectors: Sea Level Rise and Hydropower

Sea level rise and hydropower were identified as the lowest priority sectors for the Region.

5.1.3.2.9 Sea Level Rise

Climate change projections suggest sea level rise off most of the California Coast of over half a meter by mid-century and by about one meter by the end of the century (NRC 2012). Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Support DWR strategies that minimize the impact of sea level rise on salinity intrusion into the Delta and impact water quality deliveries in the SWP.

- Support DWR strategies for protecting levees in the Delta from the potential effects of projected sea level rise.

5.1.3.2.10 Hydropower

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century, affecting hydropower generation. Strategies to address potential reductions in hydropower generated by the SWP include the following:

- Support DWR strategies to maximize hydropower in SWP facilities that reduce energy charges to the Region.

5.1.4 Next Steps for Future IRWMP Updates

5.1.4.1 Data Improvement

The climate change assessment conducted in this Plan update is qualitative in some areas due to limited data, high level of uncertainty, and, in some cases, because impacts to a given sector are not expected to be severe. The intent of future data gathering is to address gaps in the current vulnerability assessment, to improve the understanding of climate change impacts and vulnerabilities, and to enable a more quantitative analyses. Recommended future data gathering efforts will include data that facilitate more quantitative analysis of the vulnerability, as described in the following sections. Data gathering efforts will be considered in the context of the current and proposed projects and funding available.

This section describes potential areas of future data gathering efforts for the priority sectors identified earlier. The recommendations focus on the top four priority sectors; namely, water supply, water quality, water demand, and flooding. The lower priority sectors include ecosystem health and habitat, sea level rise, and hydropower, which require a lesser degree of data collection. Climate change vulnerability of ecosystem health and habitat is difficult to quantify, and reliance on generalized studies will likely satisfy the Region’s needs. As previously noted, sea level rise and hydropower vulnerabilities are not directly applicable to, or not applicable to a considerable extent within, the Region. Rather, they are indirectly important to the imported SWP water supply that is the responsibility of DWR. Thus, the Region should prioritize data gathering efforts for the sectors most vulnerable to climate change impacts.

5.1.4.1.1 Climate Change Models and Scenarios

Cal-Adapt modeling results for the Santa Clarita Region were used for projections of temperature, ET, precipitation, and runoff for the Region. The California Energy Commission maintains the Cal-Adapt site and will update the modeling tools as new climate change modeling results, based on more refined data, become available from the ICCC. Thus, to the extent feasible, the available climate change tools and projections for the Region will be reviewed periodically and the vulnerability assessment updated in future versions of the Plan.

5.1.4.1.2 Updates on Climate Change Research

Research on the climate change impacts on water resources is ongoing and continues to evolve with further analysis and more refined methodologies. During the preparation of this Plan update, key literature resources on climate change have been reviewed. New scientific findings will be reviewed periodically and incorporated into the climate change vulnerability assessment, especially the findings pertinent to the sectors most vulnerable to the climate change in the Region.

5.1.4.1.3 Vulnerability Assessment Update

As noted above, a goal of further data collection is to enable a more quantitative analysis of the high priority watershed sectors that are more vulnerable to climate change in future Plan updates. Water supply and water quality were identified as the highest priority sectors and water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change.

Water Supply

In this Plan update, the assessment of the vulnerability of water supply to potential climate change impacts is presented for the SWP imported water delivery to CLWA and groundwater pumping. As discussed earlier, climate change impacts on the SWP imported water supply were based on the future projections of SWP deliveries from DWR's modeling analysis reported in the *2011 Reliability Report* (DWR 2012). The assessment of groundwater supply vulnerability is based on existing and planned pumping and the current capacity of the water banking programs to respond to reductions in imported SWP water deliveries. Future assessment of water supply climate change vulnerability will incorporate the most up-to-date data available from DWR and the most current groundwater supply availability.

Suggestions for future data gathering efforts to quantify the climate change effects on water supply include the following:

- Update DWR SWP Delivery Reliability Report projections - DWR provides updated analysis and report every two years.

- Update available groundwater supply projections – Groundwater production in a given year varies depending on hydrologic conditions. Changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage and may affect current safe operating ranges. Updates on the groundwater safe operating ranges will be needed when further assessments of water supply vulnerability to climate change are performed for future Plan updates.

- Evaluate the effects of reduction in precipitation from climate change on the groundwater operational ranges - A simplifying assumption was used for a 10 percent reduction in the operational range in response to the 10 percent reduction in precipitation. Further analysis is suggested to refine this assumption and quantify the potential reduction in groundwater supply due to reduction in precipitation from climate change.

Water Quality

The assessment of the vulnerability of water quality to potential climate change impacts is qualitative due to the limited Regional monthly and seasonal weather information related to air temperature and precipitation over long time periods and limited access to long-term water quality data. The vulnerability assessment instead relied on Cal-Adapt model outputs for annual air temperature increases and precipitation changes and prior studies of how water quality in the

Region may be affected by these climate change impacts. Key water quality changes identified for the Region include potential increases in taste and odor events due to increased likelihood of algal blooms and short-term high turbidity events due to storms, especially following wildfires. Collection of historical water quality data within the Region (e.g., Castaic Lake and other locations) would greatly improve the understanding of Regional water quality and how it may be impacted by climate change. For imported SWP water, the vulnerability analysis relied on DWR projections of water quality impacts in the Delta due to sea level rise and increases in salinity. Future analyses will incorporate updated DWR studies on the potential impacts of climate change on SWP quality.

Suggestions for future data gathering efforts to quantify the climate change effects on water quality include:

- Monitor future and collect historical water quality data within the Region during storm events.
- Develop a long-term water quality record for Castaic Lake that would assist in improving the understanding of Regional water quality.
- Collect long-term weather records associated with air temperature, precipitation, and ET to assess potential correlations with seasonal water quality.
- Develop, to the extent possible, a long term surface/ground/aerial deposition model that can be continuously updated and refined with newly available data. Model should be ready accessible to stakeholders and in an user-friendly format to allow better understanding of trends over time.

<u>Water Demand</u>

The assessment of the effect of climate change on water demand is based on the Cal-Adapt projections for ET and temperature. Cal-Adapt projections suggest water demand in the Region is likely to increase as a result of higher temperature with the greatest temperature increase anticipated during dry months compared to wet months. The ten percent increase of water demand per capita has been assumed to account for dry years in the *2010 Santa Clarita Valley UWMP*, but historical records of annual water demand data currently available are not specific enough to quantify the effects from increasing temperature. As discussed earlier in the vulnerability assessment (Section 5.1.2), the most important effect of changing weather conditions is likely to be on agricultural demand, but the overall effects on agricultural water demand is uncertain.

Suggestions for future data gathering efforts to quantify the climate change effects on municipal and agricultural water demand include the following:

- Collect and analyze historical monthly records of water demand data for the Region to quantify the weather effects on water use and seasonal variations in response to changes in historical temperature.

- Collect and analyze historical monthly records of water demand data for each purveyor in the Region to demonstrate purveyor-specific patterns in response to changes in climate.

- Based on the water demand and temperature data, develop a regression analysis correlating water demand to temperature on a monthly or seasonal basis for the Region and each purveyor. The historical response can be used to infer future response with the projected changes in temperature with climate change.

- Characterize the variations in indoor and outdoor water use, both for the Region and each purveyor. Future data gathering should focus on the seasonal and monthly patterns both in indoor and outdoor usage to evaluate the effects of weather conditions on each use category.

- Collect and analyze historical agricultural water demand to quantity the weather effects on water use and seasonal variations in response to changes in historical temperature.

- Identify the major industries in the Region that require cooling and/or process water. As water temperature increases, cooling water needs may also increase.

Flooding

A quantitative assessment of the potential impacts of climate change on flooding cannot be performed as climate projections are not sensitive enough to project short-term extreme events such as flooding. Rather, the 100-year and 500-year floodplains were used to define flooding risk zones that should be considered in location of water infrastructure. The Cal-Adapt model runoff outputs appear to represent the historical runoff record available. In examining the historical runoff record, there are data gaps as recording stations have started and stopped operation.

Suggestions for future data gathering efforts to address the potential climate change effects on flooding include the following:

- Perform an inventory of runoff monitoring stations in the Region to see if a more robust runoff record can be developed. Those data may allow an analysis of historical storm events correlated with precipitation events as well as annual precipitation to provide a better understanding of conditions that may lead to more extreme flooding conditions.

As recommended by DWR's Climate Change Handbook for Regional Water Planning, future work should focus on gathering the 200-year floodplain maps for the Region after DWR develops them under the authorization of Senate Bill 5 (SB 5) enacted in 2007. Currently, the 100-year and 500-year floodplain maps are available from FEMA. Additional information on the DWR's Best Available Maps (BAM) program can be found at the following website: http://gis.bam.water.ca.gov/bam/.

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- Coordinate with the Region stakeholders for advanced flood preparation and quick response and document the protocol(s).

- Perform an inventory of critical infrastructure located in floodplains, especially those that were impacted during the historical flood events in 1969 and 1983.

- Update the projections of runoff with climate change as updates from Cal-Adapt become available.

- Work with local flood plain managers and/or equivalent to determine areas of concern as information from FEMA evolves.

5.1.4.2 Future Actions – Create a GHG Baseline

To be accurate in the estimation of each agency's GHG emissions; an agency-specific comprehensive GHG inventory should be developed. The City of Santa Clarita Climate Action Plan recently completed this baseline for their general plan items, which could serve as a reference. A comprehensive inventory would use a well established protocol to calculate all of the GHG emissions created by each agency. It is recommended that each agency eventually conduct a GHG inventory, but in the absence of agency specific GHG inventories, gross GHG emissions can be calculated by developing agency-specific GHG intensity factors. An agency-specific GHG intensity factor calculates the estimated metric tons of CO_2 per acre foot of water delivered or million gallons of wastewater treated by the agency (MT CO_2/AF). Knowing this will enable an estimation of the GHG emission baseline for a particular agency and the Region. It will also allow for the estimation of the GHG emission reductions associated with an individual project or strategy that reduces water demand.

For each of the RWMG water or wastewater entities data will need to be collected for actual annual electricity, natural and fleet fuel used, as well as the amount of imported water from DWR and other suppliers. Using known GHG intensity factors for DWR water supplies, electrical supplies, natural gas and fleet fuel and applying these factors to the amount an agency uses, GHG emissions (MT CO_2/year) can be estimated for each agency. By dividing the total emissions by the total AF of water delivered or the million gallons of wastewater treated, agency-specific GHG intensity factors (MT CO_2/AF) can be developed. The calculation should use data from the same year. While not as precise and accurate as a comprehensive GHG inventory, a GHG intensity factor will create an estimated baseline of GHG emissions for each agency and the Region.

5.1.4.□ Future Actions – Quantify Adaption and Mitigation Strategies at the Project Level

As part of this Plan update, the climate change impacts of specific projects proposed for implementation are being considered (see Section 8). Future Plan updates may have the data available to further quantify climate change adaptation and mitigation strategies and apply them at the project level. For each proposed project it may be desirable to identify GHG emissions and to identify and evaluate GHG mitigation. Proposed projects could be evaluated against the GHG Baseline and evaluated for their ability to reduce agency-specific GHG intensity factors.

5.1.4.4 Future Actions – Develop Performance Metrics

As part of future Plan updates the Region may choose to develop performance metrics specific to water and wastewater projects and climate change. Proposed IRWMP projects would be evaluated against these metrics and these metrics would provide a measure of Plan performance. Table 5.1-4, shown above, provides a starting point for the development of performance metrics.

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Appendix J: Population and Demand Forecasts

Updated Final Technical Memorandum #2

SCV Demand Study Update: Land-Use Based Demand Forecast Analysis

To: Dirk Marks, Castaic Lake Water Agency

From: Lisa Maddaus, P.E., Maddaus Water Management (MWM), Inc.

Date: March 4, 2016

Reviewed by: Bill Maddaus, P.E., MWM and Anil Bamezai, WPR

1. INTRODUCTION

The purpose of the Demand Study Project (Project) is to update the projected demands for the four water retailer agencies (Retailers) in the Santa Clarita Valley (SCV) served by Castaic Lake Water Agency (CLWA). This technical memorandum presents the land use based demand forecasts prepared using a "bottom-up" approach based on Retailer provided information. The technical memorandum is updated from an earlier version issued in June 2015. This updated memorandum was necessary due to the revised information provided by Valencia Water Company (VWC) associated with revised development plans for Newhall Ranch, which altered their future demand forecast. This memorandum also incorporates the plumbing code updates due to a recent revision in September 2015, effective December 1, 2015, for the Title 20 Appliance Efficiency Standards adopted by the California Energy Commission. This technical memorandum now serves as the final land use based demand forecasts for each Retailer. It contains the best information currently available to support the Retailers and CLWA development of the Urban Water Management Plan in compliance with the 2015 Urban Water Management Plan Act to be completed and submitted to the Department of Water Resources by July 1, 2016.

The future growth accounted for in these forecasts is being confined to only existing service areas and annexations anticipated by the Retailers. There is some development in the OVOV Plan that is left outside of these areas that CLWA and the Retailers do not anticipate serving water. Overall, there can be seen a lower demand population projection associated with these land use based forecasts than historical estimated future buildout demand in in the 2010 UWMP.

In June 2015 the CLWA and the Retailers adopted the Water Use Efficiency Strategic Plan. For planning purposes a population based econometric model was selected (Phase I) as the more conservative strategy, given it has a lower population for 2020, meaning the per capita use is higher than it is under the projections provided herein. The forecasts in this memorandum are based on the planned land use development and deemed to be more accurate from 2021-2050 for the purposes of estimating buildout water demands.

The new buildout estimated total population is now approximately 421,500, using undeveloped parcels in the existing service CLWA service area such as the West Side Communities, and proposed annexations such as Tapia Canyon, and Tesoro Del Valle. This also includes potential future annexations to the NCWD service area that are already within the CLWA service area. Similarly, the West Side Communities are located within the CLWA service area and are assumed to be annexed into the VWC service area. The nine West Side Communities consist of the five villages comprising Newhall Ranch (Landmark Village, Mission Village, Homestead Village South, Homestead Village North, and Potrero Village), three other future communities (Legacy Village, Entrada Village South, and Entrada Village North), and buildout of an ongoing development (Valencia Commerce Center).[1]

2. PURPOSE

The purpose of this Technical Memorandum #2 (TM-2) is to document and present the demand projections for the Santa Clarita Valley. TM-2 describes:

(1) Demand projection methodologies;
(2) Data inputs used in the analysis;
(3) Demand analysis results including updated CLWA retailer agency demand projections through buildout (2050); and
(4) Demand analysis results including recommended active conservation program implementation through buildout. Active conservation program measure design is presented as Program B in the 2015 SCV Water Use Efficiency Strategic Plan (WUE SP).

3. SUMMARY OF APPROACH

The project supported the development of demand forecasts that rely on econometric models to 2020, then extended forecast from 2021 to 2050 (assumed buildout) based on Retailer and/or CLWA supplied information. The land use based demand forecast was only conducted for three of the four Retailers: Newhall County Water District (NCWD), Santa Clarita Water Division (SCWD), and Valencia Water Company (VWC), given that Los Angeles County Water District 36 did not have sufficient information and is based on a population based demand forecast. A summary of the approach employed for each Retailer is provided below followed by more detailed description of methodology and findings.

For Newhall County Water District and Santa Clarita Water Division, the overall basis for this analysis was to build future demand forecasts using a “bottom-up” approach for land use based anticipated land development, which involved the following information:

[1] GSI Water Solutions, Inc. Technical Memorandum “Updated Water Demand Projections for West Side Communities (Valencia, California),” To: Corey Harpole and Steve Zimmer, Newhall Land and Farming Company; Ken Peterson and Matt Dickens, Valencia Water Company; and Dirk Marks, Castaic Lake Water Agency; Prepared by John Porcello and Cindy Ryals, March 4, 2016.

- Estimated dwelling units proposed were provided by City of Santa Clarita and Los Angeles County data informed by general plans, specific plans, and past and remaining growth anticipated through GIS analysis
- Land use base GIS map shape files provided by the City of Santa Clarita and Los Angeles County planners for:
  - Base case (2004) used in the OVOV Study
  - 2012 recent update for transportation modeling
  - Buildout (2050) used in the OVOV Study
- Retailer provided GIS maps of service area boundaries overlaid on land use maps from the City and County
- Queries from GIS maps to determine dwelling units were multiplied by persons per household from the US Census appropriate to each Retailer's service area (that were previously present during the Population Assessment project analysis completed in June 2014)
- Billing data by customer category (single-family, multi-family, non-residential) previously provided for Water Use Efficiency Strategic Plan:
  - Base case (2004) for a water balance with setting demand factors
  - 2012 demands
- Climate and economic adjustment factors for normalizing demands in 2004 and 2012
- Future demand factors:
  - 2020 for planning for SB X7-7 (and period for economic recovery)
  - Buildout (OVOV Study)

For Valencia Water Company, the future demand hinges on the development of the nine adjoining communities that collectively comprise the West Side Communities in the Santa Clarita Valley in the VWC service area. The nine communities are five villages comprising the master planned Newhall Ranch (Landmark Village, Mission Village, Homestead Village South, Homestead Village North, and Potrero Village), three other future communities (Legacy Village, Entrada Village South, and Entrada Village North), and buildout of an ongoing development (Valencia Commerce Center). The growth projection was based on VWC providing a Technical Memorandum prepared by GSI Water Solutions, Inc. (GSI) on March 4, 2016 (GSI, 2016). This technical memorandum provided the basis for the following:

- Dwelling unit counts by type of residential development
- People per household estimates based on recent documentation of occupancy rates in more recent home developments
- Non-residential acreage
- Dedicated irrigation acreage, predominately served by recycled water
- Demand factors for all new types of land use categories

The VWC, and CLWA directed MWM's work effort and carefully reviewed the basis for the land use based demand forecast presented in this memorandum.

Los Angeles County Water District 36 did not have detailed enough information (such as specific billing data by lot type) to derive demand factors. However, future demands in the LACWD 36 service area have been included in the overall total valley-wide demand forecast using the information presented in the Water Use Efficiency Strategic Plan (WUE SP) adopted in June 2015 by the CLWA.

The overall history of Project's collaborative approach includes the following phases:

- **Phase 1:** Demand Forecast Meeting was held on September 3, 2014. Retailer management, conservation and planning staff attended to facilitate Retailer understanding of and involvement in the development of the forecasting methodology and analysis. Following the September 2014 meeting, all four Retailers confirmed their conditional acceptance of the Phase 1 Modified Demand Forecasts for planning purposes for the WUE SP project. Retailers had an opportunity to review the demand modeling preliminary results and to ask questions and offer comments to CLWA by September 15th. General acceptance of the preliminary forecasts for planning purposes was necessary to create the versions of WUE SP DSS Models that allowed for a demand forecast to populate the conservation analysis section of the DSS Models and make further progress with conservation measures analysis.

- **Phase 2:** A follow-up meeting on Phase 2 Demand Forecast was held on March 5, 2015. CLWA and the MWM team worked to address comments through April in order to release an updated TM on June 9, 2015. In February 2016, VWC, with more accurate and newly available development information for their service area, partnered with MWM and restructured their projected demands based on West Side Communities development information developed by GSI. As part of this effort, recently adopted state plumbing codes were also incorporated into the analysis for all four Retailers. CLWA and the MWM team worked to incorporate the newly available development information and plumbing codes in order to release this updated TM. Retailers confirmed their acceptance of the Phase 2 Demand Forecasts for planning purposes for the 2015 UWMP.

4. DEMAND METHODOLOGY OVERVIEW

The demand projection for each Retailer combines the results of two different analytic models – the Econometric Model and the Least Cost Planning Decision Support System Model (DSS Model). The purpose of using these two models is to leverage the strengths of each to obtain the best forecast through the year 2050. This approach, described in this section, was reviewed with the Retailers at a meeting on June 19, 2014 and conducted in two phases that are described in the prior technical memorandum issued in June 9, 2015. The revised findings reviewed and approved by the Retailers is presented in this technical memorandum.

This project effort takes results from refined econometric models developed for CLWA's Retailers in the WUE SP to project demand out to 2020, transitioning to a land use based approach (in lieu of a population and employment-based approach) because such an approach can further improve upon assumptions about how future water usage patterns might be significantly different than they were in the past as the Santa Clarita Valley moves toward build-out.

The Econometric Model estimates the impact of economic conditions on water demand. The model can then be used to project, based upon historical patterns, the future rebound in demand associated with economic recovery, while taking into account other factors such as rate increases and weather. Since the Econometric Models are calibrated using historical data, their reliability depends on the historical relationship between water demand and its influencing factors remaining unchanged between the calibration and forecasting periods. Further into the future, changes in demographics, living patterns, housing stock and industrial structure can alter these historical relationships, which is why we do not use the Econometric Model for forecasting demand past 2020.

The DSS Model incorporates historical data provided by each Retailer to set up a water balance on a monthly time-step. Then the DSS Model can be used to forecast future demand (or to incorporate a previously developed forecast) as the basis for analyzing conservation measures aimed at achieving water savings to meet future gallons per capita per day (GPCD) targets. The DSS Model can accommodate data and assumptions reflecting how future service area and water use characteristics may differ from the past in each Retailer service area. To accommodate all of these considerations, Econometric Models are used to forecast baseline demand through 2020, and the DSS Model from 2021 through 2050.

The DSS Model also has a conservation component that quantifies savings from plumbing codes and from a user-selected menu of active conservation programs. This memorandum only includes the DSS Model's estimates of savings from plumbing codes so that each Retailer can evaluate its future water demand if it does not undertake any active conservation programs between now and the year 2050. Quantification of savings from active conservation programs use the same measures as presented in Program B list in the Water Use Efficiency Strategic Plan (WUE SP). However, the savings estimates are updated with the revision to the DSS Models associated with the plumbing code changes for all Retailers.

The demand analysis for each Retailer has three distinct parts (Figure 1):

(1) Historical View – Analysis of historical data between 1995 and 2013 (or a shorter window if a Retailer was unable to provide complete data going back to 1995). The purpose of this analysis is to identify the impacts of factors such as water rates, economic conditions and weather on water demands. Data analyzed include historical system production, water rates, weather (rainfall and reference ETo), population, unemployment rate, and other data as approved and verified by each Retailer. The source data of production and water rates that were provided by the Retailers were compiled into a single MS Excel workbook for each individual Retailer and verified by the Retailer staff prior to the modeling effort.

As part of Phase 2, a historical land use assessment was conducted using land use data by Traffic Analysis Zones (TAZ) for years 2004 and 2012. The land use assessment was conducted by evaluating the land use types in each TAZ to determine what portion of the land use residing in that TAZ was located in each Retailer's service area. Furthermore, the 2014 CLWA Population Assessment provided 2010 Census-based estimates for residential dwelling units land use types. The Phase 2 analysis based on available information previously provided by, or confirmed by, each Retailer includes historical billing data or water use by large customers. Using historical billing data supported some limited validation of demand factors applied to future development by land use type. More information about this approach used for SWCD and NCWD as well as the source of land use data by TAZ and water demand factors can be found in Appendix D. More information about the approach used for the VWC can be found in Appendix E.

(2) Short-Term Future – Forecast of demands between 2014 through 2020 assuming normal weather, incorporating economic recovery predictions as well as water rate forecasts and population growth. Normal weather is defined as average reference ETo and rainfall between 1995 and 2006, corresponding roughly to the baseline that water utilities will choose for testing compliance with SB X7-7. The analysis incorporates the federal government's projection[2] that the US economy will return to its long-term growth path by 2020, reaching a national unemployment rate of 5.2%, or roughly the average of the US unemployment rate

[2] Congressional Budget Office: *Testimony - The Budget and Economic Outlook: Fiscal Years 2013 to 2023*
Douglas W. Elmendorf, Director Before the Committee on the Budget, United States Senate, February 12, 2013.
Bay Area Council Economic Institute, *Recession and Recovery: An Economic Reset*, April 2010.

between 1993 and 2000. The unemployment rate may differ across utilities at any given point in time. However, movements in this metric for any given utility over time parallels movement in the national unemployment rate quite well. To demonstrate this point, we have included Figure 2 comparing the unemployment rate over time in progressively higher jurisdictions starting with the City of Santa Clarita to the United States as a whole. Unemployment rates over time specific to each Retailer's service area are not available. Model testing suggested that the unemployment rate for Los Angeles County fit CLWA's water demand patterns marginally better than the unemployment rate for the City of Santa Clarita. This is not entirely surprising because economic conditions in CLWA's service area are substantially influenced by economic conditions in the broader region. Therefore, we are using Los Angeles County's unemployment rate for forecasting demand out to 2020. Water rates have been assumed to increase by 1.5% per year in real terms between 2013 and 2020. Population projections were developed as a separate component of this overall project, being anchored in the Census for the years 2000 and 2010, and the OVOV population forecast for 2050.

(3) Long-Term Future – Long-term water demand (2021-2050) was forecasted using the DSS Model, which estimates increases in each Retailer's demand by category. The land use based forecasting approach using build-out estimates for year 2050 from the One Vision One Valley Valley-Wide Traffic Study (OVOV) was substituted for this simple population and employment-based approach. For development in VWC's water service area, the most recently available land use development, demand factors, and projected demand data was provided by GSI Water Solutions for nine communities adjoining the VWC service area that collectively comprise the West Side Communities (GSI, 2016).

Figure 1. Demand Forecasting Methodology

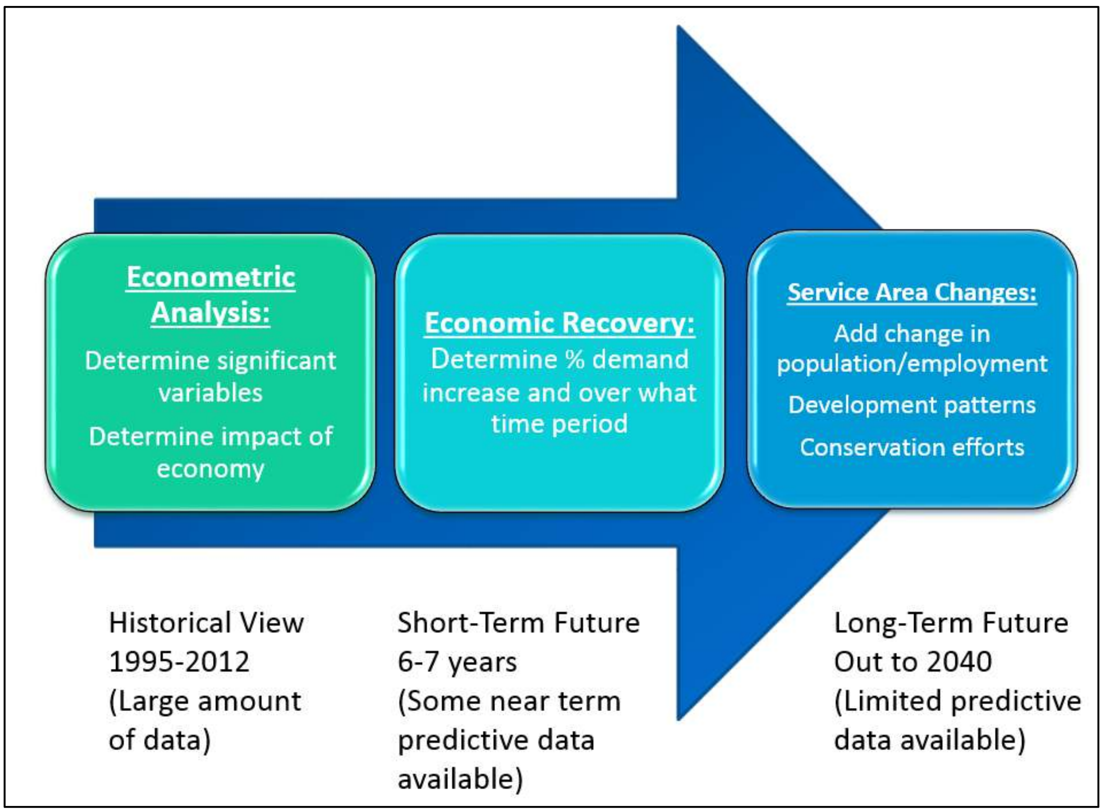
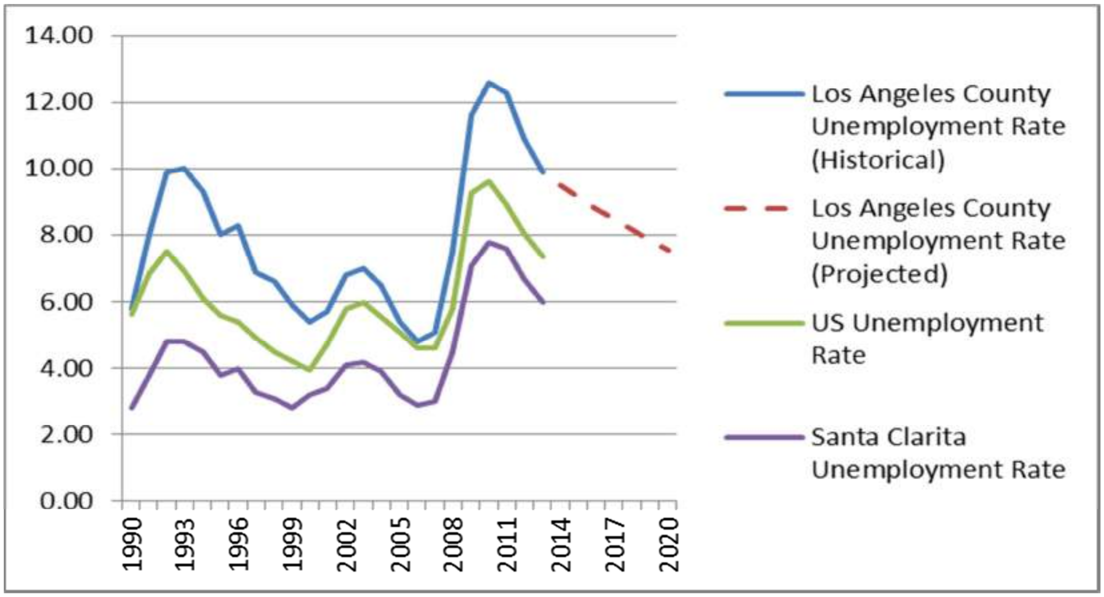


Figure 2. Unemployment Rate Comparisons



4.1 Econometric Analysis Methodology

This project uses Econometric Models to project short-term demand to the year 2020. This tool was incorporated into the demand analysis to estimate the relationship between water demand and factors that may be impacting it, such as price, economic conditions and weather. Relying on knowledge of past historical relationships and assuming that they continue in the short-run, this analysis provided insights into questions associated with demand, such as:

- At what rate will demand rebound as the unemployment rate falls reflecting the economy's return to its long-term growth path?
- How have price increases depressed demand?
- How has demand responded to weather?

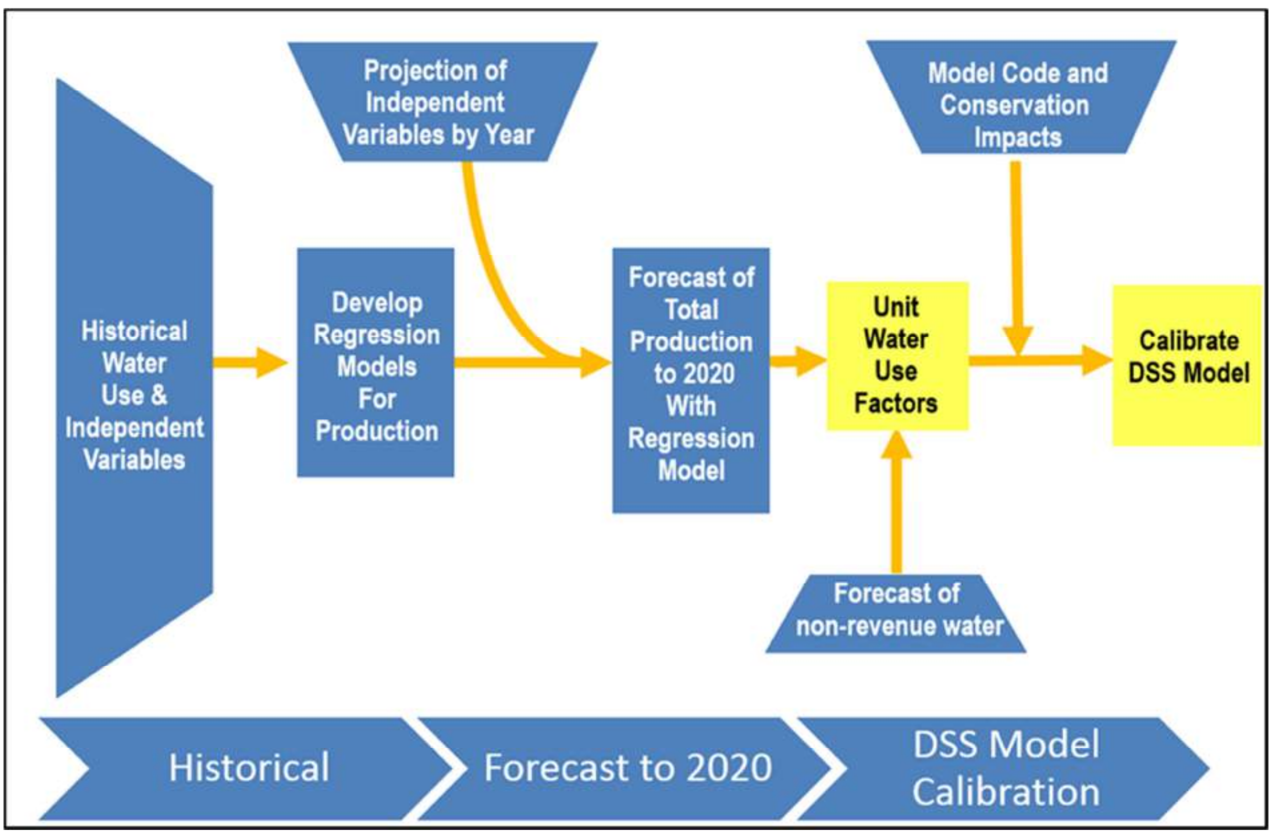
An Econometric Model of water demand was constructed for each Retailer using up to 19 years of monthly production data (where available, data from 1995 through 2013 were used). Each Retailer's Econometric Model utilizes Retailer-specific data to depict retail water rates and population. These data were submitted and verified by each Retailer through the data collection process using a verification of a MS Excel data collection workbook. The model also included additional locally specific data provided by the MWM team. In Phase 1, temperature and rainfall data were used to capture the impact of weather on water demand. These data were obtained from the NOAA (National Oceanic and Atmospheric Administration) weather station located in Newhall, California. For Phase 2, however, the MWM team was able to obtain reference ETo and rainfall data made available by Department of Water Resources (DWR) through their PRISM weather modeling program. These are the weather data that both DWR and CUWCC recommend water suppliers use to weather-normalize their compliance year GPCD in 2015 and 2020. So there is every reason to favor PRISM over NOAA data. PRISM weather data are available with a high level of granularity. However, sensitivity analyses did not indicate that any of the four Retailers were sensitive to which PRISM grid was used to model weather impacts. Accordingly, the grid that includes Santa Clarita City Hall was used for all Retailers. Similarly, the Los Angeles County's unemployment rate was used to model economic conditions in each Retailer's service area as mentioned earlier.

After the Econometric Models were developed, they were then used to generate water demand forecasts out to the year 2020. The estimated model coefficient associated with each variable included in the models, such as rainfall corrected reference ETo, water rates and the unemployment rate, were also incorporated into the 4 Retailer DSS models.

A flow diagram for the overall modeling process with econometric models supporting the near turn 2014-2020 demand forecast is shown in Figure 3 and further described in Section 4.2 and Appendix C. All this information was reviewed and calibrated with the DSS Model. This process generated one complete model for each Retailer with data between 2013 and 2050.

For each Retailer, the econometric analysis estimated the relative impact of various factors on water demand. The Phase 1 Enhanced and more sophisticated Phase 2 results have been provided in Appendix A. For comparison purposes, the projected demands and population that were reported in CLWA's 2010 UWMP for each Retailer can be found in Appendix B. A more detailed description of the Econometric Modeling framework can be found in Appendix C.

Figure 3. SCV Demand Forecast Modeling Approach Flow Diagram



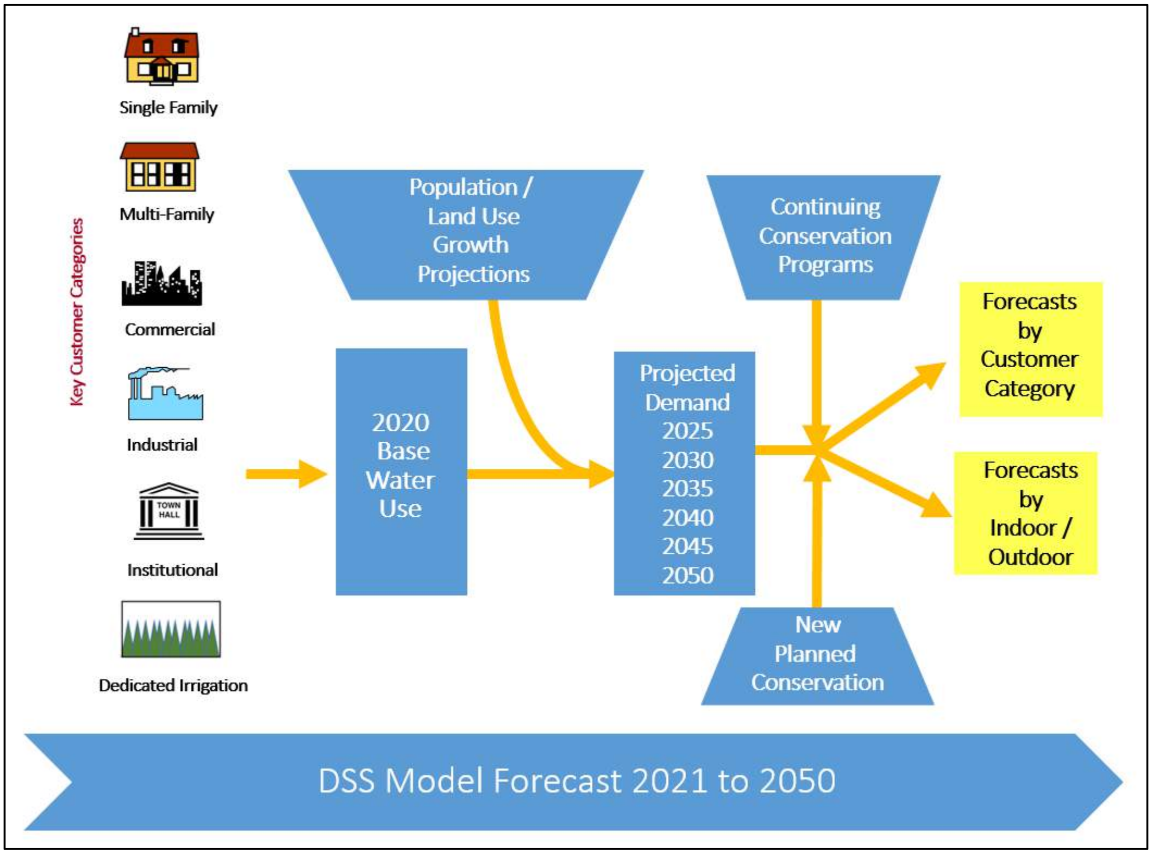
4.2 DSS Model Methodology

For the long-term projections (2021 through 2050), the DSS Model was used to generate demand forecasts for each Retailer. The DSS Model also includes a conservation component that quantifies savings from passive conservation (e.g. plumbing codes) and active conservation programs. The DSS Model's conservation component covers the entire forecast period, 2014-2050. Quantification of savings from active conservation programs is covered in the WUE SP. In this memorandum, only the DSS Model's estimates of savings from plumbing codes are provided so each Retailer can evaluate what its future "normal weather" demand would likely be if the Retailer did not undertake any active conservation programs between now and the year 2050.

4.2.1 Overview of the DSS Model

The DSS Model prepares long-range, water demand and conservation water savings projections. The model is an end-use model that breaks down total water production (i.e., water demand in the service area) into specific water end uses such as (e.g., toilets, faucets, or irrigation). This "bottom-up" approach allows for detailed criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes and conservation efforts. The purpose of using the end-use data is to enable a more accurate assessment of the impact of water efficiency programs on demand and to provide a rigorous and defensible modeling approach necessary for projects subject to regulatory or environmental review.

Figure 4. Retailer DSS Model Flow Diagram



As shown in Figure 4, the first step for forecasting water demands using the DSS Model was to gather customer category billing data from each Retailer. The next step was to calibrate the model by comparing water use data with available demographic data to characterize water usage for each customer category (single-family, multi-family, commercial, industrial and institutional) in terms of number of users per account and per capita water use. During the model calibration process, data were further analyzed to approximate the indoor/outdoor split by customer category. The indoor/outdoor water usage was further divided into typical end uses for each customer category. Published data on average per-capita indoor water use and average per-capita end use were combined with the number of water users to calibrate the volume of water allocated to specific end uses in each customer category. In other words, the DSS Model reflects social norms from end use studies on water use behavior (e.g., for flushes per person per day).

As part of the Phase 1 analysis, future population projections (originally derived from Retailer Master Plans then published in the 2010 UWMP and subsequently updated in the Population Assessment Project) were confirmed by each Retailer then incorporated into the DSS model. As part of Phase 2, future land use projections based on OVOV build-out estimates in year 2050 were incorporated into the DSS Model. These growth projections were used to develop projected demands for year 2021 through year 2050.

The conservation analysis portion of the Project was completed in April 2015 and updated in February 2016. As shown in Figure 3, the conservation measures analyzed were inputted into the DSS Model. These conservation measures are a combination of existing conservation measures and new conservation measures selected by a poll of the Retailers. Recommended active conservation program list of measures and designed parameters (e.g., unit costs and savings) is presented as Program B in the WUE SP. The only modification to the measures list was for VWC to not include landscape ordinance as a conservation measure, as demand factors appeared consistent with long-term performance anticipated from the local landscape ordinance for the Newhall Ranch development plans.

4.2.2 Future Population Data

Historical population from 1994 through 2010 was validated through the Population Assessment project in spring 2014. The population was then extended from 2010 through 2013 based on new account data using the same assumptions developed for the Population Assessment Project.

The land use based population estimates are founded on dwelling unit projection estimates from each Retailers' land use buildout projection with the people per household (PPH) estimates determined for each Retailer in the 2014 Population Assessment Technical Memorandum (lasted updated November 2014). In February 2016, VWC provided a revised projected land use population based on PPH estimates derived from average PPH for more recent developments including the communities of Bridgeport, North Park, and Stevenson Ranch (GSI, March 4, 2016).

The land-use based population (Figure 6) is based on an assessment of future dwelling units based on schedule provided by Valencia Water Company, or where not available a linear extrapolation from 2012 count of dwelling units to buildout (as determined from the GIS query by Retailer service area boundary and land use type). For other service areas potential future development information was provided by CLWA based on recent NCWD Master Plans and historical information from the OVOV Plan such that additional future potential dwelling units between existing service area boundaries and known annexations were included in the analysis.

The population forecasts are presented in Table 1, Figure 5, and Figure 6. For reference, the 2010 Urban Water Management Plan (UWMP) population is also presented in Table 1 and Figure 6.

Table 1. Valley-Wide Population-Based Forecasts*

Valley-Wide Population Forecast Source	2015	2020	2025	2030	2035	2040	2045	2050
Land-Use Based	272,600	289,000	321,900	354,700	383,400	396,100	408,800	421,500
2010 UWMP	318,200	345,900	373,000	401,200	428,900	456,600	486,200	511,900

*Note: The 2010 UWMP population forecast is provided for comparison purposes only.

Figure 5. Valley-Wide Land-Use Based Population Forecasts

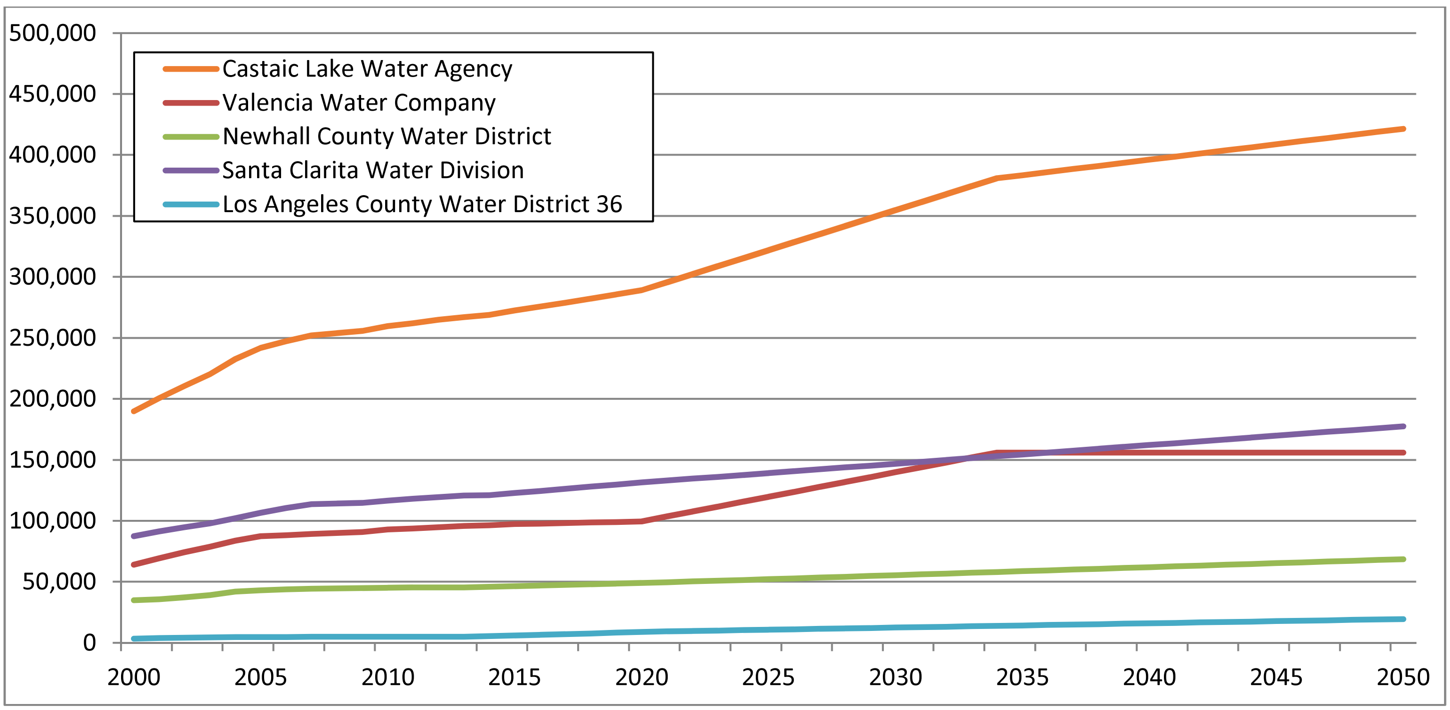
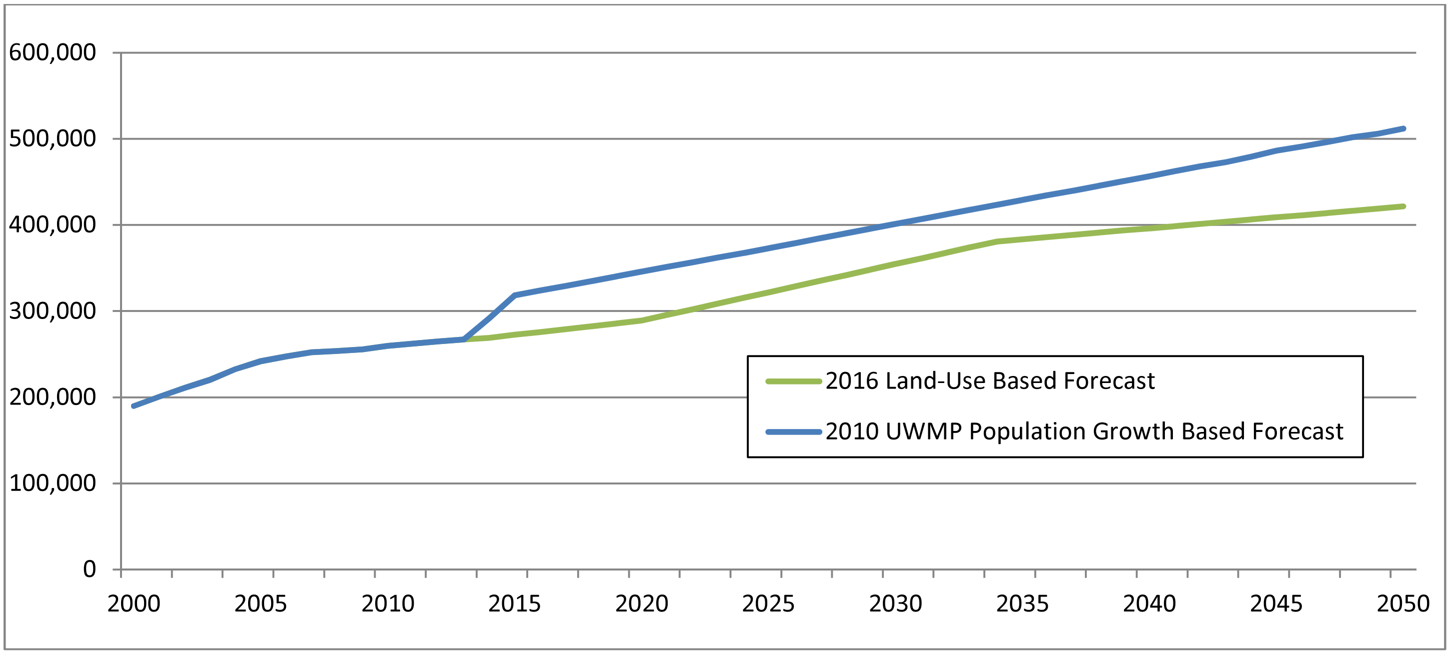


Figure 6. 2016 Land-Use Based Valley-Wide Population Forecast



4.2.3 Future Land Use Data

Future land use projections were based on build-out estimates from a combination of Retailer-approved development agreements and the OVOV study for VWC, NCWD and SCWD. LACWD land use was queried but a land use based demand forecast was not prepared due to data limitations. A diagram depicting the flow of work effort to prepare the land use analysis is presented in Figure 7.

Initial build-out estimates for land use types for each Retailer were determined using the GIS TAZ analysis presented in Section 3 and further explained in Appendix D. Three areas that are currently outside of Retailers' service area were added: West Side Communities for the VWC service area, and Tesoro Canyon and Tapia Canyon for NCWD. Nine adjoining communities collectively comprise the West Side Communities in the VWC service area. The nine communities are five villages comprising Newhall Ranch (Landmark Village, Mission Village, Homestead Village South, Homestead Village North, and Potrero Village), three other future communities (Legacy Village, Entrada Village South, and Entrada Village North), and buildout of an ongoing development (Valencia Commerce Center) (GSI, 2016).

For planning purposes, the residential land use types were consolidated and used average gallons per day per account for demand factors. This planning assumption was applied primarily due to the lack of enough detail on specific lot types. More specific details on the dwelling unit counts and land use values are provided in Appendix D and E for each Retailer, and an overall summary for all three Retailers is presented in Table 2.

A validation of the demand factors was prepared for 2004 and 2012 based on a review of GIS data, Retailer-provided billing data, and then the demand factors were applied to planned future development by land use type and projected development schedule. A summary of demand factors by Retailer is provided below and in Appendix D.

Figure 7. Flow Chart of Steps for Land Use Based Demand Projections

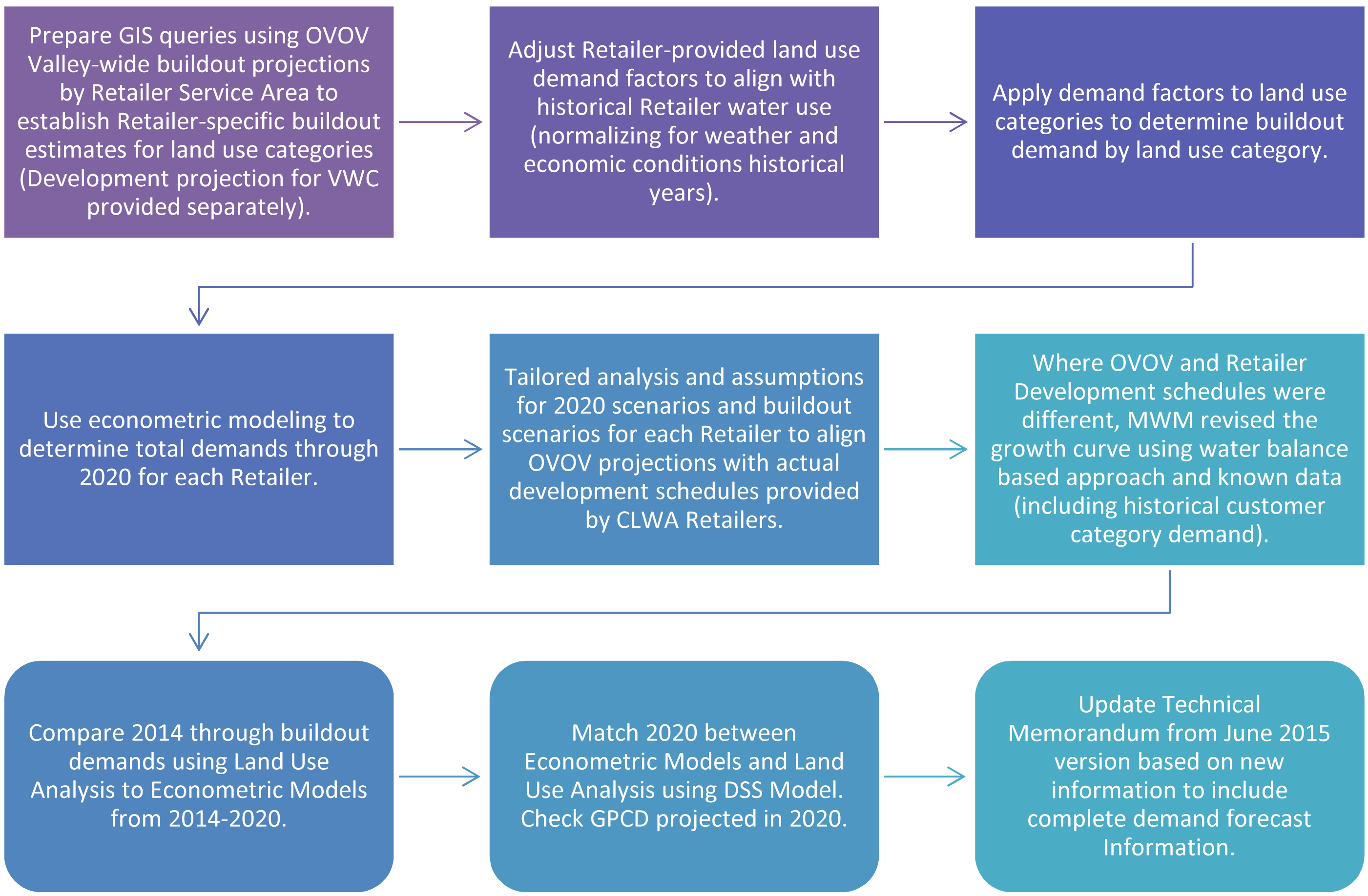


Table 2. Summary of Residential Land Use Type Data

Land Use Type	Units	2004	2012	2020	Build-out
Newhall County Water District[1]					
Single-Family	DU	7,618	8,606	9,011	14,249
Multi-Family	DU	4,870	4,984	5,696	7,147
Santa Clarita Water Division[2]					
Single-Family	DU	19,142	21,538	23,333	30,064
Multi-Family	DU	12,104	13,385	16,091	26,239
Valencia Water Company[3]					
Single-Family	DU	23,584	25,962	26,027	33,166
Multi-Family	DU	7,327	8,726	9,531	23,892

[1] Dwelling unit counts for Tesoro and Tapia Canyon Developments were provided by the County planners and assumed that they will develop by 2020. Additional development is based on OVOV projections aligned with NCWD and CLWA service area boundary using GIS analysis to build-out. All non-residential development is scaled as a percent increase based on OVOV projections as provided by the City of Santa Clarita and Los Angeles County Water District Planning Departments, and service area boundary shape files provided by NCWD and CLWA.
[2] All data presented is aligned with SCWD service area boundary using GIS analysis with OVOV database as provided by the City of Santa Clarita and Los Angeles County Water District Planning Departments, and shape files provided by SCWD.
[3] Dwelling unit counts are based on information provided in Attachment 3. Table A-2 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

NCWD and SCWD's projected land use by specific land use type can be found in Appendix D. VWC projected demands is presented in Appendix E. Individual Retailer's historical and projected land use can be found in the tables presented in Appendix D and E and includes the following for each Retailer. The following is a summary of the basis for the land use data sources:

- SF Land Use – based on historical population assessment DUs and added DUs by land use type as provided by Retailers, or if not provided used OVOV estimates
- MF Land Use – based on historical population assessment DUs and added DUs by land use type as provided by Retailers, or if not provided used OVOV estimates
- CII Land Use – based on GIS queries for growth with added irrigation or as provided by Retailers
- IRR – added in and assumed not to be double counted with other land use demand factors (given water balance based approach used in 2004 and 2012 as cross reference)
- Other – Utility (for all Retailers)
- Recycled Water – based on recycled water provided information by CLWA and Retailers

More explanation on the development of the Retailers' land use based demand projections is provided in Appendix D and Appendix E.

4.2.4 Future Demand Projections

Next, the Econometric Model and DSS Model were used to generate water demand projections for each Retailer. As previously described, the Econometric Model generated water demand projections for years 2014 to 2020 while the DSS Model generated water demand projections for years 2021 to 2050. Figure 8 presents a summary of the entire service area land use based demand projections through 2050.

The detailed Retailer specific land-use based demand projections for each Retailer through 2050 can be found in Appendix A in Tables A-1 through A-4 (and corresponding Figures A-1 through A-4) and include the following information for each Retailer:

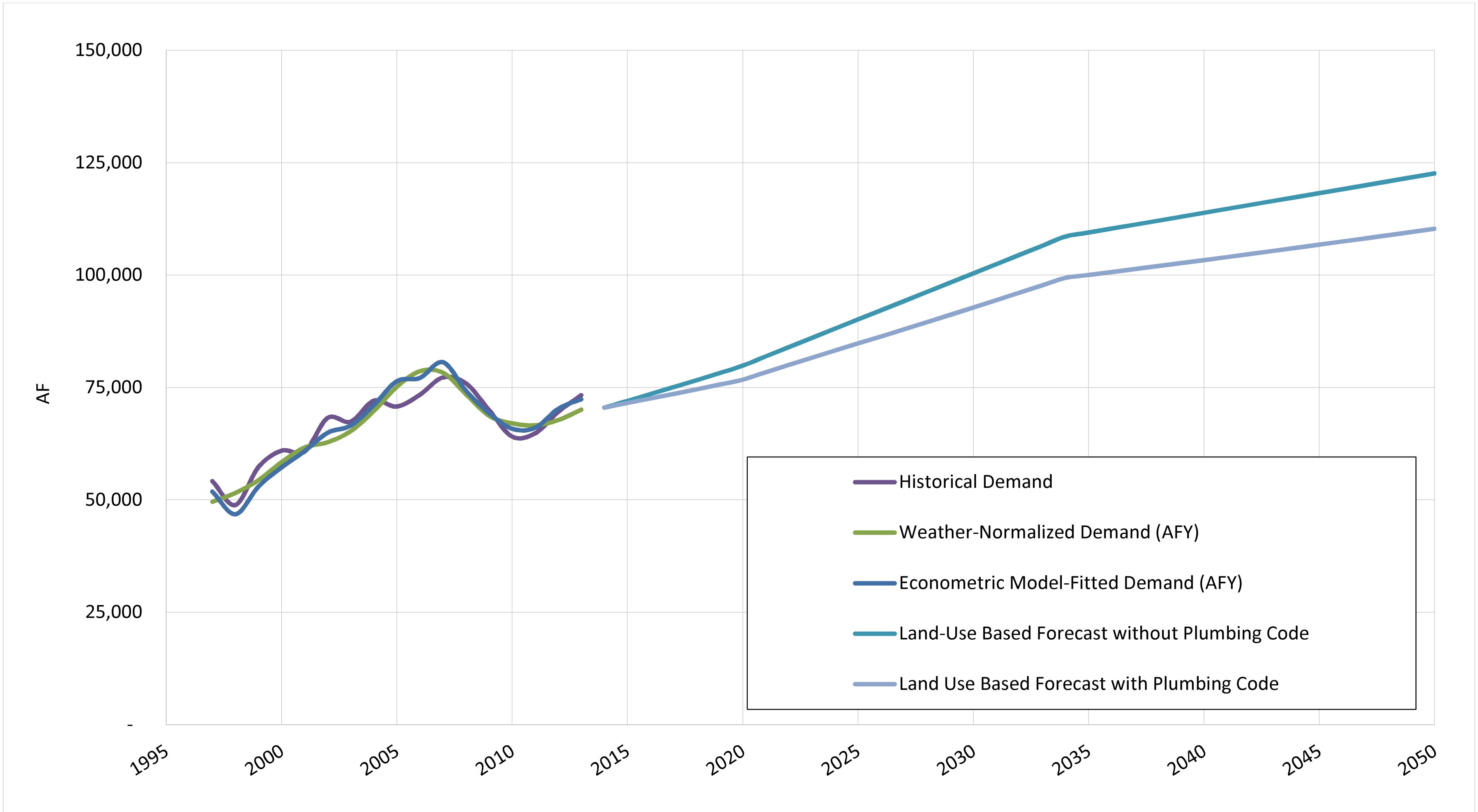
- *Projected Population* (Retailer-specific). Population provided for each Retailer based on land use dwelling unit projections using buildout estimates with the people per household (PPH) estimates determined for each Retailer in the 2014 Population Assessment Technical Memorandum. VWC projected land use population is based on PPH estimates derived from average SF attached, SF detached, and MF attached people per household based on more recently developed communities including Bridgeport, North Park, and Stevenson Ranch and presented in Attachment 3. Table A-2 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, 2016).
- *Projected Total Demand with No Plumbing Code Savings.* Water demands by each Retailer on five year increments that do not include the plumbing code
- *Projected Total Demand with Plumbing Code & Standards Savings.* Water demands by each Retailer in five year increments that nets out the effect of plumbing codes
- *Projected Total Demand with Active Conservation Program including Plumbing Code & Standards Savings*. Water demands by each Retailer in five year increments that nets out the effect of projected active conservation program implementation and plumbing codes. Recommended active conservation program measure design and water savings is presented as Program B in the WUE SP.

For comparative purposes, the 2010 Urban Water Management Plan (UWMP) population and demand projections for each Retailer through 2050 can be found in Appendix B in Tables B-1 through B-4 in five year increments.

Table 3. Valley-Wide Land-Use Based Population and Demand Projections

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Projected Population	272,600	289,000	321,900	354,700	383,400	396,100	408,800	421,500
Estimated Total Demand with No Plumbing Code Savings (AFY)	72,000	79,800	90,100	100,400	109,500	113,800	118,200	122,600
Estimated Total Demand With Plumbing Code Savings (AFY)	71,600	76,700	84,800	92,800	100,000	103,300	106,800	110,300
Estimated Total Demand With Active Conservation and Plumbing Code Savings (AFY)	69,100	69,000	74,600	80,800	86,100	88,500	91,000	94,000

Figure 8. Valley-Wide Land-Use Based Projected Demands to 2050 (AFY)



Individual Retailer's historical and projected water demands can be found in the graphs in Figure A-1 through A-4 and include the following curves:

- Actual Demand – This is historical demand as submitted in spring 2014 to MWM from each Retailer.
- Econometric Model-Fitted Demand – The Retailer Econometric Model results that try to match actual demand using the regression equation described in Appendix C.
- Weather Normalized Demand – Normalizes historical demand considering historical weather conditions.
- Estimated Demand - Assumes 1) normal weather, 2) economic recovery by 2020 as described previously, 3) price escalation projections of roughly 1.5% per year, 4) land use analysis land-use based population projections from land use buildout projection with the people per household (PPH) estimates determined for each Retailer in the 2014 Population Assessment, and 5) no plumbing code. Note VWC projected land-use based population is based on PPH estimates derived from more recently developed communities including Bridgeport, North Park, and Stevenson Ranch (GSI, 2016).
- Estimated Demand *with* Plumbing Code - Assumes 1) normal weather, 2) economic recovery by 2020 as described previously, 3) price escalation projections of roughly 1.5% per year, 4) land use analysis land-use derived population projections, and 5) plumbing code.
- Estimated Demand *with* Recommended Active Conservation Program Implementation and Plumbing Code - Assumes 1) normal weather, 2) economic recovery by 2020 as described previously, 3) price escalation projections of roughly 1.5% per year, 4) land use analysis land-use derived population projections, 5) active conservation program measure implementation as described as Program B in the WUE SP, and 6) plumbing code.

As presented in Appendix C, the Econometric Models quantify the relative impact of weather, price, and economic conditions on historical water demands.

5. CONCLUSIONS

The population and water demand forecasts contained in this memorandum reflect a refinement from those used in the 2010 UWMP. Significant work was performed to reassess the populations for each of the Retailers. 2010 Census data was used on at the Census Block level to update population estimates for each Retailer's service area. This analysis indicated that population was overestimated in the 2010 UWMP by approximately 10 percent. The updated population estimates along with individual water retailer water historic water use was incorporated into an econometric model used in the Water Use Efficiency Strategic Plan to project water demands through 2020. The Water Use Efficiency Strategic Plan contains more background information about conservation program design and presents modeling results. For reference, baseline GPCD, actual 2013 GPCD, and 2015 and 2020 GPCD targets are presented in Table 4. Also presented are projected 2020 GPCD with new growth and plumbing code savings taken into account, including active conservation.

The 2010 UWMP generally used a projected population growth rate of 1.5 percent through 2050. With the adoption of One Valley One Vision general plan and refinement of specific development plans, the 2015 UWMP references the land use based approach provided in this document. This approach provides the advantage of future projections reflecting anticipated changes in water usage patterns that might be significantly different than already developed land uses were in the past as the Santa Clarita Valley approaches buildout. Thus, as estimates provided within this Technical Memorandum are based on anticipated land use, it should provide a more accurate future water demand estimates than contained in the 2010 UWMP.

Table 4. Retailer Baseline for Water Use Efficiency Strategic Plan (Phase I Enhanced) and Target GPCD

Retailer	GPCD Demand				Projected 2020 Demand		
	Baseline	2015 Target[2]	2020 Target[2]	Actual 2013	Without Plumbing Code	With Plumbing Code[3]	With Plumbing Code & Active Conservation
Los Angeles County Waterworks District 36[1]	235	212	188	227	250	242	227
Newhall County Water District	238	214	190	207	214	209	188
Santa Clarita Water Division	251	226	201	221	221	216	194
Valencia Water Company	335	301	268	295	307	301	264
Valley-wide[2]	280	252	225	246	252	247	220

[1] Los Angeles County Waterworks District 36 does not have 3,000 AF served or 3,000 connections, so SB X7-7 targets do not apply.
[2] Valley-wide 2015 and 2020 target GPCDs are based on a weighted average using projected 2020 populations for NCWD, SCWD, and VWC. Valley-wide target calculations do NOT include LACWD GPCD. Reference Water Use Efficiency Strategic Plan for more details.
[3] Without active conservation includes estimated savings from the 2015 Plumbing Code standards only.

Projected 2020 demand (with plumbing code) values presented in the table above illustrate that additional active conservation programs are projected to be necessary to meet SB X7-7 GPCD targets.

APPENDIX A: DEMAND PROJECTIONS AND GPCD TARGETS – RETAILER SPECIFIC INFORMATION

This Appendix presents the land use based demand projections for each Retailer. Note that these forecasts have updated parameters with better data quality from the previous Technical Memorandum dated June 9, 2015 and draft memorandum from August 29, 2014. As compared to the previous Technical Memorandum dated June 9, 2015, the model has updated plumbing code savings estimates due to recent legislation enacted as a result of the recent drought. Both the 2015 CALGreen Building Code and the California Code of Regulations Title 20 Appliance Efficiency Regulations adopted by the California Energy Commission (CEC) on September 1, 2015 yielded more aggressive plumbing code savings, which has consequently affected the active conservation savings potential and savings estimates. Furthermore, for VWC, the land use development parameters provided were refined using better available data quality in relation to what was in the previous Technical Memorandum dated June 9, 2015.

OVOV based and land use based population projections are also presented by Retailer. For comparison purposes Appendix B presents the projected demands and population that were reported in CLWA's 2010 UWMP for each Retailer. In each Retailers case, the 2010 UWMP population estimates are higher than the land use based population estimates.

The land use based population is derived from planned dwelling units (Table 2, Appendix D and E) multiplied by the person per household from the US Census analysis prepared during the Population Assessment project. VWC projected land use population is based on PPH estimates derived from more recent developed communities including Bridgeport, North Park, and Stevenson (GSI, 2016). Where possible, conservative assumptions have been made related to the type of development (for example, more water intensive single-family demand factors were applied to future development in Newhall County Water District for future in-fill development not accounted for in Tapia and Tesoro Canyon developments). More refined land use specific plans that allowed for more specificity on the housing mix of future dwelling unit counts in terms of lot type and schedule for buildout would improve the analysis. Note the demand factors are averaged and validated in 2004 and 2012, which means that there is an inherent assumption that the housing mix in the future is assumed to be similar to the built environment in the existing service areas. It is assumed this added level of detail is either not available or not necessary to include at this time, given the land use based forecast will be revisited over time as the valley continues to build out.

Total demand projections presented in this Appendix account for the total projected water production in a service area water system, including non-revenue water, regardless of source. Source can be from CLWA surface water, groundwater or recycled water.

Both passive code and standards estimated water savings and active recommended conservation program implementation water savings are presented in this Appendix. Recommended active conservation program savings are based on Program B as presented in the Water Use Efficiency Strategic Plan.

Table A-1. Retailer Land-Use Based Demand Projections – Newhall County Water District

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Population (Land-Use Based)	46,500	49,000	52,200	55,500	58,800	62,000	65,300	68,500
Land-Use Based Total Demand with No Plumbing Code Savings (AFY)	10,400	11,900	13,200	14,400	15,600	16,800	18,000	19,200
Land-Use Based Total Demand With Plumbing Code Savings (AFY)	10,400	11,500	12,400	13,200	14,100	15,100	16,100	17,100
Land-Use Based Total Demand With Active Conservation Program and Plumbing Code Savings (AFY)	10,000	10,100	10,700	11,200	11,800	12,600	13,400	14,200

Notes:

1. The demands estimates account for additional development beyond what was found to be feasible within the existing service areas and approved annexations as of 2014. For planning purposes. CLWA is accounting for more future development beyond these planned annexations, mainly associated with additional development adjacent to NCWD and within the CLWA service area.
2. Total Demand accounts for the total projected water demand in a service area water system regardless of source. Source can be from CLWA surface water, groundwater or recycled water. Demands with and without plumbing code savings do not include planned active conservation savings estimates.
3. Updated demand forecasts were accepted as final by Mike Alvord, NCWD on March 2, 2016. More details on how the demands were prepared are presented in Appendix D.

Figure A-1. Retailer Land-Use Based Demand Projection – Newhall County Water District (AFY)

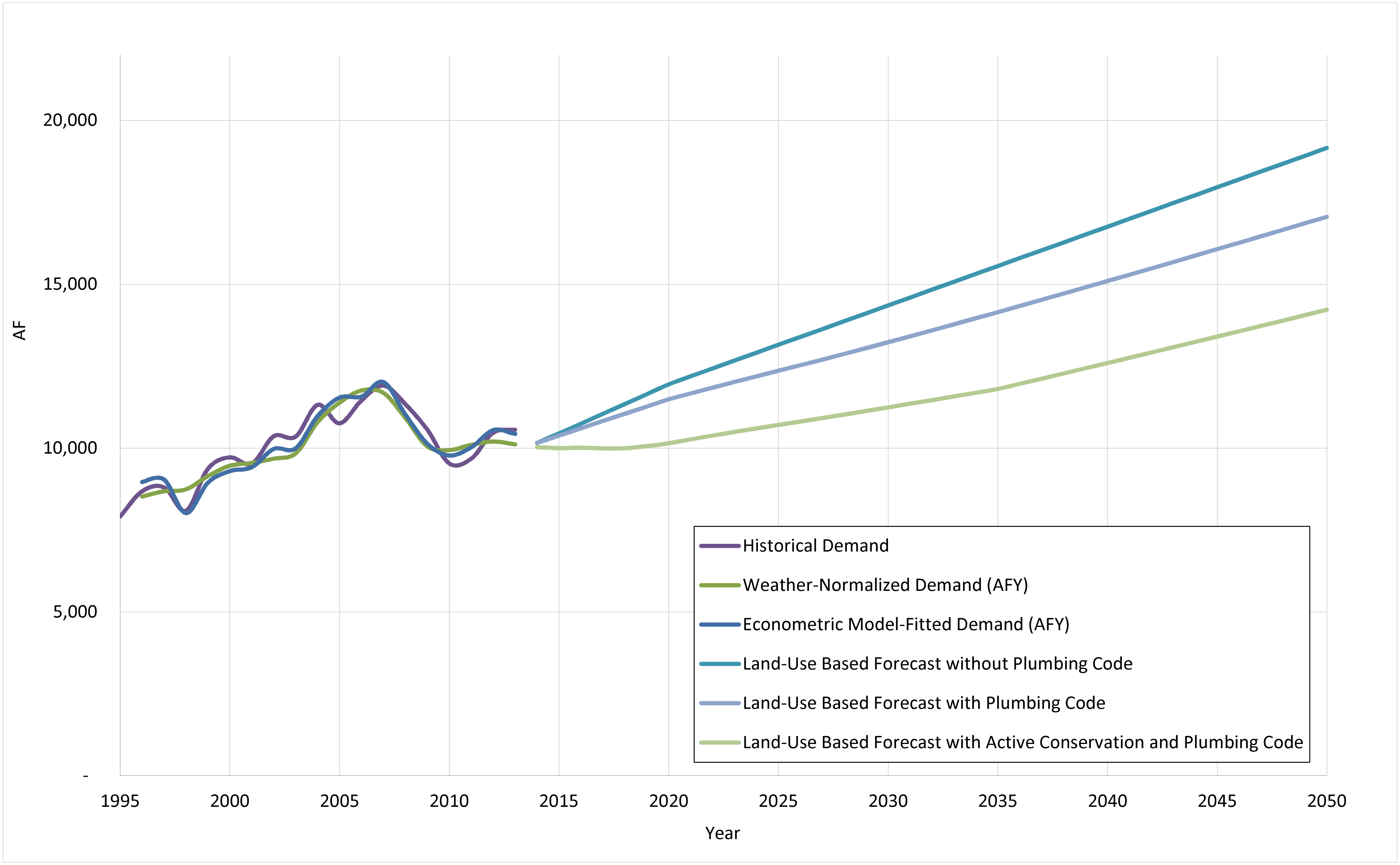


Table A-2. Retailer Land-Use Based Demand Projections – Santa Clarita Water Division

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Population (Land-Use Based)	122,700	131,500	139,200	146,800	154,500	162,200	169,800	177,500
Total Land-Use Based Demand with No Plumbing Code Savings (AFY)	29,000	32,500	35,200	37,900	40,600	43,300	46,000	48,700
Total Land-Use Based Demand With Plumbing Code Savings (AFY)	28,800	31,500	33,400	35,300	37,400	39,500	41,700	43,900
Total Land-Use Based Demand With Active Conservation Program and Plumbing Code Savings (AFY)	27,900	28,400	29,100	29,900	30,800	32,400	33,900	36,000

Notes:

1. The demands estimates account for additional development beyond what was found to be feasible within the existing service areas and approved annexations as of 2014.
2. Total Demand accounts for the total projected water demand in a service area water system regardless of source. Source can be from CLWA surface water, groundwater or recycled water. Demands with and without plumbing code savings do not include planned active conservation savings estimates.
3. Updated demand forecasts were accepted as final by Keith Abercrombie, SCWD on March 2, 2016. More details on how the demands were prepared are presented in Appendix D.

Figure A-2. Retailer Land-Use Based Demand Projection – Santa Clarita Water Division (AFY)

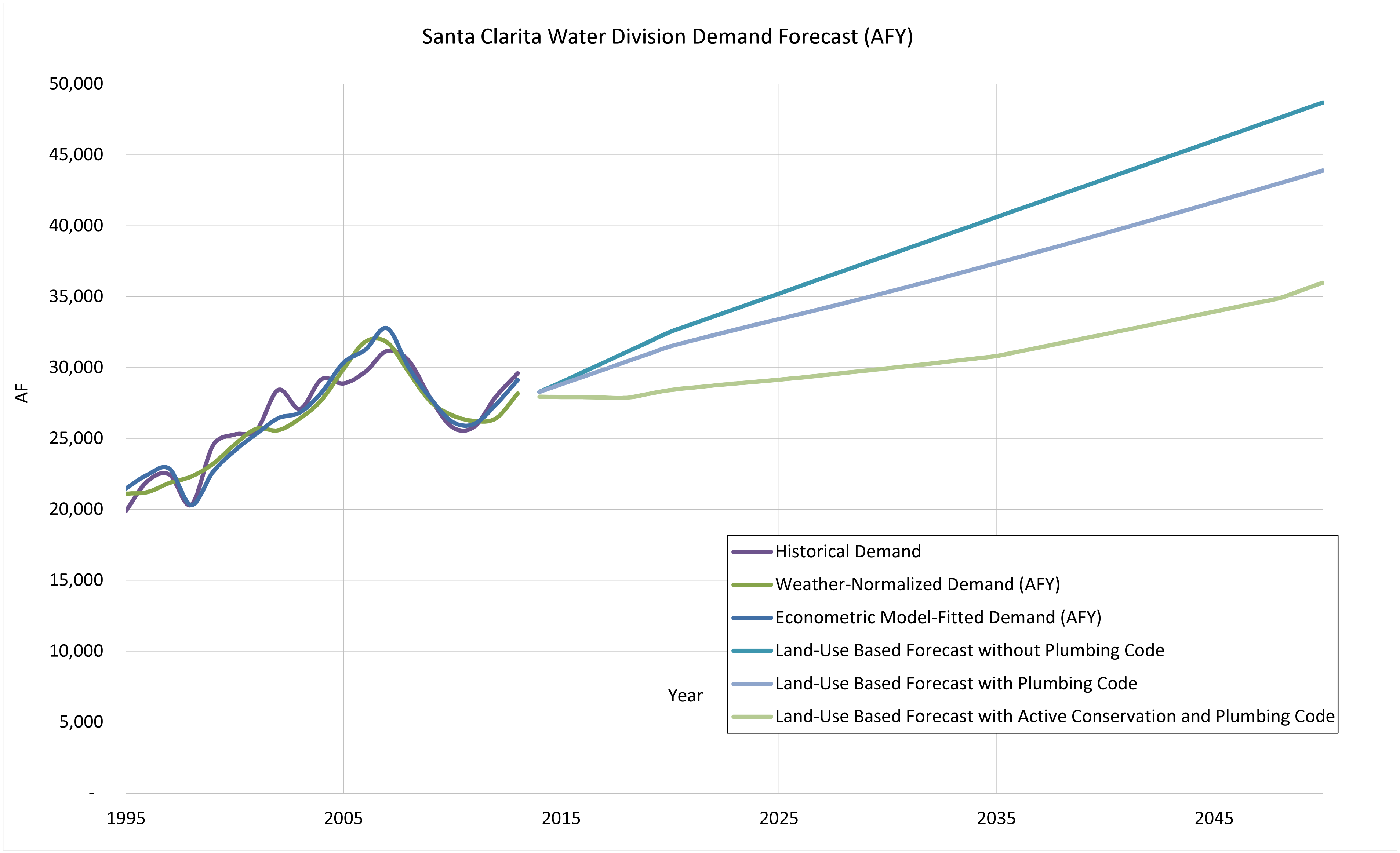


Table A-3. Retailer Land-Use Based Demand Projections – Valencia Water Company

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Population (Land-Use Based)	97,300	99,600	119,700	139,800	155,900	155,900	155,900	155,900
Total Land-Use Based Demand with No Plumbing Code Savings (AFY)	31,100	32,900	38,700	44,600	49,300	49,300	49,300	49,300
Total Land-Use Based Demand With Plumbing Code Savings (AFY)	30,900	31,300	36,100	40,900	44,800	44,600	44,400	44,300
Total Land-Use Based Demand With Active Conservation Program and Plumbing Code Savings (AFY)	29,700	28,100	32,100	36,600	40,000	39,600	39,300	39,000

Notes:
1. Past OVOV population and demands estimates are higher and assumed to be accounting for additional development beyond what was found to be feasible within the existing service areas and approved annexations as of 2014.
2. Total Demand accounts for the total projected water demand in a service area water system regardless of source. Source can be from CLWA surface water, groundwater or recycled water. Demands with and without plumbing code savings do not include planned active conservation savings estimates.
3. Updated demand forecasts were accepted as final by Ken Petersen on March 2, 2016. More details on how the demands were prepared are presented in Appendix E. Future population for 2017-2050 is provided in Table E-1.

Figure A-3. Land-Use Based Demand Projection – Valencia Water Company (AFY)

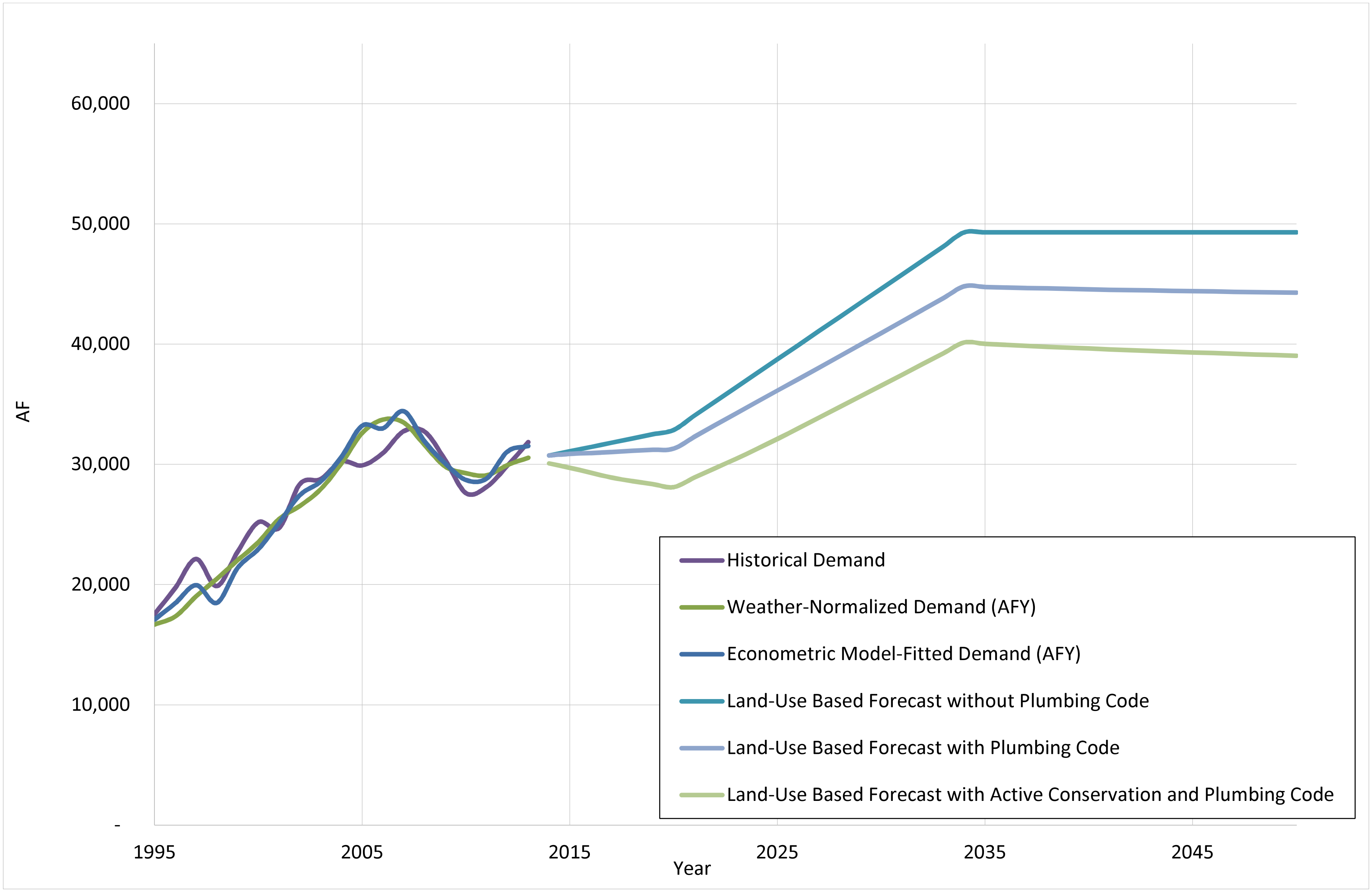


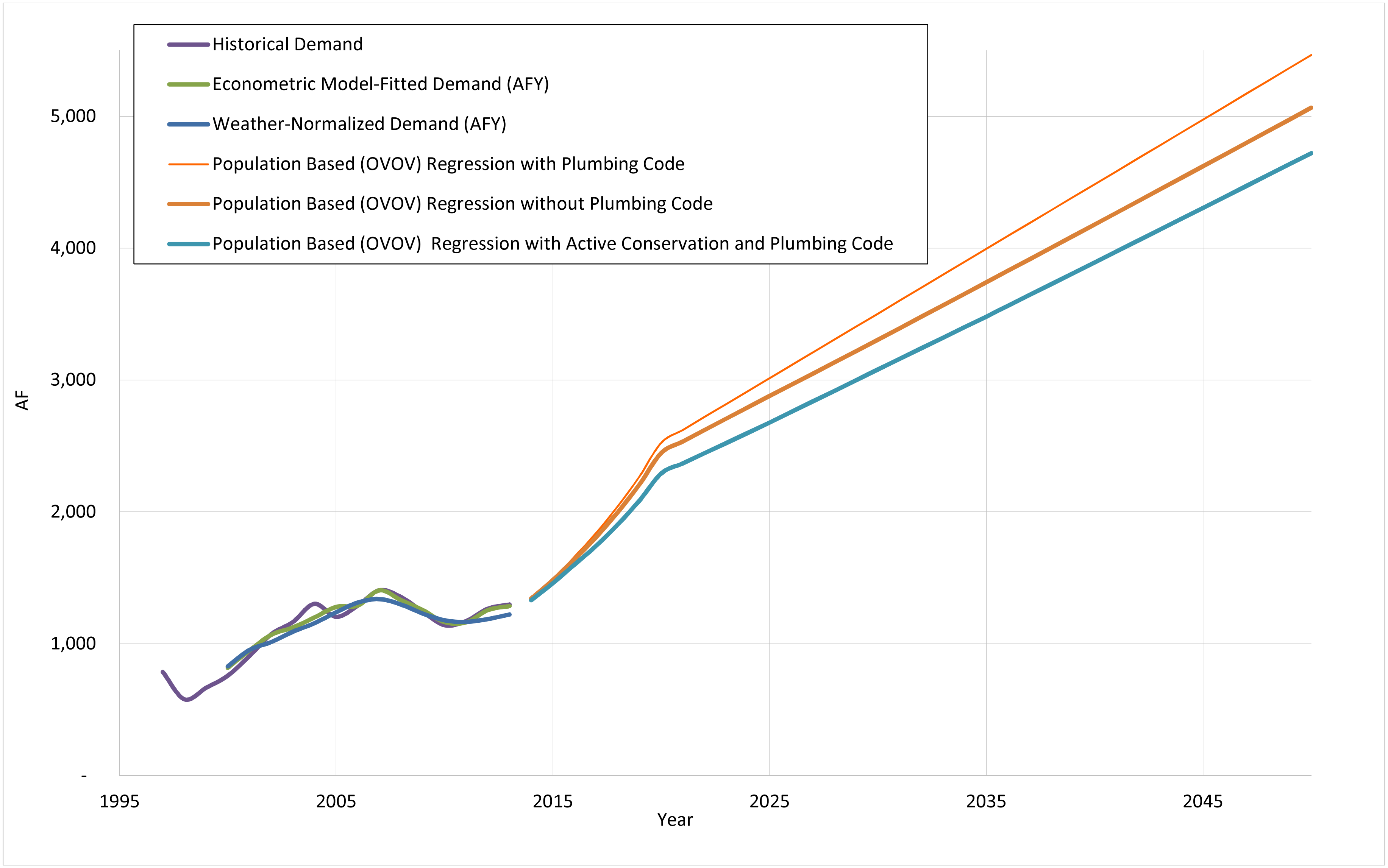
Table A-4. Population-Based Demand Projections – LA County Water District 36

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Population (OVOV Based)	6,000	9,000	10,800	12,500	14,300	16,000	17,800	19,500
Population-Based Total Demand with No Plumbing Code Savings (AFY)	1,500	2,500	3,000	3,500	4,000	4,500	5,000	5,500
Population-Based Total Demand With Plumbing Code Savings (AFY)	1,500	2,400	2,900	3,300	3,700	4,200	4,600	5,100
Population-Based Total Demand With Active Conservation Program and Plumbing Code Savings (AFY)	1,500	2,300	2,700	3,100	3,500	3,900	4,300	4,700

Notes:

1. Past OVOV population and demands estimates are higher and assumed to be accounting for additional development beyond what was found to be feasible within the existing service areas and approved annexations as of 2014.
2. Total Demand accounts for the total projected water demand in a service area water system regardless of source. Source can be from CLWA surface water, groundwater or recycled water. Demands with and without plumbing code savings do not include planned active conservation savings estimates.
3. Demand estimates were previously adopted as part of the WUE SP in June 2015.

Figure A-4. Retailer Demand Projection – LA County Water District 36 (AFY)



APPENDIX B PAST 2010 UWMP RETAILER DEMAND FORECAST AND POPULATION PROJECTIONS

For comparison purposes this appendix presents the projected demands and population that were reported in CLWA's 2010 UWMP for each Retailer. Phase 2 Retailer-specific demands can be found in Appendix A.

Table B-1. 2010 Urban Water Management Plan Demand Projections – Newhall County Water District

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand (AFY)	12,571	14,246	15,922	17,598	19,273	20,949	22,624	24,300
Population	49,933	54,559	58,612	63,824	68,450	73,079	78,715	82,341

Source: 2010 UWMP Demand without Conservation Table 2-2

Table B-2. 2010 Urban Water Management Plan Demand Projections – Santa Clarita Water Division

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand (AFY)	31,633	34,814	37,995	41,176	44,357	47,538	50,719	53,900
Population	133,868	143,544	153,220	162,896	172,572	182,248	192,924	201,600

Source: 2010 UWMP Demand without Conservation Table 2-2

Table B-3. 2010 Urban Water Management Plan Demand Projections – Valencia Water Company

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand (AFY)	34,107	37,235	40,362	43,490	46,617	49,746	52,872	56,000
Population	127,241	138,862	150,477	162,098	173,716	185,330	196,952	208,570

Source: 2010 UWMP Demand without Conservation Table 2-2. Total demand includes recycled water.

Table B-4. 2010 Urban Water Management Plan Demand Projections – LA County Water District 36

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand (AFY)	1,759	2,189	2,619	3,048	3,478	3,908	4,339	4,768
Population	7,157	8,908	10,658	12,405	14,159	15,906	17,657	19,407

Source: 2010 UWMP Demand without Conservation Table 2-2.

APPENDIX C ECONOMETRIC MODEL DESCRIPTION

C.1 Introduction

In the past, CLWA has relied on projections of population and jobs to predict future baseline water demand. These estimates of baseline demand were then converted into estimates of net demand by subtracting likely savings from various plumbing codes and active conservation programs. While the simplicity of this methodology makes it appealing and easy to understand, econometric analysis of historical data (assuming historical relationships remain valid) can provide helpful information for answering questions such as:

- How much and at what rate will demand rebound as the economy expands?
- How much will future price increases continue to depress demand?
- How does demand respond to weather?

To address these questions, we have developed econometric demand models for each Retailer that aim to estimate the relationship between water demand and its key drivers such as price, economic conditions and weather. We have evaluated the following independent variables (Table C-1) for inclusion in the models and will evaluate a few more in Phase 2:

Table C-1. Independent Variables Evaluated for the Econometric Analysis

Variable Type	Variables	Units	Data Source	Comment
Weather	Precipitation	Inches per month	NOAA Weather Data	Phase 1
Weather	Avg Daily Max Air Temp	Fahrenheit	NOAA Weather Data	Phase 1
Weather	Reference ETo	Inches	Not available for all areas	Phase 2
Economy	# of Jobs	Jobs per capita	SCAG, LA County, City of Santa Clarita	Phase 2
Economy	Unemployment	Unemployment rate	CA EDD / BLS	Phase 1
Service Area Housing Mix	SF and MF Units	Dwelling units	DOF	Phase 2
Service Area Data	Rates	$/AF	Provided by Retailers	Phase 1
Service Area Data	Population	People	Census	Phase 1
Conservation	Conservation savings per year	Million gallons per day	CUWCC	Phase 2

Based on the Phase 1 analysis, the following best fit equation was developed:

$$Ln(monthly\ GPCD) = \alpha + \beta Trend + \theta Ln(unemployment\ rate) + \delta Ln(marginal\ price) + \vartheta Temperature\ Deviation + \vartheta Rainfall\ Deviation + \pi monthly\ indicators + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..Eq.\ 1$$

Where,

- Monthly production is measured in gallons per capita per day (GPCD).
- α is a scaling constant. Trend is a variable that takes on a value of 0 in the first year, 1 in the second year, and so on.
- Unemployment rate is captured as an annual percent (for example, 7%).

- Marginal price for single-family customers, measured in dollars per hundred cubic feet
- Temperature deviation is measured in degrees Fahrenheit (average maximum daily temperature in a given month minus average for the same month between 1995 and 2012).
- Rainfall deviation is measured in total inches (total rainfall in a given month minus average total rainfall for same month between 1995 and 2012).
- Monthly indicators are binary 0-1 variables, taking on a value of 1 for a given month in question, 0 otherwise.
- ε denotes random statistical error.

Each variable on the right hand side of the equation (independent variable) is preceded by a coefficient (i.e. β, etc.)that measures the strength of the impact of an independent variable on monthly demand (the variable on the left hand side of the equation is also known as the dependent variable). A positive coefficient implies that increases in an independent variable will cause an increase in the dependent variable; a negative coefficient implies the opposite. The purpose of model development is both to select the elements of the equation, as well as to estimate each independent variable's coefficient. Continuous variables such as the marginal price and the unemployment rate are logarithmically transformed so that their respective coefficients can be given a proportional interpretation. So, for example, the coefficient on logarithmically transformed marginal price becomes the price elasticity, and so on. The trend variable captures changes in GPCD over time not accounted for by price, unemployment rate, or weather.

Our basic model specification (Eq. 1) includes several features. First, Retailer-specific production data are modeled at a monthly, not annual, level. The reason for estimating monthly level models is to allow for the impact of weather to vary by time of year. Prior research strongly indicates that abnormal reference ETo and abnormal rainfall do not have the same effect in January as, say, in May.[3] Working with monthly production data allows one to incorporate time-varying weather effects.

Second, rainfall corrected reference ETo enter the model as deviations from their respective monthly averages, capturing directly how demand reacts to weather as it deviates from average. Normal seasonality in monthly demand (that is, July demand being much higher than January demand) is captured by the monthly indicator variables.

In Phase 1, we used temperature and rainfall from the NOAA weather station located in Newhall, California to control for weather. In Phase 2 we used reference ETo and precipitation from Department of Water Resources' PRISM weather tool that are likely to be recommended by both DWR and CUWCC for the purpose of weather normalization of compliance year GPCD. Thus, there is every reason to favor PRISM over NOAA data.

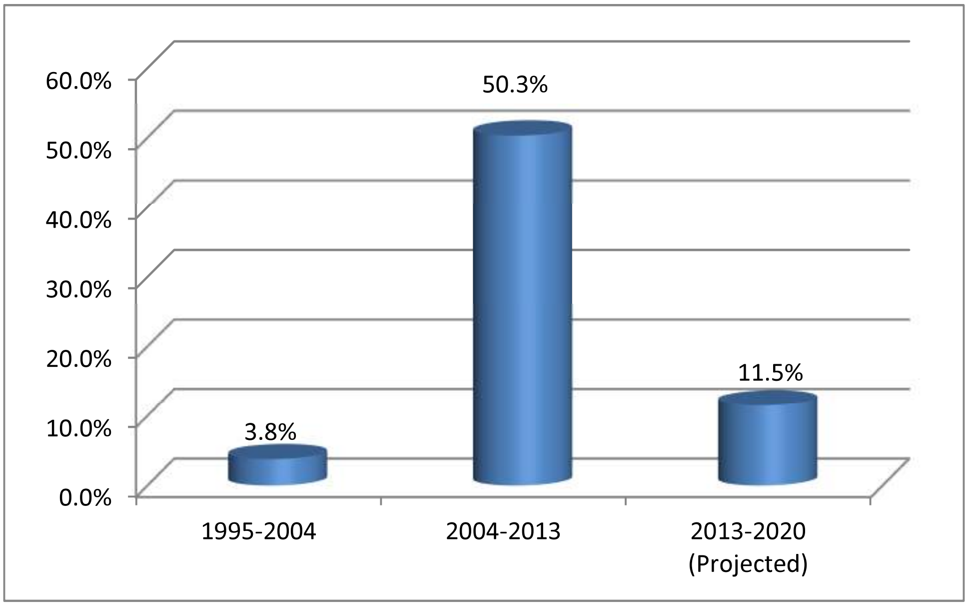
Third, economic conditions are captured by the unemployment rate obtained from the Bureau of Labor Statistics for Los Angeles County. We tested whether the city of Santa Clarita's unemployment rate predicts water use patterns better than a metric that reflects broader economic conditions, but it did not. In Phase 2, we have also evaluated whether changing proportion of single- and multi-family housing could be used to improve the models, but this metric did not show sufficient independent variation to merit inclusion in the final models.

Finally, our models also include a measure of the marginal price of water in real terms (that is, price deflated by the consumer price index published by the Bureau of Labor Statistics). We have used marginal price of water

[3] Bamezai, A., *GPCD Weather Normalization Methodology*, final report submitted to the California Urban Water Conservation Council, 2011.

faced by the average single-family customer in a Retailer to depict price variation over time. By and large, Commercial, Institutional, and Industrial (CII) and SFR price trends appear similar. Figure C-1 shows price escalation faced by single-family customers in the CLWA service area overall, calculated as a weighted average of each Retailer's price data.

Figure C-1. Valley-Wide Trends in the Single-Family Real Price of Water



C.2 Econometric Model Results

We developed models as shown in Equation 1 for each Retailer using their own unique data. To illustrate the method in general we also developed a monthly GPCD model for all CLWA Retailers combined. Results for this rolled-up valley-wide model are shown in Table C-2. This type of model is known as a time-series, cross-sectional model. This valley-wide model incorporates Retailer-level fixed effects, a correction for autocorrelation in the error term, and population weighting to account for different Retailer sizes. Autocorrelation refers to model error is successive months exhibiting a positive or negative correlation. Model estimation techniques that account for this correlation produce more accurate hypothesis tests. Retailer-specific fixed effects capture the impact of Retailer characteristics that do not vary much over time, such as average household income and lot size, leading to a much more robust model specification than one without these fixed effects. In other words, this model captures the impact on GPCD of income, lot size and other unobservable time-invariant differences across Retailers implicitly through these fixed effects.

In addition to the fixed effects, each Retailer is allowed to have its own time trend, if necessary, to capture the impact of service area dynamics that influence water use but are not fully captured either by price, unemployment rate or weather. Only in the case of WW36 did a positive time trend appear necessary, which matches anecdotal evidence suggesting that newer development in the area is more affluent than what has existed historically. The normal seasonality in water use is also allowed to vary across retailers as is the impact of weather deviations from normal. The differences across retailers are small, but in the interest of accuracy each is allowed to have their own unique seasonal pattern.

The estimated valley-wide model (Table C-2) has three columns, including one for the estimated coefficient, one for the likely band of error surrounding this coefficient (referred to as standard error), and one for the t-statistic. An independent variable's t-statistic is the ratio of the coefficient over its standard error. A t-statistic of 2 or greater indicates a statistically significant relationship between the dependent and independent variable; less than 2 indicates that the data are not able to conclusively demonstrate a relationship. The latter finding may reflect the lack of any relationship. Or, it may occur because of data errors or other problems, such as two or more independent variables being highly correlated with one another. The model's R-square is shown at the bottom, which is indicative of the explanatory power of a statistical model. It can vary between zero and a maximum of 1, with higher numbers indicating greater explanatory power.

Table C-2's coefficients have the following interpretations:

- A price elasticity of -0.154 indicates that a 10% real increase in the marginal price of water can be expected to reduce demand by 1.5%. Our valley-wide estimate of price elasticity compares well with the published literature on this topic.
- A 10% increase in the annual unemployment rate is likely to depress water demand by 1.7%, a statistically significant effect, and comparable to the effect of price. The weather coefficients are all significant and behave in expected ways.
- An extra inch of reference ETo per month (adjusted for rainfall) during the spring season increases monthly demand by roughly 15.8%, during the summer months by 8. 7%, and during the winter months by roughly 15.0%. Lower than average reference ETo would have the opposite effect.

The monthly indicator variables also exhibit the expected pattern with July and August exhibiting the largest coefficients, indicating that July and August demand is greatest during the year, reaching a minimum during February.

Figure C-2 shows how the model prediction compares with CLWA's valley-wide GPCD trend. The resulting R^2 value of 0.93 shows that there is a good fit between actual and predicted values. The models capture the downturn in demand experienced during the 2008-2011 period. The models suggest that a good chunk of the uptick in demand during 2012 and 2013 was weather related. Once this weather effect is removed it causes a downshift in projected normal-weather demand going forward. This normal weather baseline demand is expected to rise as the economy expands, but tempered by projected price increases (shown in Figure C-1) which have been factored into the forecast.

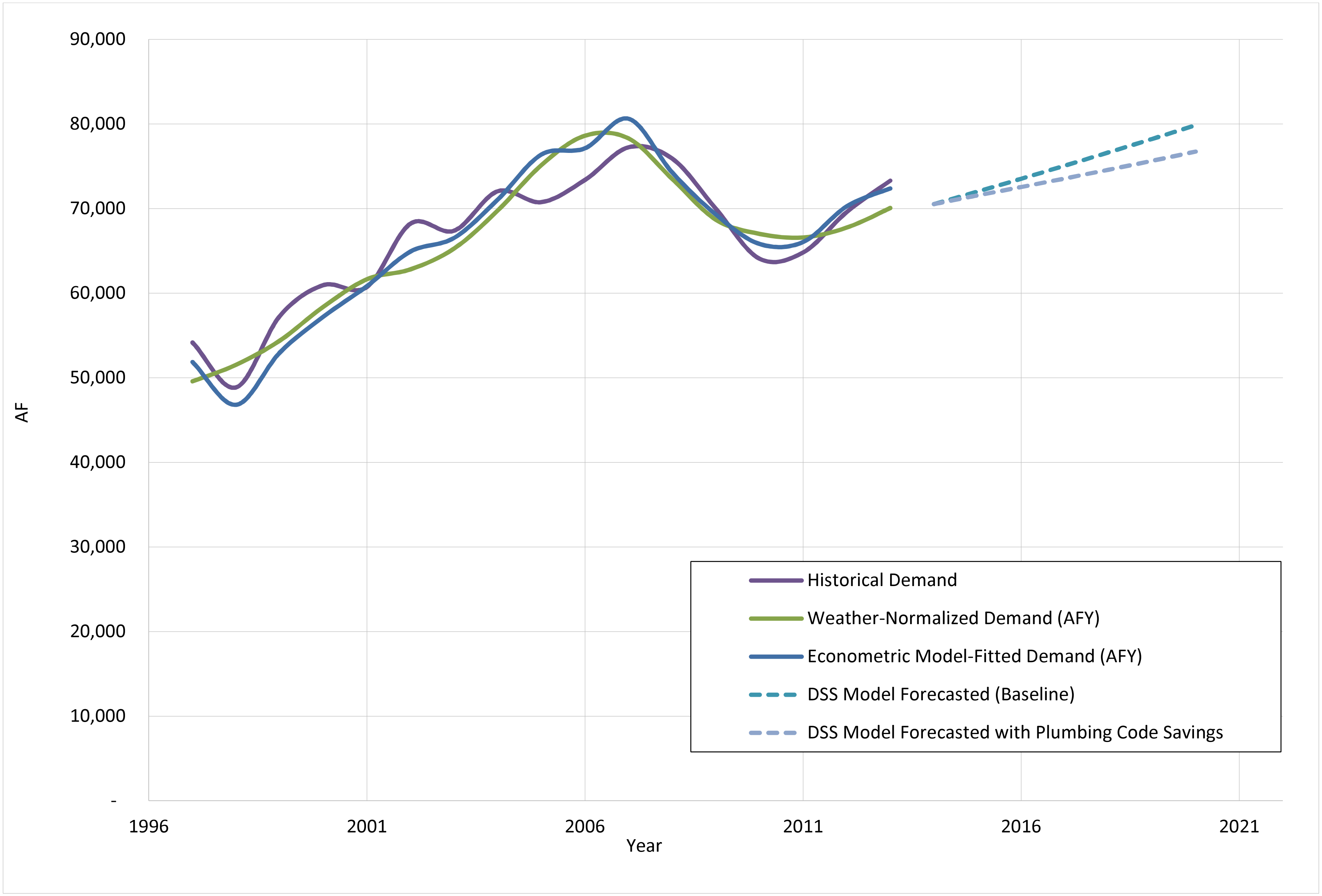
Table C-2. CLWA Valley-Wide Model Results

Dependent Variable: Ln (Monthly Baseline GPCD)

Independent Variable	Coefficient	Std. Error	t-statistic
Ln(Marginal Price)	-0.154	0.023	-6.7
Ln(Unemployment Rate)	-0.169	0.014	-12.4
Rainfall adj. Ref. ETo (Apr-Jun)	0.158	0.009	17.5
Rainfall adj. Ref. ETo (Jul-Oct)	0.087	0.010	8.4
Rainfall adj. Ref. ETo (Nov-Mar)	0.150	0.009	15.7
Jan Indicator	-0.082	0.020	-4.1
Feb	-0.145	0.023	-6.4
Mar	0.028	0.021	1.3
Apr	0.287	0.018	15.6
May	0.527	0.017	31.2
Jun	0.682	0.016	43.8
Jul	0.804	0.016	51.1
Aug	0.815	0.015	52.9
Sep	0.708	0.016	44.6
Oct	0.480	0.017	27.5
Nov	0.227	0.017	12.9
Constant	5.283	0.034	155.0
Retailer specific fixed effects	Included		
Retailer specific trend terms	Included		
Retailer interactions with monthly dummies	Included		
R-Square	0.93		

NOTE: The large number of coefficients associated with the Retailer fixed effects, Retailer trend terms and Retailer interactions with monthly dummies not shown for the sake of brevity.

Figure C-2. CLWA Valley-Wide Land Use Based Projection: Econometric Model Fit and Forecast



APPENDIX D - LAND USE DEMAND ANALYSIS METHODOLOGY FOR NCWD AND SCWD

This Appendix presents the land use demand analysis methodology steps, TAZ and land use background data, land use demand factors, and projected land use and land use based demand. Also presented is how a water balance was used as check on the basis of appropriate water demand factors using OVOV Study data prepared based on 2004 validated land uses aligned with Retailer water demand and account data.

D.1 Land Use Analysis Steps

As part of this project, the land use assessment was conducted using the following basic steps for the Newhall County Water District and Santa Clarita Water Division:

1. Prepared the GIS analysis using:
    a. Imported City and County provided GIS layers and traffic model level 59 land use categories for existing and planned build-out development,
    b. Imported CLWA and Retailer water service boundary maps,
    c. Appended new annexation and buildout boundary maps provided by NCWD and CLWA
    d. Developed a database of GIS exported data for land use in each service area boundary for 2004 (base year) and OVOV build-out.
2. Reviewed historical water use data to build a water balance for 2004 using retailer supplied billing data by generalized customer categories (SF, MF, Commercial, Industrial, Institutional, Irrigation, Other and Recycled Water).
3. Reviewed previously supplied dwelling unit counts from the Spring 2014 Population Assessment Project.
4. Reviewed historic documents with past demand factors (GSI 2008, 2010), including memorandums and overall boundary maps.
5. Discussed demand factors with CLWA, and received a memo dated November 25, 2014 with proposed demand factors.
6. Prepared weather normalized demand factors for 2004 and 2012 based on adjustment factors provided by Western Policy Research.
7. Adjusted demand factors to match water balance for 2004 based on GIS query of OVOV data.
8. Checked the percentage growth to 2012 based on an updated City of Santa Clarita provided model data (lesser quality than 2004 base year analysis by transportation modeling team).
9. Further tested and checked water balance with 2012 data.
10. Confirmed questions related to historical water use to finalize the water balances with adjusted demand factors.
    a. Residential demand factors are based on historical average gallons per day per account for each Retailer. This demand is only based on interior and exterior building use using per accounting historic billing data.
    b. Commercial demand factors are based on past demand factors provided by Retailers and adjusted to be weather normalized. This demand is only based on interior building use.
    c. Industrial demand is based on historical demand increased by percent future development by land use. This demand is only based on interior building use.
    d. Golf Course and Developed Park demand factors are based on average ETo aligned applied water requirement and 70% watering efficiency.

   e. Future dedicated irrigation (recycled water) was used based on estimates provided by CLWA for availability of recycled water for Newhall Land Development and scaled by the residential development in individual villages. In the case of NCWD and SCWD the growth in irrigation was scaled to future residential growth.

11. Applied planned development for NCWD for future residential development according to an assumed Retailer schedules provided with development occurring between 2014 and 2020 or between 2021 and 2050. Linear interpolation was assumed to occur between 2014-2020 and 2021-2050.
12. Applied land use percentage increase growth by units provided (i.e., dwelling units, thousand square feet) between existing and build-out based on 2013 units growth to 2050 build-out units.

D.2 Processing TAZ and Land Use Data

This section presents the TAZ land use assessment methodology and the land use data by Retailer. The land use data by Traffic Analysis Zone (TAZ) is provided for years 2004, 2012 and build-out in 2050. The land use assessment was conducted by evaluating the land use types in each TAZ to determine what portion of the land use residing in that TAZ was located in each Retailer's service area. Furthermore, the 2014 CLWA Population Assessment provided 2010 Census-based estimates for residential land use types as a basis for comparison and methodology confirmation. Build-out was estimated from the One Vision One Valley Valley-Wide Traffic Study (OVOV). The analysis also included the development of demand factors for each land use type based on aligning with historical water use by land use type provided by or confirmed by the Retailers. In February 2016, VWC decided to pursue using better available development data using GSI's analysis of VWC's only projected development West Side Communities instead of the OVOV study approach.

TAZ Approach Methodology

A TAZ is the unit of geography most commonly used in transportation planning models. Though the size of a TAZ varies, typically a zone of less than 3,000 people is common. The spatial extent of zones varies, ranging from very large areas in undeveloped regions to zones as small as a city block or group of buildings in a central business district.

This project's Phase 2 GIS analysis was conducted by MWM sub-consultant Matt Pegler who coordinated with Retailer GIS specialists, water resources planners, City of Santa Clarita planners and Los Angeles County planners. The OVOV Study build-out land use data to cross reference with the analysis outcomes was provided by Jeff Ford, Water/Environmental Resources Planner at CLWA, and Fred Follstad, Associate Planner at the City of Santa Clarita, in June 2014. Initially, two principal GIS queries were conducted:

- 2004 OVOV-based data on the "built" environment
- Build-out (2050) OVOV-based "forecast" based on a build-ability review at the TAZ level for the Metropolitan Transportation Plan (MTP)

After review with Santa Clarita City Planner, Ian Pare, additional information, including updated GIS files for the TAZ layers with 2012 land use data, was provided in November 2014. According to the City and CLWA, these data contain all the existing development that was actually on the ground and generating traffic in 2012.

Like CLWA's 2010 Census-based 2014 Population Assessment, the Phase 2 Demand Analysis' TAZ assessment followed similar steps:

1. Each Retailer’s service area Geographic Information System (GIS) maps were used for their service area boundaries. Retailer service area boundaries were validated as part of the Spring 2014 Population Assessment.
2. Retailer and CLWA service area maps were super-imposed onto TAZ maps to identify which TAZ’s are included within CLWA’s (and each Retailer’s) service area, which TAZ’s are excluded, and which TAZ’s are bisected by the service area boundaries. This exercise was performed for each analysis year (2004, 2012 and 2050). This step includes applying the associate land use data for each TAZ that is either wholly within or bisected by the Retailer service area boundary or proposed future Retailer service area boundaries.
3. The next step involved dealing with the allocation of the land use types in the conflicted (bisected) blocks. This allocation is done by identifying the proportion of a TAZ that is within the service area and then using this proportion to split the TAZ-level land use type units into the portion that needs to be counted and the portion that falls outside the designated Retailer service area.
4. Once land use was determined and validated for the conflicted TAZ’s, the final step was to add up the land use units in each Retailer’s service area for each land use type by TAZ. Because the blocks are relatively small, the majority of the land use type units are located in non-conflicted TAZ’s which can be summed easily. The remaining land use type units are located in conflicted blocks and are proportionally included.
5. An additional review was conducted of potential future development and some additional dwelling units were accounted for adjacent to NCWD service area boundaries. The GIS analysis uncovered an approximately 16% higher population planned to reside in outlying areas that is not currently planned for annexation.

The following three tables present the GIS logs of each year’s analysis. These logs will allow CLWA and Retailer planners to reproduce this analysis.

Table D-1. Project Log for 2004 Land Use Unit Data

Description	Files, Databases Altered, Notes
Reformat 2004 Unit Type data to join to TAZ Shape file Note: TAZ Shape file contains 18 records that have no TAZ number but do contain other record data	OVOVData.xls Utilized a Macro written by Chris Matyas at MWM to reformat the data
Multiple Entries Found for TAZ 19, Zone 20. There was a duplicate record with unique values 775 and 1430. Until we can receive clarification on this issue we are combining the values	OVOVData.xls
Create a subset shape file of TAZ zones that touch the 2004 CLWA boundary	2004 TAZ Intersects.shp
Join OVOVData.xls to the TAZ shape file (Keep all Records)	
Added AREA_SQ_FT field to database and performed a geometry calculation to determine the Whole SQ_MI Area	2004 TAZ Intersects.shp
Discovered multiple records for same TAZ Zones	115 (2), 178 (2), 180 (4), 213 (3), 214 (3), 279 (2), 386 (2), 418 (2)
Removed multiple TAZ records Items with no area	2004 TAZ Intersects.shp 115, 178, 180, 213, 214, 279, 418
TAZ 386 has two unique boundaries and area values.	
Created union of data with the CLWA boundaries and TAZ zones	CLWA_TAZ_Union.shp
Added a NAREASQFT field and performed a geometric calculation of the TAZ areas split along service boundaries	CLWA_TAZ_Union.shp
Performed a calculation to determine the percentage of the original TAZ. [NAREASQFT]/[AREA_SQ_MI]*100	CLWA_TAZ_Union.shp
Exported The Table to a Comma-Delimited File	2004_TAZ_Unit_Types.csv
Formatted the Comma-Delimited File in Excel to remove unnecessary data	2004 CLWA TAZ Unit Types - Draft.xls

Table D-2. Project Log for 2012 Land Use Unit Data

Description	Files, Databases Altered, Notes
Reformat 2012 Unit Type data to join to TAZ Shape file	2012 LUI.xlsx Utilized a Macro written by Chris Matyas (MWM) to reformat the data
Join 2012 LUI.xlsx to the TAZ shape file (Keep all Records)	
Added AREA_SQ_FT field to database and performed a geometry calculation to determine the Whole SQ_MI Area	TAZ 2012 CLWA.shp
Created union of data with the CLWA boundaries and TAZ zones	CLWA_TAZ_2012_LU_union.shp
Added a NAREASQFT field and performed a geometric calculation of the TAZ areas split along service boundaries	CLWA_TAZ_2012_LU_union.shp
Performed a calculation to determine the percentage of the original TAZ. [NAREASQFT]/[AREA_SQ_MI]*100	CLWA_TAZ_2012_LU_union.shp
Exported The Table to a Comma-Delimited File	CLWA_LU_2012.csv
Formatted the Comma-Delimited File in Excel to remove unnecessary data	CLWA_LU_2012.csv

Table D-3. Project Log for OVOV Build-out Land Use Unit Data

Description	Files, Databases Altered, Notes
Reformat OVOV Unit Type data to join to TAZ Shapefile	OVOVData.xls
Combine annexed features and 2010 CLWA boundaries to create the OVOV CLWA boundaries	CLWA OVOV.shp Source files: 2010 CLWA Boundaries, Legacy Village, Tapia, Tesoro boundaries
Merge Tapia and Tesoro boundaries with NCWC boundary	CLWA OVOV.shp
Merge NCWD Buildout Boundary with NCWC boundary	CLWA OVOV_v2.shp
Create a subset shapefile of TAZ zones that touch the CLWA OVOV boundary	TAZ CLWA OVOV.shp
Join OVOVData.xls to the TAZ shapefile (Keep all Records)	
Added AREA_SQ_FT field to database and performed a geometry calculation to determine the Whole SQ_MI Area	TAZ CLWA OVOV.shp
Note: TAZ Shapefile contains 18 records that have no TAZ number but do contain other record data	
TAZ 386 has two unique boundaries and area values. Require clarification	
Created union of data with the CLWA boundaries and TAZ zones	OVOV_TAZ_CLWA_Union.shp
Added a NAREASQFT field and performed a geometric calculation of the TAZ areas split along service boundaries	OVOV_TAZ_CLWA_Union.shp
Performed a calculation to determine the percentage of the original TAZ. [NAREASQFT]/[AREA_SQ_MI]*100	OVOV_TAZ_CLWA_Union.shp
Exported The Table to a Comma Delimited File	OVOV_CLWA_TAZ_Unit_Types_-_Draft.csv
Formatted the Comma Delimited File in Excel to remove unnecessary data	OVOV_CLWA_TAZ_Unit_Types_-_Draft.csv

Land Use Types and Retailer Estimates

There are 42 types of land uses which include estimates of dwelling units (DU), total square footage (TSF), students (STU), acreage (AC), rooms, and seats by relevant land uses; for example, the number of seats per movie theater, number of students per school, and number of dwelling units in the category of single-family housing with 1-5 du/ac. A list of the types of unit codes included in the transportation model GIS Shape files provided by the City of Santa Clarita and County of Los Angeles is presented in the following table.

As part of this analysis, where necessary some land use categories were further consolidated to align with demand factors and water use data. Since the land use data was generated for transportation models, the land use types with special generator (SG) units are applicable only in transportation planning scenarios and not in water resources planning. Actual water use data were provided by CLWA and the Retailers for these SG land use types.

Table D-4. City of Santa Clarita and County of Los Angeles Transportation Model Land Use Types

Land Use Type	UNITS
Single-Family (<1 du/ac)	DU
Single-Family (1-5 du/ac)	DU
Single-Family (6-10 du/ac)	DU
Condominium/Townhouse	DU
Apartment	DU
Mobile Homes	DU
Senior (Active)	DU
Commercial Center (>30ac)	TSF
Commercial Center (10-30a)	TSF
Commercial Center (<10ac)	TSF
Commercial Shops	TSF
Hotel	ROOM
Sit-Down Restaurant	TSF
Fast Food Restaurant	TSF
Movie Theater	SEAT
Health Club	TSF
Car Dealership	TSF
Elementary/Middle School	STU
High School	STU

Land Use Type	UNITS
College	STU
Hospital	TSF
Library	TSF
Church	TSF
Day Care	STU
Industrial Park	TSF
Business Park	TSF
Manufacturing/Warehouse	TSF
Utilities	TSF
Regional Post Office	TSF
Commercial Office	TSF
High-Rise Office	TSF
Medical Office	TSF
Post Office	TSF
Golf Course	AC
Developed Park	AC
Undeveloped Park	AC
Wayside Honor Ranch[1]	AFY

[1] Wayside ranch has its own water supply.

Residential Land Uses

The number of dwelling units by land use type were separated by Retailer and combined into summary groupings that would allow for Retailer TAZ-based 2004 and 2012 data to be compared to and checked with other available data.

For example, single-family land use type units were totaled by Retailer and compared to the number of SF accounts in 2004 and 2012. The same was done for multi-family land use categories and accounts. The methodology and data from Phase 2 were further verified by comparing 2012 year SF and MF DU from the 2010 Census-based 2014 Population Assessment effort to 2012 TAZ land use values for SF and MF.

Table D-5. Land Use Units versus Number of Accounts – NCWD

Land Use Code and Type / Account Customer Category	Units	Population Assessment 2004 DU[1]	Population Assessment 2012 DU[1]	Projected Future 2020 DUs[2]	Projected Future Buildout DUs[2]
Single Family	DU	7,618	8,606	9,011	14,249
Multi-Family	DU	4,870	4,984	5,696	7,147

[1] SF based on historical accounts. MF based on 2014 Population Assessment DU results.
[2] SF projected units based on CLWA provided Tapia development information through 2020 and OVOV service area buildout estimates. MF values are based on CLWA provided Tesoro development information through 2020 OVOV service area buildout estimates.

Table D-6. Land Use Units versus Number of Accounts – SCWD

Land Use Code and Type / Account Customer Category	Units	Population Assessment 2004 DU[1]	Population Assessment 2012 DU[1]	Projected Future 2020 DUs[2]	Projected Future Buildout DUs[2]
Single Family	DU	19,142	21,538	23,333	30,064
Multi-Family	DU	12,104	13,385	16,091	26,239

[1] SF based on historical accounts. MF based on 2014 Population Assessment DU results.
[2] Projected DU's based on land use category OVOV service area buildout with linear interpolation from historical 2012 values.

Non-Residential Land Uses

Unit water demand factors provided by the Retailers were weather normalized for 2004 and 2012 and applied to 2004 and 2012 TAZ non-residential land use units. The demand factors were adjusted appropriately to create a water balance confirming that total 2004 and 2012 historical water use for non-residential accounts aligned with 2004 and 2012 water use calculated using TAZ non-residential land use 2004 and 2012 units.

Table D-7. Land Use Units – NCWD

Land Use Code and Type	Units	TAZ Analysis 2004 Data	TAZ Analysis 2012 Data	2020 Projection	Build-out Projection
Commercial Center (>30ac)	TSF	266	377	567	1,281
Commercial Center (10-30a)	TSF	389	359	514	1,098
Commercial Center (<10ac)	TSF	111	171	193	276
Commercial Shops	TSF	297	324	375	564
Hotel	ROOM	24	5	56	249
Sit-Down Restaurant	TSF	60	14	24	63
Fast Food Restaurant	TSF	-	4	4	4
Movie Theater	SEAT	-	-	-	-
Health Club	TSF	-	-	-	-
Car Dealership	TSF	-	-	-	-
Elementary/Middle School	STU	3,687	4,042	4,619	6,785
High School	STU	2,273	1,940	1,940	1,940
College	STU	1,479	765	1,035	2,051
Hospital	TSF	81	7	10	25
Library	TSF	17	17	21	34
Church	TSF	153	181	197	256
Day Care	STU	-	-	-	-
Industrial Park	TSF	179	152	1,356	5,870
Business Park	TSF	-	-	339	1,608
Manufacturing/Warehouse	TSF	83	68	82	135
Utilities	TSF	257	87	196	603
Regional Post Office	TSF	-	1	1	2
Commercial Office	TSF	137	62	97	227
High-Rise Office	TSF	-	-	-	-
Medical Office	TSF	-	20	20	20
Post Office	TSF	-	-	-	-
Golf Course	AC	77	0	7	34
Developed Park	AC	3	3	10	36
Undeveloped Park	AC	-	45	66	145

Table D-8. Land Use Units – SCWD

Land Use Code and Type	Units	TAZ Analysis 2004 Data	TAZ Analysis 2012 Data	2020 Projection	Build-out Projection
Commercial Center (>30ac)	TSF	130	564	818	1,773
Commercial Center (10-30a)	TSF	1,785	1,983	2,313	3,550
Commercial Center (<10ac)	TSF	973	1,053	1,120	1,371
Commercial Shops	TSF	509	607	667	896
Hotel	ROOM	0	0	92	436
Sit-Down Restaurant	TSF	15	12	31	101
Fast Food Restaurant	TSF	5	1	4	11
Movie Theater	SEAT	-	-	-	-
Health Club	TSF	-	-	-	-
Car Dealership	TSF	-	-	-	-
Elementary/Middle School	STU	14,955	14,411	16,025	22,077
High School	STU	7,017	5,510	6,179	8,686
College	STU	11	4,589	5,731	10,011
Hospital	TSF	15	-	-	-
Library	TSF	17	17	17	17
Church	TSF	99	167	194	294
Day Care	STU	-	-	-	-
Industrial Park	TSF	2,147	2,195	2,696	4,575
Business Park	TSF	383	154	677	2,640
Manufacturing/Warehouse	TSF	1,668	1,614	1,876	2,859
Utilities	TSF	122	97	108	151
Regional Post Office	TSF	-	-	-	-
Commercial Office	TSF	109	210	629	2,200
High-Rise Office	TSF	-	-	63	300
Medical Office	TSF	2	103	111	137
Post Office	TSF	-	-	-	-
Golf Course	AC	199	513	524	566
Developed Park	AC	159	156	269	694
Undeveloped Park	AC	-	-	-	-

Dedicated Irrigation

Golf Course and Developed Park 2004 and 2012 demand factors are based on 2004 and 2012 ETo-based applied water requirements with 100% watering efficiency (prior to conservation). The ETo applied water factor for 2004 was 6.04 ft/yr and 5.8 ft/yr for 2012. The Undeveloped Park demand factor was provided by the Retailers. Values were further weather normalized using factors presented in the following section.

Table D-9. Baseline Irrigation Demand (before conservation)

Land Use Type	Retailer-Provided GPD/AC	MWM Developed 2004 GPD/AC	MWM Developed 2012 GPD/AC
Golf Course	2,680	5,215	4,908
Developed Park	3,580	5,215	4,908
Undeveloped Park	200	194	190

D.3 Normalized Land Use Demand Factors

The Phase 2 analysis included the development of demand factors for each of the land use types shown in the previous table; these demand factors are based on historical water use. Land use demand factors were generated from historical billing data provided by Retailers for various land use and account types. Land use demand factors were tested in historical years 2004 and 2012 and normalized for weather and economic conditions in those years.

MWM worked with CLWA, Retailers and Los Angeles County/City land use and water planners. A critical step in was conducting more analysis demand factors by aligning billing data with water connections and current and future land use types to validate that usage patterns from the demand factors in the study were aligned with how water actually being used by these customer categories.

Western Policy Research provided the adjustment factors based on the econometric models for purpose of adjusting demand factors used in the water balances for years in years 2004 and 2012, where available land use and historical water billing data was available. These adjustment factors were taken as approximations and in some cases weight averaged to align with demand factors as necessary to make the water balances match as best as possible. These adjusted demand factors were then carried forward into analysis to develop the future demand projections.

Table D-10. Economic Adjustment Factors

		Correction Factor to GPCD in given year				
Year	**LA County Unemployment Rate[1]**	**LACWD**	**NCWD**	**SCWD**	**VWC[2]**	**Average as percent**
2004	6.5	0.976	0.971	0.978	0.977	**2.49%**
2012	10.9	1.062	1.076	1.057	1.060	**-6.37%**
		Total Difference				**-8.86%**

[1]Normal LA County unemployment rate is assumed to be 7.55%, which is what LA County is expected to return to in 2020.
[2]Economic adjustment factors were NOT used in determining VWC's 2013-buildout demand. Demand from 2013 buildout is based on the West Side Communities demand analysis conducted by GSI in March 2016.

Table D-11. Weather Normalization Factors

	WN Factors by Customer Class in Key Calibration Years					WN factor for total production
Year	SF	MF	CII	IRR	Weighted Average (CII & IRR)	
VWC*						
2004	-3.13%	-2.52%	-0.67%	-5.24%	-3.23%	-1.73%
2012	-3.46%	-1.79%	-2.25%	-7.31%	-5.19%	-3.64%
NCWD						
2004	-3.07%	-1.93%	-3.12%	-5.51%	-4.30%	-1.65%
2012	-4.08%	-1.33%	-3.22%	-7.71%	-5.78%	-3.29%
SCWD						
2004	-3.07%	-1.93%	-3.12%	-5.51%	-4.70%	-1.89%
2012	-4.08%	-1.33%	-3.22%	-7.71%	-6.41%	-3.54%

*Weather normalization factors were NOT used in determining VWC's buildout demand. VWC demand by land use type at buildout is based GSI's Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

A thorough analysis of available data yielded a water balance assessment comparing 2012 historical consumption to 2012 calculated water use based on 2014 Population Assessment 2012 DUs, TAZ non-residential land use 2012 units multiplied by unit water demand factors. Phase 2 Retailer unit water demand factors in gallons per day per unit (GPD/Unit) are presented in the following tables.

Table D-12. Normalized Water Demand Factors

Land Type*	Units	NCWD (GPD/Unit)	SCWD (GPD/Unit)
Single Family (<1/DU/ac)	DU	593	557
Single Family (5-10 DU/ac)	DU	593	557
Single Family (6-10 DU/ac)	DU	593	557
Multi-Family (Condominiums)	DU	252	211
Multi-Family (Apartment, Mobile Homes, Senior (Active))	DU	252	211
Commercial Center (>30ac)	TSF	207	210
Commercial Center (10-30a)	TSF	207	210
Commercial Center (<10ac)	TSF	207	210
Commercial Shops	TSF	207	210
Hotel	ROOM	104	105
Sit-Down Restaurant	TSF	311	314
Fast Food Restaurant	TSF	207	210
Movie Theater	SEAT	5	5
Health Club	TSF	5	5
Car Dealership	TSF	207	210
Elementary/Middle School	STU	5	5
High School	STU	21	21
College	STU	21	21
Hospital	TSF	415	419
Library	TSF	104	105
Church	TSF	104	105
Day Care	STU	311	314
Industrial Park	TSF	259	262
Business Park	TSF	259	262
Manufacturing/Warehouse	TSF	259	262
Utilities	TSF	207	210
Regional Post Office	TSF	71	72
Commercial Office	TSF	207	210
High-Rise Office	TSF	207	210
Medical Office	TSF	207	210
Post Office	TSF	9	9
Golf Course	AC	5,365	5,649
Developed Park	AC	5,365	5,649
Undeveloped Park	AC	207	210

* Land use categories have actual annual water use provided to align calculated 2012 demands with historical 2012 consumption, refining the water balance.

D.4 Projected Land Use Based Demand

Land use units projection based on OVOV and/or developer build-out estimates and GIS analysis to isolate Retailer-specific values are presented in the following table. Water demands for each type, based on the demand factors introduced in the previous section, are also shown.

Table D-13. Projected Land Use Water Demand (AFY) – NCWD*

Land Use Code and Type	2020 Demand (AFY)	2050 Buildout Demand (AFY)	Comments
Single Family (<1/DU/ac, 5-10 DU/ac, 6-10 DU/ac)	5,984	9,462	Consolidated all SF land use categories and aligned with average use based on 2012 normalized demand factor
Multi-Family (Condo & Apartment, mobile home, senior)	1,605	2,014	Consolidated all SF land use categories and aligned with average use based on 2012 normalized demand factor
Commercial Center (>30ac)	132	297	
Commercial Center (10-30a)	119	255	
Commercial Center (<10ac)	45	64	
Commercial Shops	87	131	
Hotel	7	29	
Sit-Down Restaurant	8	22	
Fast Food Restaurant	1	1	
Movie Theater	-	-	
Health Club	-	-	
Car Dealership	-	-	
Elementary/Middle School	27	39	
High School	45	45	
College	24	48	
Hospital	5	12	
Library	2	4	
Church	23	30	
Day Care	-	-	
Industrial Park	393	393	
Business Park	98	467	
Manufacturing/Warehouse	24	39	
Utilities	45	140	
Regional Post Office	0	0	
Commercial Office	23	53	
High-Rise Office	-	-	
Medical Office	5	5	
Post Office	-	-	
Golf Course	-	-	
Developed Park	62	219	
Undeveloped Park	15	34	

* Table presents land use category demand only since Appendix D solely presents land-use based methodology. Two water using components of irrigation (approximately 4,200 AF) and non-revenue water (approximately 1,200 AF) are not included in the above table, but are included in total projected demand as presented in Appendix A are irrigation and non-revenue water.

Table D-14. Projected Land Use Water Demand (AFY) – SCWD*

Land Use Code and Type	2020 Demand (AFY)	2050 Buildout Demand (AFY)	Comments
Single Family (<1/DU/ac, 5-10 DU/ac, 6-10 DU/ac)	14,546	18,742	Consolidated all SF land use categories and aligned with average use based on 2012 normalized demand factor
Multi-Family (Condo & Apartment, mobile home, senior)	3,806	6,206	Consolidated all SF land use categories and aligned with average use based on 2012 normalized demand factor
Commercial Center (>30ac)	192	416	
Commercial Center (10-30a)	543	834	
Commercial Center (<10ac)	263	322	
Commercial Shops	157	210	
Hotel	11	51	
Sit-Down Restaurant	11	36	
Fast Food Restaurant	1	3	
Movie Theater	-	-	
Health Club	-	-	
Car Dealership	-	-	
Elementary/Middle School	94	130	
High School	145	204	
College	135	235	
Hospital	-	-	
Library	2	2	
Church	23	34	
Day Care	-	-	
Industrial Park	396	671	
Business Park	199	775	
Manufacturing/Warehouse	551	839	
Utilities	25	36	
Regional Post Office	-	-	
Commercial Office	148	517	
High-Rise Office	15	70	
Medical Office	26	32	
Post Office	-	-	
Golf Course	3,316	3,580	
Developed Park	1,704	4,389	
Undeveloped Park	-	-	

* Table presents land use category demand only since Appendix D solely presents land-use based methodology. Two water using components of irrigation (approximately 7,200 AF) and non-revenue water (approximately 3,800 AF) are not included in the above table, but are included in total projected demand as presented in Appendix A are irrigation and non-revenue water.

APPENDIX E - LAND USE DEMAND ANALYSIS METHODOLOGY FOR VWC

This Appendix E presents the land-use based demand projection approach for Valencia Water Company based on direction provided by VWC. In February 2016, VWC provided updated projected 2017-2034 land use development parameters per its anticipated West Side Communities Development residential units, non-residential acreage, demand factors, residential people per household, and demands were provided by land use type in the GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

Projected West Side Communities Development residential units by year 2020 and year 2034 (buildout) were provided in Table 2020 and Table 2034 in the "Estimated Residential Land Uses and Occupancy Rates for West Side Communities (9 Villages Combined)" updated February 13, 2016. The percentage of residential units constructed by year 2020 and after year 2020 was 4% and 96%, respectively. This residential development schedule was likewise applied uniformly to non-residential growth timing. (GSI, personal communication, 2016).

VWC projected population is based on a people per household (PPH) estimate derived from average SF attached, SF detached, and MF attached people per household for more recently developed communities including: Bridgeport, North Park, and Stevenson Ranch in the "Single Family and Multi-Family Persons Per Household Assessment" based on 2010 US Census Block Data as shown in the GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016). These PPH estimates were applied to the projected West Side Communities residential units as is shown in the following Table E-1.

Table E-1. West Side Communities Residential Dwelling Units and Population

	Dwelling Units*				Population		
	Near-term 2017-2020	Remaining 2021-2034	2017-2034 (Total)	2017-2034 PPH*	Near-term 2017-2020	Remaining 2021-2034	2017-2034 (Total)
Single Family (<1 du/ac)	-	589	589	3.29	-	1,939	1,939
Single Family (1-5 du/ac)	65	3,134	3,199	3.29	214	10,317	10,531
Single Family (6-10 du/ac)	-	3,351	3,351	3.29	-	11,032	11,032
Total SF	**65**	**7,074**	**7,139**	**N/A**	**214**	**23,288**	**23,502**
Condominium /Townhouse	215	9,809	10,024	2.37	509	23,219	23,728
Apartment	590	3,747	4,337	2.10	1,241	7,879	9,120
Total MF	**805**	**13,556**	**14,361**	**N/A**	**1,750**	**31,098**	**32,848**
Total	**870**	**20,630**	**21,500**	**N/A**	**1,964**	**54,386**	**56,350**

* Source: Attachment 3. Table A-2. GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

The number of dwelling units by residential land use type were combined into summary groupings that would allow for VWC TAZ-based 2004 and 2012 data to be compared to and checked with projected West Side

Communities development data. For example, single-family land use type units were totaled and compared to the number of SF accounts in 2004 and 2012. The same was done for multi-family land use categories and accounts. The methodology and data from the land-use based analysis were further verified by comparing 2012 year SF and MF DU from the 2010 Census-based 2014 Population Assessment effort to 2012 TAZ land use values for SF and MF. Table E-2 presents the historical and projected number of SF and MF residential dwelling units in VWC's service area by taking the year 2012 number of dwelling units from the previous TAZ analysis explained earlier and adding the West Side Communities new development residential units as presented in the previous table.

Table E-2. Land Use Units versus Number of Accounts – VWC

Land Use Code and Type / Account Customer Category	Units	Population Assessment 2004 DU[1]	Population Assessment 2012 DU[1]	Projected Future 2020 DUs[2]	Projected Future Buildout DUs[2]
Single Family	DU	23,584	25,962	26,027	33,166
Multi-Family	DU	7,327	8,726	9,531	23,892

[1] As directed by VWC, SF based on historical accounts and MF based on 2014 DU results Population Assessment Memo (Maddaus, 2014).
[2] SF and MF values are based on data provided by VWC in Table 1 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

VWC West Side Communities unit water demand factors in gallons per day per dwelling unit (GPD/DU) are presented in the following table as provided in Table 2 of GSI's March 4, 2016 technical memorandum.

Table E-3. VWC West Side Communities Water Demand Factors

Land Use Type	GPD/DU*
Single Family (<1/DU/ac)	527
Single Family (5-10 DU/ac)	428
Single Family (6-10 DU/ac)	395
Multi-Family (Condominiums)	284
Multi-Family (Apartment, Mobile Homes, Senior (Active))	236

*Source: Table 2 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

Non-residential demands by land use type for the West Side Communities Development were aligned with GSI's Attachment 3. Table C-1 in their Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

The following Table E-4 presents VWC projected West Side Communities Development at buildout by land use types, units, and projections as provided by GSI in their Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

Table E-4. West Side Communities Water Using Land Use Types and Acreage

Land Use Type	New VWC Development Acreage for Water Using Land Use Types between 2013 and Buildout*
Mixed-Use Commercial (Retail)	52
Commercial (Retail)	152
Mixed-Use Commercial (Office)	167
Business Park (Industrial)	246
Hotel/Spa	4
Sr. Assisted Living	11
Visitor Serving	37
Water Reclamation Plant	11
Fire Stations	13
Schools	118
Recreation Centers	54
Neighborhood Parks	119
Lake – Water	0.3
Arterial Highways Landscape Area	243
Irrigated Slopes, Wet Zones	1,004
O.S. LDZ, O.S. Trail LDZ, and SD&SS Easements	55

*Source: Attachment 3. Table A-1 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016). Buildout acreage for water using land use types only includes the entire footprint of the land use type area and NOT only the water using area.

Table E-5a presents projected VWC West Side Communities demand by land use type for the 2017-2020 and 2020-2034 time periods. Non-residential demands by land use type will align with GSI's Attachment 3, Table C-1 in their Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016).

Table E-5a. Projected New Land Use Water Demand (AFY) - VWC*

Land Use Type	VWC 2017-2020 West Side Communities Demands (AFY)	VWC 2021-Buildout West Side Communities Demands (AFY)	VWC 2017-Buildout West Side Communities Demands (AFY)
Single Family (<1/DU/ac)	-	350	350
Single Family (5-10 DU/ac)	30	1,530	1,560
Single Family (6-10 DU/ac)	-	1,480	1,480
Multi-Family (Condominiums)	70	3,190	3,260
Multi-Family (Apartment)	160	1,150	1,310
Subtotal Residential	260	7,700	7,960
Mixed-Use Commercial (Retail)	3	80	80
Commercial (Retail)	30	720	750
Mixed-Use Commercial (Office)	20	410	430
Business Park (Industrial)	50	1,160	1,210
Hotel/Spa	3	60	60
Sr. Assisted Living	5	120	130
Visitor Serving	3	60	60
Water Reclamation Plant	1	10	10
Fire Stations	2	50	50
Schools	8	200	210
Subtotal Nonresidential	125	2,870	3,000
Recreation Centers	8	210	220
Neighborhood Parks	19	460	480
Lake - Water	0.1	2	-
Landscape Area	180	4,350	4,530
Subtotal Recreation, Arterials, and Open Space	200	5,020	5,220
Total	570	15,590	16,160

* Source: Buildout demand based on Attachment 3. Table C-1 of GSI Technical Memorandum "Updated Water Demand Projections for West Side Communities (Valencia, California)" (GSI, March 4, 2016). VWC provided estimated distribution of 4% of new development is planned for before year 2020 with the remaining 96% planned for after 2020 through buildout year 2034.

West Side communities non-residential land use type demands were aligned with 2004 and 2012 land use categories as best as possible with the primary goal of aligning the land use types into the correct non-residential billing categories as presented in Table E-5b. In addition, Table 5b takes results from refined econometric models developed for CLWA's Retailers to project demand out to 2020, refer to Section 4 and Appendix C for more explanation on the influence of these models for each Retailer on their demand forecasts. The VWC econometric model and recently added new accounts since 2012 are the basis for any differences between Table 5a and Table 5b. The table presents historical and projected demand by VWC customer account categories. For VWC, all West Side Communities projected land use types falling into the "Recreation, Arterials, Open Space" non-residential subcategory was projected to use recycled water.

Table E-5b. Projected Customer Category Water Demand (AFY) - VWC*

Customer Category	Demand (AFY)				Comments
	2004	2012	2020	Buildout	
Single Family	13,800	14,300	14,400	17,700	Includes SF unit <1/DU/ac, 5-10 DU/ac, 6-10 DU/ac)
Multi-Family	1,300	1,600	1,800	6,100	Includes MF condominiums, townhouses, and apartments)
Commercial	4,100	4,800	5,100	6,500	Includes non-residential land use types
Industrial	1,600	1,600	1,700	2,700	Includes non-residential industrial land use types
Institutional	800	800	800	1,200	Includes non-residential institutional land use types
Irrigation	6,300	6,400	6,400	6,400	Irrigation total account type use did not change from year 2012 levels – as new irrigation demands are expected to be met by recycled water deliveries.
Other	100	40	40	50	Includes utility site demands.
Recycled	110	800	1,000	6,100	Includes all West Side Communities recreation, arterials, and open space demands.
Subtotal	**28,110**	**30,340**	**31,240**	**46,750**	
Non-Revenue Water	1,500	1,600	1,700	2,500	NRW is estimated to be approximately 5% based on VWC's AWWA Water Audit analysis 2011-2012.
Total	**29,610**	**31,940**	**32,940**	**49,250**	

MADDAUS WATER MANAGEMENT INC.

Prepared for: Stephanie Anagnoson, Castaic Lake Water Agency

Project Title: Population Assessment – GPCD Review

Subject: **CLWA Population Assessment and GPCD Review**

Date: November 20, 2014

From: Lisa Maddaus, Maddaus Water Management

Reviewed: Anil Bamezai, Western Policy Research

1. Executive Summary

Maddaus Water Management (MWM Team) has prepared an assessment of population for the purpose of tracking water consumption on a gallons per capita per day (GPCD) basis, by the Santa Clarita Valley Water Suppliers (retail agency) within the Castaic Lake Water Agency (CLWA) service area. This assessment was conducted using United States Census block data from the years 2000 and 2010. The population assessment was conducted by evaluating the population in each census block to determine what portion of the population residing in that block was located in a particular retail agency service area. The population assessments were verified by using high resolution aerial maps to visually review census blocks which contained more than one service area. Agency specific populations from the map verified review are as follows:

Agency	2000 Population	2010 Population	Growth
Newhall County Water District	34,859	45,036	29%
Santa Clarita Water Division	87,455	115,296	32%
Valencia Water Company	63,922	92,851	45%
Los Angeles County Water District	3,512	5,046	44%
Total	**189,748**	**258,229**	**36%**

It is noteworthy that for the year 2010, the total population was determined to be 258,229, which is approximately 10% lower than the population estimate of 286,751 which was identified in the area's 2010 Urban Water Management Plan. A similar pattern was seen for the year 2000 where the population was estimated at 189,748, versus the 2000 UWMP population of 207,690 (difference of approximately 8.6%)

This population assessment updated both population and people per household estimates which supported determining GPCD estimates. In tracking GPCD, the primary project driver is the SB X7-7 20x2020 compliance requirements that require calculation using population in future UWMPs including tracking of: baseline GPCD (10 years between 1994 and 2010), a 2015 target, and a 2020 target. Since Los Angeles County Water District does not have 3,000 AF served or 3,000 connections and SB X7-7 does not apply, and GPCD target analysis was not performed.

GPCD targets for the retail agencies primarily increased given that the adjusted population was less. GPCD presented for baseline, targets and 2013 recalculated GPCD values based on updated data and are as follows:

Agency	Baseline GPCD	2015 GPCD Target	2020 GPCD Target	Current 2013 GPCD
Newhall County Water District	238	214	190	207
Santa Clarita Water Division	251	226	201	221
Valencia Water Company	335	301	268	295

The following charts present baseline, 2015 and 2020 targets as well as 2013 recalculated GPCDs based on updated population data. Only actual water demand is presented for Los Angeles County Water District, due its' not being required to have demand targets.

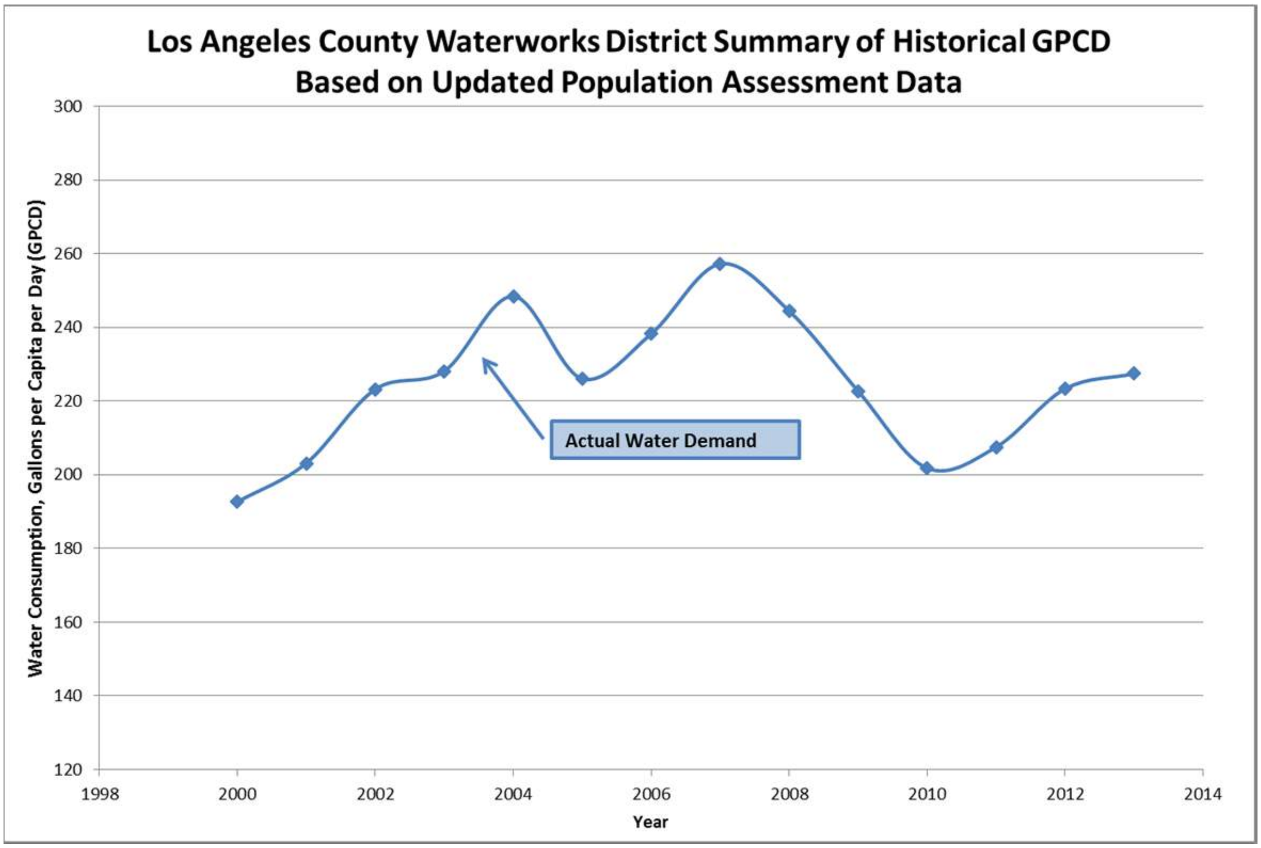


Figure 1: Los Angeles County Water District Summary of Historical GPCD Based on Updated Population Data

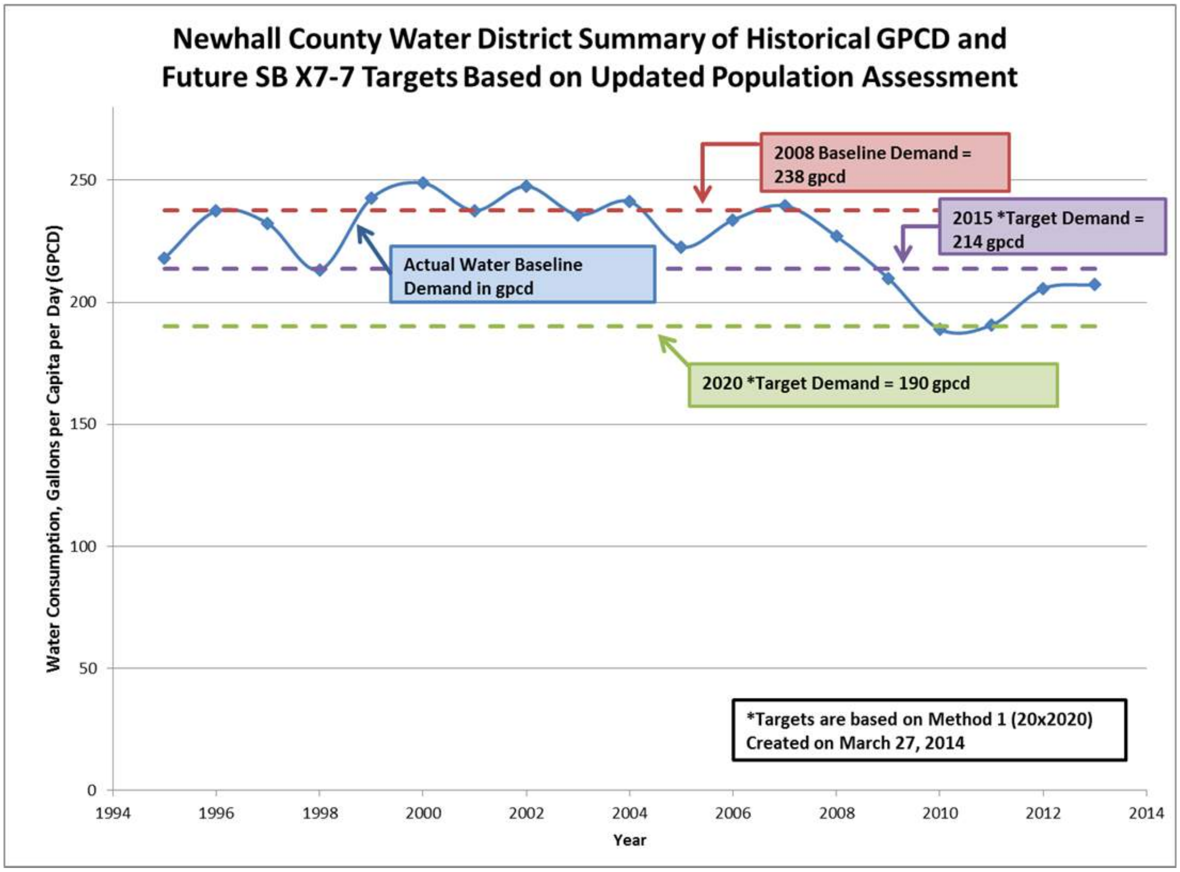


Figure 2: Newhall County Water District Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

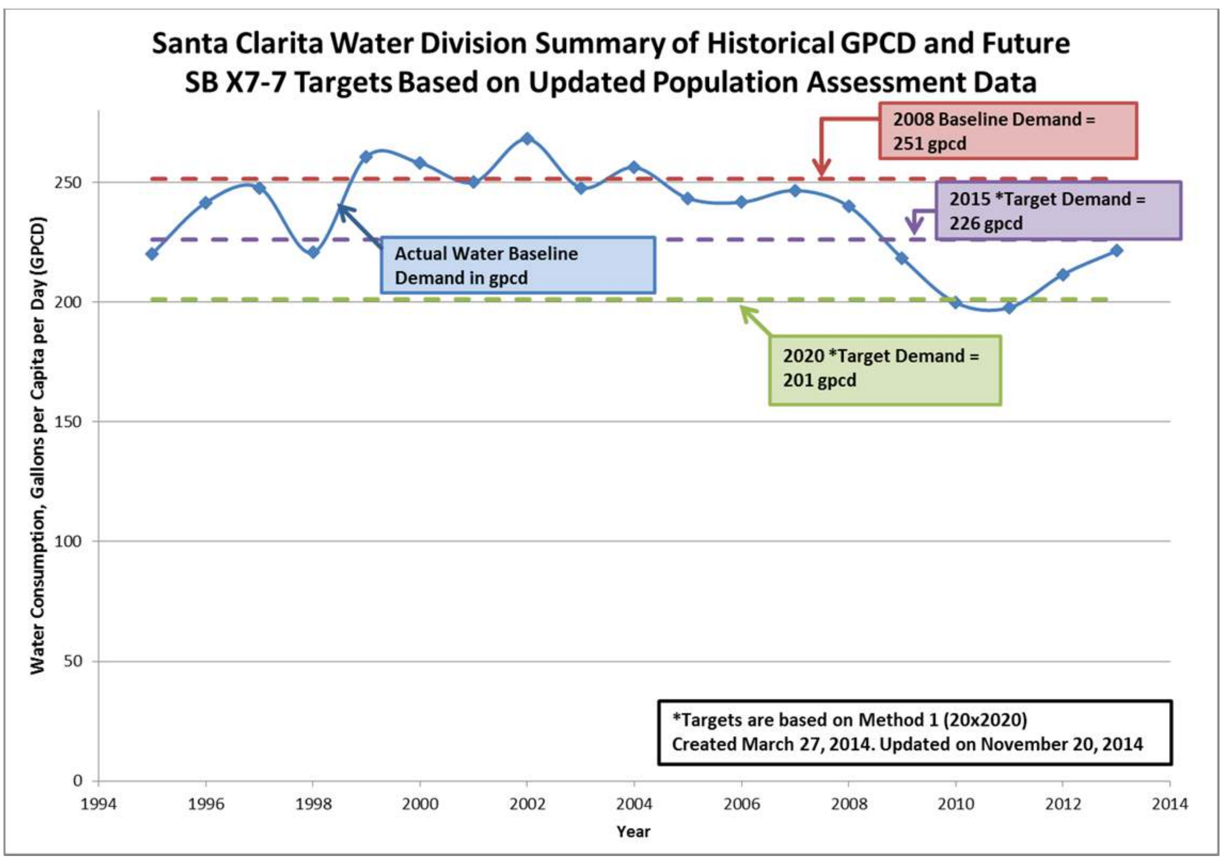


Figure 3: Santa Clarita Water Division Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

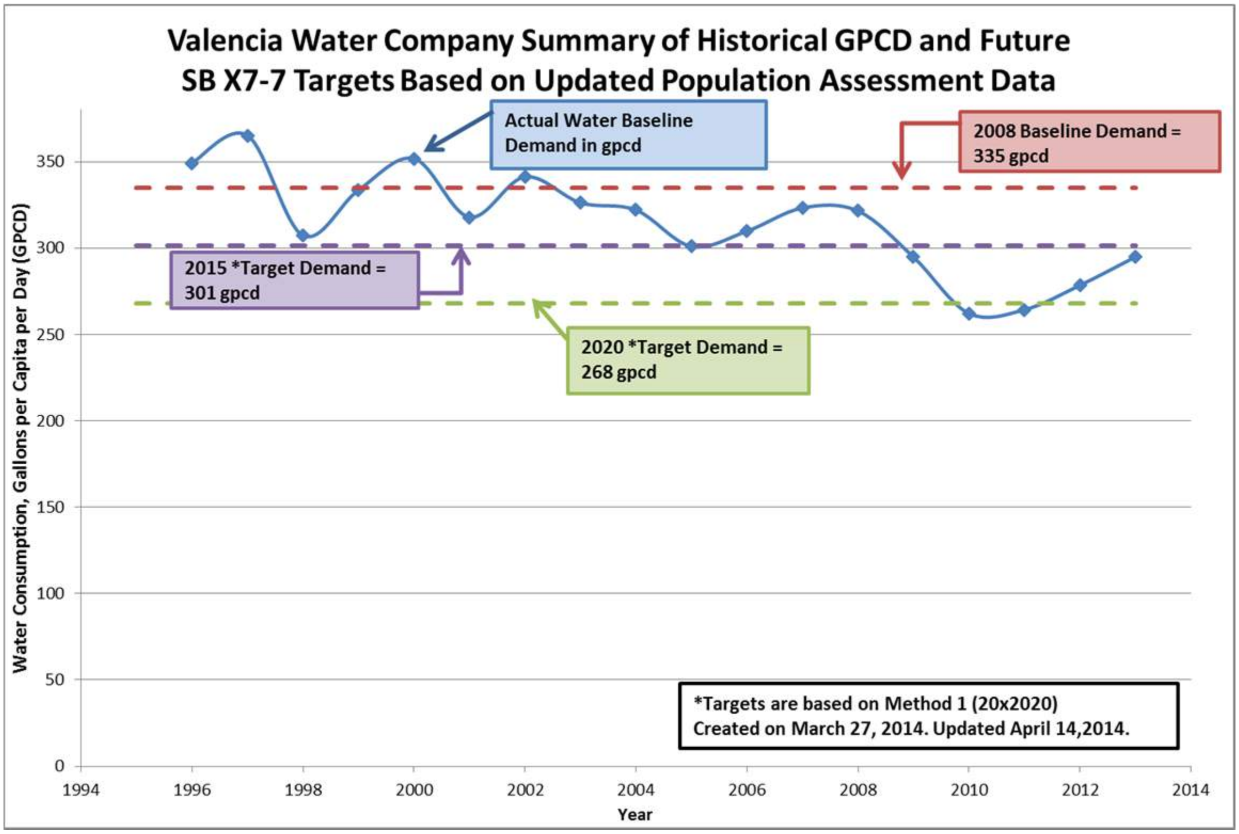


Figure 4: Valencia Water Company Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

2. Introduction

The MWM team was retained by Castaic Lake Water Agency (CLWA) to perform a population assessment which would identify the population of the four constituent water purveyors of the CLWA service area. These population estimates would then be used to validate existing or provide the basis for updating the 2010 UWMP demand forecasts and GPCD targets, and consequently used in the design of the Water Use Efficiency Strategic Plan for deciding on future investments in water conservation. The population was to be prepared for the years 1990, 2000, and 2010, which are the three most recent years for which United Stated Census data is available.

3. Approach

Two methodologies were identified to perform the population assessment: (1) a Numerical Approach and (2) a Map Based approach. In either scenario, the population assessment is reliant on the availability of census data which identifies population at the census “block” level. A census “block” is the smallest geographical area for which census data is tabulated and reported. Census blocks are areas bounded on all sides by visible features, such as streets, roads, streams, and railroad tracks, and by invisible boundaries, such as city, town, township, and county limits, property lines, and short, imaginary extensions of streets and roads. In highly urbanized areas, a block may literally be the size of a city block, but may be much larger in suburban or rural areas where populations are less dense. Analysis on a block level, versus the large geographic areas provided by census block groups or census tracts is advantageous because it minimizes the population in blocks that are bisected by a service area boundary, or “conflicted” blocks, and can therefore not be easily tabulated in a spreadsheet.

After review of the available Census and boundary map data it has been determined that a population assessment for the 1990 census year by the methods outlined above is not feasible at this time. The reasons for this are that census block data with reliable population figures are unavailable, as is any suitable aerial mapping. For these reasons, population assessments have been prepared for the years 2000 and 2010 only.

Census Block Level Approach (Numerical Method):

This method closely follows DWR's guidelines for estimating population for CLWA as a whole, and for each of its retailers. DWR's methodology involves several steps.

The first step involves creating/validating each retailer's service area Geographic Information System (GIS) maps for their service area boundaries. The second step is to superimpose these service area maps onto the US Census Bureau's electronic provided maps associated with the demographic data (including population) to identify which census blocks are included within CLWA's (and each retailer's) service area, which are excluded, and which are bisected by the service area boundaries. This exercise needs to be performed twice, once for each census year (2000 and 2010).

The second step involves obtaining population data for each block that is either wholly within or bisected by the service area boundary. This step needs to be performed for both census years, and involves downloading relevant data from the US Census Bureau's website.

The third step involves dealing with allocation of the population in the conflicted (bisected) blocks. Generally, this allocation is done by identifying the proportion of a block that is within the service area and then use this proportion to split the block-level population into the portion that needs to be counted and the portion that falls outside the service area (see example below).

Once population was determined and validated for the conflicted blocks, the final step was to add up the population in each service area by census block. Because the blocks are relatively small, the majority of the population is located in non-conflicted blocks which can be summed easily. The remaining population is located in conflicted bocks which must be tabulated, as illustrated below:

Census Block	NCWD Pop.	VWD Pop.	SCWD Pop.	LAD36 Pop.	Total
1000	xx	xx	xx	xx	xx
1001	xx	xx	xx	xx	xx
1002	xx	xx	xx	xx	xx
1003	xx	xx	xx	xx	xx
…….	…..	…..	…..	…..	…..
Total	**xx**	**xx**	**xx**	**xx**	**xx**

2010 Map Verification Approach:

In order to verify that the numerical method described above in providing an accurate assessment of population, MWM performed a comprehensive review of all conflicted blocks using aerial imagery onto which service area boundaries and census block boundaries have been superimposed. The 2010 service area has a total of 2966 blocks, of which 367 are conflicted. Of those, 182 contain no population and therefore require no review, leaving 185 which required visual verification. The visual verification is done by viewing an aerial image of the conflicted block in order to determine what proportion of the population of that block lives in one service area versus another.

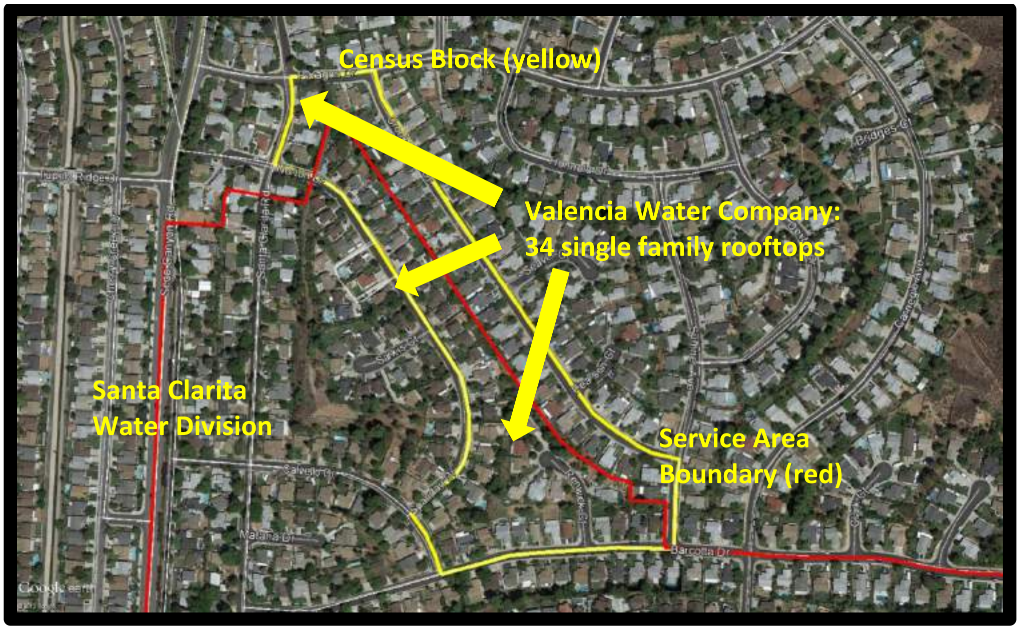


Figure 5: Visual Verification of Tract 9200.18, Block 1003

Tract 9200.18, Block 1003 is taken as an example. The numerical approach described above would use a GIS query which superimposes the service area boundary and the census block boundary to determine that out of the total land area of block 1003, 41.1% is within the Valencia service area, and 58.9% is in the Santa Clarita service area. According to the 2010 U.S. Census, the total population for this block is 220 people. No mapping is used for this process. The population attributable to each service area is then calculated:

Valencia Population in Block 1003 = 41.1% x 220 = 90 people
Santa Clarita Population in Block 1003 = 58.9% x 220 = 130 people

The numerical method can then be checked by reviewing aerial imagery. Again, from the 2010 U.S. Census, it can be determined that the total block population is 220, and the average persons per household for the Block Group: 2.78. From the aerial view, 34 single family household rooftops are visible in on the Valencia side of the conflicted block. The total population within the block who are served by Valencia is then calculated as:

Valencia Population in Block 1003 = 2.78 x 34 = 94 people

The population served by Santa Clarita is then calculated by subtracting the portion served by Valencia from the block total:

Santa Clarita Population in Block 1003 = 200 – 94 = 126 people

If the map verification method is accepted as “correct”, then the numerical method has calculated the population to within 95% accuracy. However, it is important to note that 83% of the CLWA population lives in census blocks that are not conflicted. That portion of the population can be tabulated with 100% accuracy. The error introduced by using a numerical method (less than 5% in the example above) only occurs in conflicted blocks. As a result, the overall results of a population assessment conducted by the numerical approach are quite accurate.

The map verification process for the 2010 population assessment lead to two modifications to the criteria used in step 3 of the numerical approach:

It was observed during the visual review of the 185 conflicted blocks containing a population that in cases where a block was conflicted between a service area and a non-service area, in the vast majority of cases the entire population were located within the service area. This makes intuitive sense because it would not be expected to encounter a large population living in an area not served by a water purveyor. In these cases the entire block population is ascribed to the service area portion of the conflict, regardless of land area.

It was also observed that in the instances where a block was conflicted by two service areas and one of the service areas constituted a very small proportion of the land area (<2%), it was almost always because the service area with the small land area conflict only had an incidental conflict. Examples would be where the centerline of a roadway might define a service area boundary but the back of sidewalk defines the census block boundary. The "conflict" is then only that area in the roadway between the back of walk and the centerline, where there is obviously no population. In these cases the entire block population is ascribed to the larger service area portion of the conflict, regardless of land area.

2000 Map Verification Approach:

Another general observation was that after conflicted blocks with zero population are removed, and the population within conflicted blocks falling into one of the two categories above is tabulated, very few blocks actually require a detailed and rigorous visual verification. This observation turned out to be useful due to the lack of readily available high quality and cost effective aerial mapping for the year 2000.

Because of the limited (cost effective) aerial mapping available for 2000, the MWM team elected to refine the map verification process for the year 2000 to make it less reliant on aerial images. A review of the results of the 2010 population assessment revealed that accurate results could be obtained by implementing modifications to the numerical approach, as described above, and also limiting visual verification to only those conflicted blocks with a population of 500 or greater. Purchasing aerial imagery, overlaying GIS layers, and conducting the subsequent analysis is a relatively resource intensive process which is more appropriate for situations where large errors are possible due to the presence of a large population. As can be seen with the map verification example above, detecting an error of only 4 people out of a total population greater than 100,000 is not a good return on the investment of resources needed to detect the error. By using the method described here, it was determined that the 2010 population assessment could be completed to better than 98% accuracy. These results indicate that a similarly accurate population assessment for 2000 is possible by this method.

4. Results

The population assessment for the year 2000 and 2010 yielded the following results:

Agency	2000 Population	2010 Population	Growth
Newhall County Water District	34,859	45,036	29%
Santa Clarita Water Division	87,455	115,296	32%
Valencia Water Company	63,922	92,851	45%
Los Angeles County Water District	3,512	5,046	44%
Total	**189,748**	**258,229**	**36%**

It should be noted that the census based population assessment performed here shows population which is generally less than the populations shown in the 2000 and 2010 UWMP's. The UWMP's have populations which are approximately 10 percent higher than the populations found during this study. More detailed results are available in Appendix A.

Agency	2000 Population Assessment	2000 UWMP Population	2000 Difference	2010 Population Assessment	2010 UWMP Population	2010 Difference
NCWD	34,859	34,121	2.2%	45,036	44,316	1.6%
SCWD	87,455	93,128	-6.1%	115,296	124,192	-7.2%
VWC	63,922	77,476	-17.5%	92,851	113,296	-18.0%
LACWD	3,512	2,965	18.4%	5,046	4,947	2.0%
Total	**189,748**	**207,690**	**-8.6%**	**258,229**	**286,751**	**-9.5%**

There are several factors that are most likely contributing to the difference in the population figures. The method of population computation for the 2010 UWMP is documented as an extrapolation based on a population assessment for the year 2000. MWM understands that the year 2000 account data by retail service area was escalated by annual account growth and dwelling unit persons per household (PPHH) factor of 3.31 to determine 2010 population. Based on a review of US Census prepared by the Maddaus Water Management team, the actual PPHH for the service is, on average, significantly lower than 3.31. Additional differences in the previous estimates used in Urban Water Management Plan may have been introduced by a difference in actual population growth compared to assumed population growth and/or error in the original population assessment in the year 2000, upon which the extrapolation was based.

The population computation method used in the 2000 UWMP was not reviewed in detail, but is likely to have much of the same methodology. The GPCD analysis presented for baseline, targets and 2013 recalculated GPCD values based on updated data yielded the following results:

Agency	Baseline GPCD	2015 GPCD Target	2020 GPCD Target	Current 2013 GPCD
Newhall County Water District	238	214	190	207
Santa Clarita Water Division	251	226	201	221
Valencia Water Company	335	301	268	295

GPCD values for Santa Clarita Water Division and Valencia Water Company increased given that the adjusted population was less than the 2010 UWMP estimate. GPCD values for Newhall County Water District decreased given that the adjusted population was higher than the 2010 UWMP estimate. 2010 UWMP GPCD values are from Tables 2-15, 2-17, 2-19.

Agency	Baseline GPCD			2015 GPCD Target			2020 GPCD Target		
	Adjusted	2010 UWMP	% Diff	Adjusted	2010 UWMP	% Diff	Adjusted	2010 UWMP	% Diff
NCWD	238	244	-2.52%	214	229	-7.01%	190	195	-2.63%
SCWD	251	235	6.00%	226	212	5.78%	201	188	6.00%
VWC	335	278	17.01%	301	250	16.94%	268	222	17.16%

The following charts present baseline, 2015 and 2020 targets as well as 2013 recalculated GPCDs based on the updated population data. Only actual water demand is presented for Los Angeles County Water District since due its size, SB x7-7 does not apply.

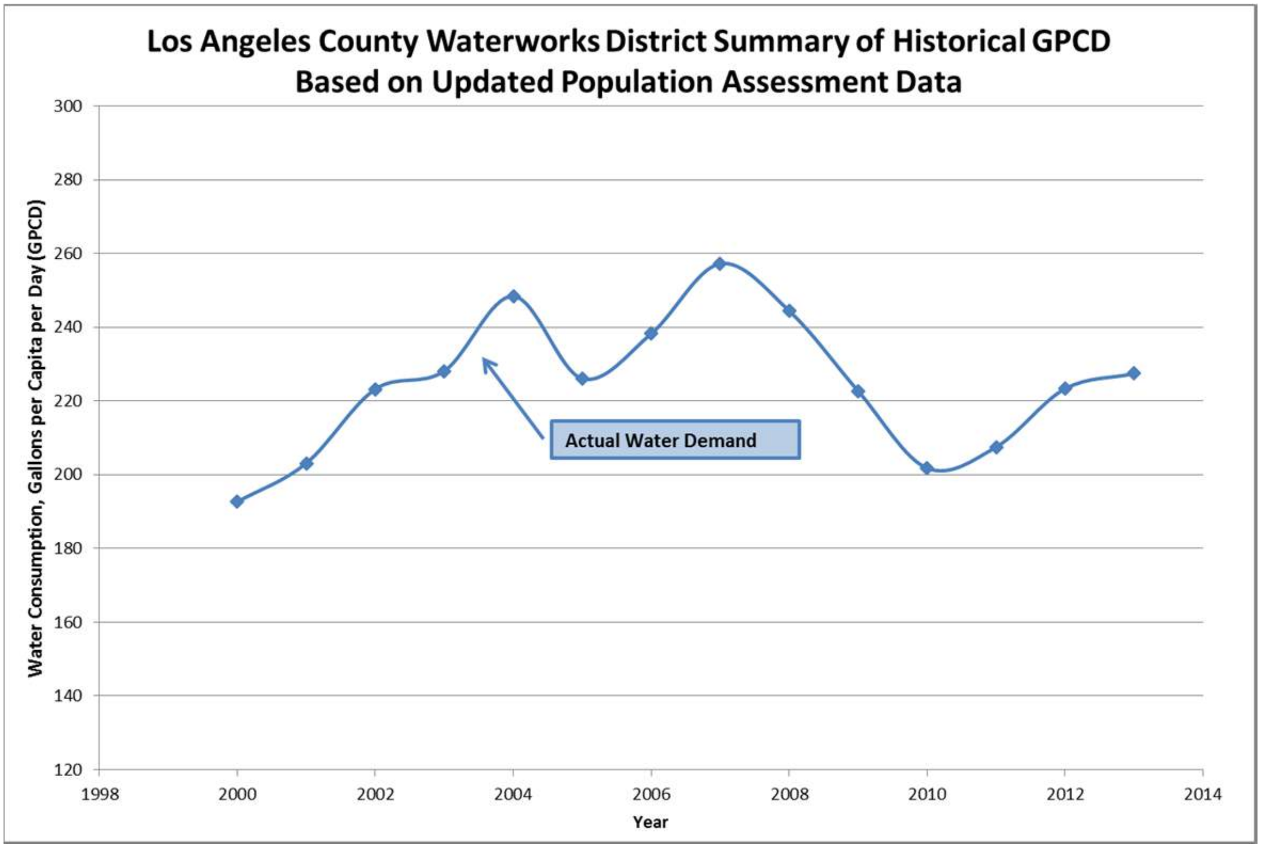


Figure 6: Los Angeles County Water District Summary of Historical GPCD Based on Updated Population Assessment Data

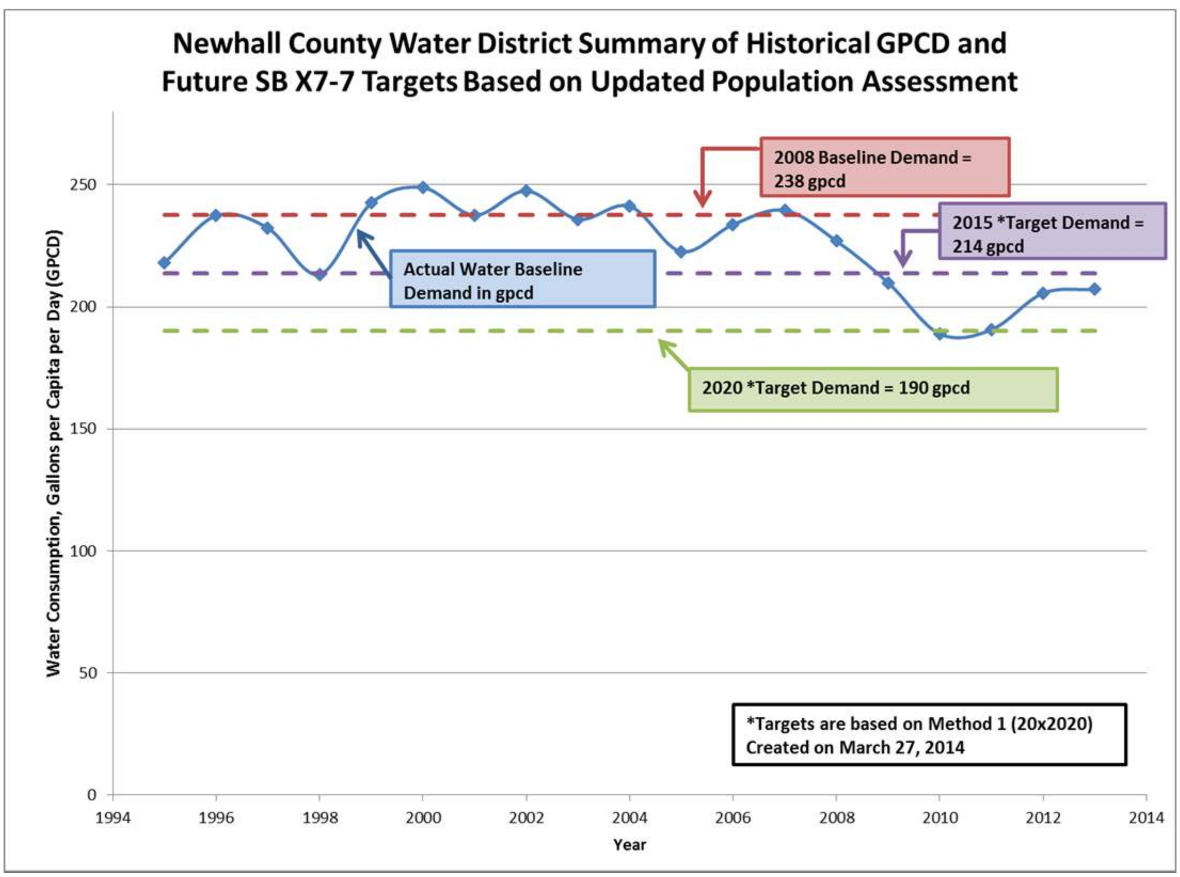


Figure 7: Newhall County Water District Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

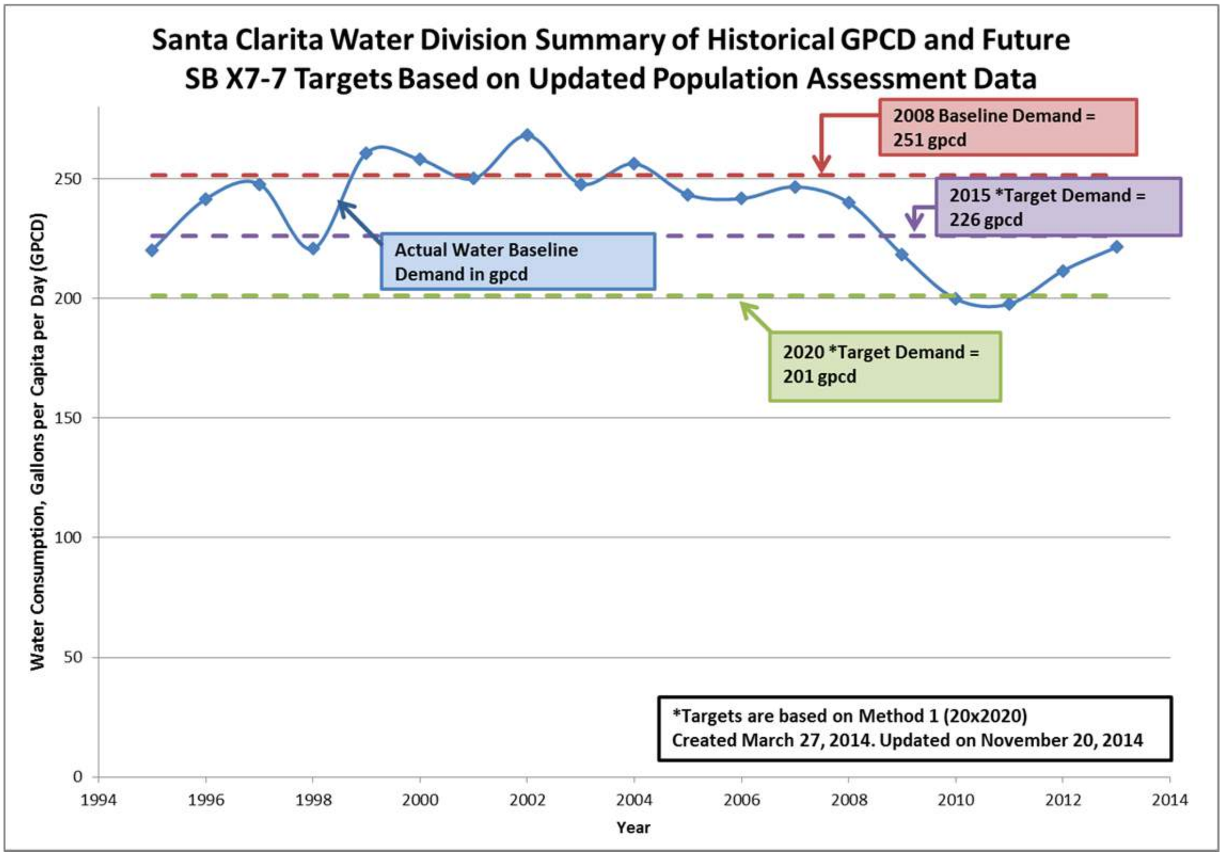


Figure 8: Santa Clarita Water Division Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

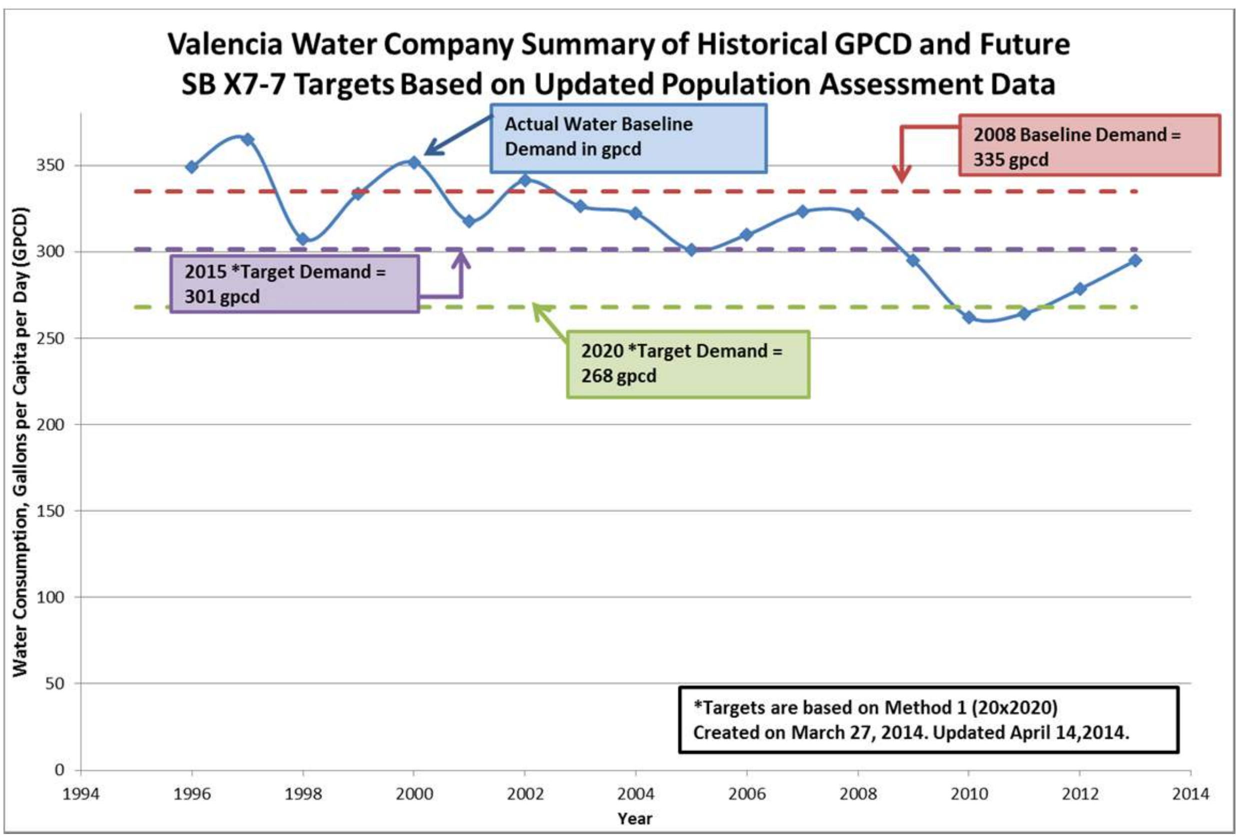


Figure 9: Valencia Water Company Historical GPCD and Future SB X7-7 Targets Based on Updated Population Assessment Data

APPENDIX A. Detailed Results for Population Estimates and GPCD

Population Estimates

The previously explained population assessment updated population and people per household estimates. Retail agency staff reviewed and confirmed both production and number of single family or multi-family units from data published in the 2010 UWMP. GPCD calculations presented for baseline, targets and recalculated 2013 are based on this updated population and household size data as shown in the following tables.

Newhall County Water District Population Estimate

Year	SF Residential Units	MF Residential Units	Census Population	Population Proportion living in MF housing units	SF Persons Per Unit	Annual SF Growth Rate	MF Persons Per Unit	Updated Population Estimate
1995	5,680	4,552			3.78		2.40	32,395
1996	5,723	4,589			3.78	0.76%	2.40	32,647
1997	6,035	4,612			3.77	5.45%	2.40	33,821
1998	6,037	4,622			3.77	0.03%	2.40	33,852
1999	6,202	4,651			3.76	2.73%	2.40	34,482
2000	**6,255**	**4,713**	**34,859**	**32.51%**	**3.76**	**0.85%**	**2.40**	**34,859**
2001	6,428	4,768			3.76	2.77%	2.44	35,783
2002	6,777	4,823			3.76	5.43%	2.47	37,371
2003	7,199	4,852			3.75	6.23%	2.50	39,169
2004	7,873	4,870			3.75	9.36%	2.53	41,886
2005	8,163	4,875			3.75	3.68%	2.57	43,127
2006	8,292	4,875			3.75	1.58%	2.60	43,751
2007	8,431	4,875			3.74	1.68%	2.63	44,365
2008	8,450	4,875			3.74	0.23%	2.66	44,595
2009	8,492	4,875			3.74	0.50%	2.70	44,911
2010	**8,398**	**4,995**	**45,036**	**30.28%**	**3.74**	**-1.11%**	**2.73**	**45,036**
2011	8,478	4,991			3.74	0.95%	2.73	45,305
2012	8,515	4,984			3.74	0.44%	2.73	45,452
2013	8,530	4,982			3.74	0.18%	2.73	45,503

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-7) and updated by Maddaus Water Management, Feb 2014
2. MF Units include duplexes - small fluctuations due to vacancies. Assumed the same number from 2010 through 2013 other minor reclassifications in billing system. Used the same adjusted for MF Units for 2010-2013.

Santa Clarita Water Division Population Estimate

Year	SF Residential Units	MF Residential Units	Census Population	Population Proportion living in MF housing units	SF Persons Per Unit	Annual SF Growth Rate	MF Persons Per Unit	Updated Population Estimate
1995	17,632	10,062			3.28		2.27	80,674
1996	17,812	10,100			3.28	1.0%	2.27	81,350
1997	17,856	9,842			3.28	0.2%	2.27	80,909
1998	18,222	9,884			3.28	2.0%	2.27	82,205
1999	18,671	9,994			3.28	2.5%	2.27	83,927
2000	19,408	10,527	**87,455**	**27.28%**	**3.28**	**3.9%**	**2.27**	**87,455**
2001	20,145	10,985			3.30	3.8%	2.27	91,348
2002	20,691	11,458			3.32	2.7%	2.27	94,674
2003	21,278	11,685			3.34	2.8%	2.28	97,602
2004	22,152	12,104			3.36	4.1%	2.26	101,700
2005	23,035	12,479			3.38	4.0%	2.26	105,967
2006	23,620	13,066			3.40	2.5%	2.26	109,736
2007	24,347	13,195			3.42	3.1%	2.25	112,846
2008	24,398	13,133			3.44	0.2%	2.25	113,364
2009	24,374	13,126			3.46	-0.1%	2.25	113,748
2010	24,707	13,212	**115,296**	**25.54%**	**3.47**	**1.4%**	**2.23**	**115,296**
2011	25,039	13,299			3.47	1.3%	2.23	116,644
2012	25,372	13,385			3.47	1.3%	2.23	117,991
2013	25,704	13,471			3.47	1.3%	2.23	119,339

Note: Data supplied by retail agency (2010 UWMP Table 2-7) and updated by Maddaus Water Management, November 2014

Valencia Water Company Population Estimate

Year	SF Resid Units	MF Resid Units	Revised SF Units	Revised MF Units	Census Population	Population Proportion living in MF housing units	SF Persons Per Unit	Annual SF Growth Rate	MF Persons Per Unit	Updated Pop Estimate
1995	14,834	4,184	14,834	3,986			2.86		1.44	48,165
1996	15,433	4,285	15,571	4,088			2.86	4.04%	1.44	50,420
1997	16,276	4,285	16,856	4,088			2.86	5.46%	1.44	54,095
1998	17,311	5,191	17,891	4,567			2.86	6.36%	1.44	57,745
1999	18,264	5,457	18,844	4,831			2.86	5.51%	1.44	60,850
2000	**19,179**	**5,725**	**19,759**	**5,101**	**63,922**	**11.46%**	**2.86**	**5.01%**	**1.44**	**63,922**
2001	20,631	6,342	21,211	5,695			2.88	7.57%	1.48	69,409
2002	21,818	6,941	22,398	6,275			2.89	5.75%	1.52	74,192
2003	22,822	7,676	23,402	7,005			2.90	4.60%	1.57	78,757
2004	24,193	7,949	24,773	7,327			2.91	6.01%	1.61	83,816
2005	24,953	8,405	25,533	7,815			2.92	3.14%	1.65	87,425
2006	25,044	8,437	25,624	7,815			2.93	0.36%	1.70	88,304
2007	25,131	8,537	25,711	7,815			2.94	0.35%	1.74	89,174
2008	25,211	8,590	25,791	7,815			2.95	0.32%	1.78	90,026
2009	25,171	8,854	25,751	8,035			2.96	-0.16%	1.83	90,925
2010	**25,836**	**8,854**	**26,098**	**8,179**	**92,851**	**16.48%**	**2.97**	**2.64%**	**1.87**	**92,851**
2011	26,012	8,854	26,252	8,423			2.97	0.68%	1.87	93,765
2012	25,988	8,854	26,439	8,726			2.97	-0.09%	1.87	94,888
2013	26,341	8,854	26,708	8,726			2.97	1.36%	1.87	95,687

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-7) and updated by Maddaus Water Management, June 2014
2. SF Residential Units is detached and attached individually metered households. All other units are MF residential housing (Mobile Homes, Apartments, etc)

Los Angeles County Water District Population Estimate

Year	SF Residential Units	MF Residential Units	Census Population	Population Proportion living in MF housing units	SF Persons Per Unit	MF Persons Per Unit	Updated Population Estimate
2000	**948**	**113**	**3,512**	**16.96%**	**3.08**	**5.27**	**3,512**
2001	1,093	113			3.12	5.14	3,989
2002	1,177	113			3.16	5.00	4,285
2003	1,251	113			3.20	4.87	4,556
2004	1,278	113			3.24	4.74	4,680
2005	1,289	113			3.29	4.60	4,755
2006	1,300	113			3.33	4.47	4,830
2007	1,303	113			3.37	4.34	4,879
2008	1,310	113			3.41	4.20	4,942
2009	1,310	113			3.45	4.07	4,982
2010	**1,317**	**113**	**5,046**	**8.81%**	**3.49**	**3.94**	**5,046**
2011	1,317	113			3.49	3.94	5,042
2012	1,322	113			3.49	3.94	5,059
2013	1,331	113			3.49	3.94	5,090

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-7) and updated by Maddaus Water Management, Feb 2014
2. MF Units are based on one trailer park property of 113 dwelling units of estimated 5.3 people per dwelling unit.

Gallons Per Capita Per Day SB X7-7 Targets and Current Status

Driven by SB X7-7 20x2020 compliance requirements, GPCD estimates for Santa Clarita Water Division, Valencia Water Company, and Newhall County Water District GPCD are required to be calculated using population in future UWMPs. Los Angeles County Water District does not serve 3,000 AF or have 3,000 connections, therefore SB X7-7 does not apply and no GPCD target analysis was completed. To calculate GPCD, annual production values as reported in acre-feet per year in the 2010 UWMP were converted into gallons and divided by the adjusted population estimates and 365 days. Again, the population values were updated from the aforementioned GIS analysis.

For Santa Clarita Water Division, Valencia Water Company, and Newhall County Water District baseline GPCD was calculated averaging 10 years between years 1994 and 2010. With the goal of a 20% reduction in per capita water use from baseline estimates, 2020 GPCD targets were calculated as 80% of baseline; 2015 targets were calculated as 90% of baseline per capita water use. The following tables display both the 2010 UWMP GPCD estimates and the revised targets.

Newhall County Water District Base Daily Per Capita Water Use

Year	Distribution System Population	Annual System Gross Water Use (AFY)	Daily Per Capita Water Use (GPCD)			Adjusted after Population Assessment						
						Distribution System Population	Daily Per Capita Water Use (GPCD)					
			Annual	10-Year Avg	5-Year Avg		Annual	10-Year Avg	5-Year Avg	2008 Baseline	2020 Target	2015 Target
1995	30,898	7,913	229			32,395	218			238	190	214
1996	31,323	8,680	247			32,647	237			238	190	214
1997	32,533	8,800	241			33,821	232			238	190	214
1998	32,764	8,089	220			33,852	213			238	190	214
1999	33,561	9,369	249			34,482	243			238	190	214
2000	**34,121**	**9,717**	**254**			**34,859**	**249**			**238**	**190**	**214**
2001	35,041	9,524	243			35,783	238			238	190	214
2002	36,526	10,362	253			37,371	248			238	190	214
2003	38,178	10,351	242		241	39,169	236		235	238	190	214
2004	40,618	11,320	249	243	240	41,886	241	235	233	238	190	214
2005	41,814	10,756	230	243	233	43,127	223	236	227	238	190	214
2006	42,490	11,454	241	242		43,751	234	236	220	238	190	214
2007	43,206	11,906	246	243		44,365	240	236	211	238	190	214
2008	43,539	11,339	232	244		44,595	227	238	204	238	190	214
2009	43,951	10,559	214	240		44,911	210	234	200	238	190	214
2010		**9,530**				**45,036**	**189**	**228**	**198**	**238**	**190**	**214**
2011		9,676				45,305	191			238	190	214
2012		10,469				45,452	206			238	190	214
2013		10,561				45,503	207			238	190	214

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-11) and updated by Maddaus Water Management, November 2014

2. Grey-shaded cells represent adjusted values after population assessment.

3. Annual water use consistent with 2010 UWMP values.

4. Targets are based on Method 1 (20x2020).

Santa Clarita Water Division Base Daily Per Capita Water Use

Year	Distribution System Population	Annual System Gross Water Use (AFY)	Daily Per Capita Water Use (GPCD)			Adjusted after Population Assessment						
						Distribution System Population	Daily Per Capita Water Use (GPCD)					
			Annual	10-Year Avg	5-Year Avg		Annual	10-Year Avg	5-Year Avg	2008 Baseline	2020 Target	2015 Target
1995	83,628	19,898	212			80,674	220			251	201	226
1996	84,784	22,006	232			81,350	241			251	201	226
1997	84,634	22,456	237			80,909	248			251	201	226
1998	86,394	20,319	210			82,205	221			251	201	226
1999	88,642	24,513	247			83,927	261			251	201	226
2000	**93,128**	**25,280**	**242**			**87,455**	**258**			**251**	**201**	**226**
2001	97,430	25,589	234			91,348	250			251	201	226
2002	101,230	28,429	251			94,674	268			251	201	226
2003	104,427	27,090	232		230	97,602	248		247	251	201	226
2004	109,189	29,191	239	234	228	101,700	256	247	246	251	201	226
2005	113,897	28,884	226	235	220	105,967	243	249	238	251	201	226
2006	118,385	29,704	224	234		109,736	242	249	229	251	201	226
2007	121,903	31,174	228	233		112,846	247	249	220	251	201	226
2008	122,631	30,476	222	235		113,364	240	251	213	251	201	226
2009	123,302	27,816	201	230		113,748	218	247	210	251	201	226
2010		**25,795**				**115,296**	**200**	**241**	**208**	**251**	**201**	**226**
2011		25,826				116,644	198			251	201	226
2012		27,956				117,991	212			251	201	226
2013		29,596				119,339	221			251	201	226

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-11) and updated by Maddaus Water Management, November 2014
2. Grey-shaded cells represent adjusted values after population assessment.
3. Annual water use consistent with 2010 UWMP values.
4. Targets are based on Method 1 (20x2020).

Valencia Water Company Base Daily Per Capita Water Use

Year	Distribution System Population	Annual System Gross Water Use (AFY)	Daily Per Capita Water Use (GPCD)			Adjusted after Population Assessment						
						Distribution System Population	Daily Per Capita Water Use (GPCD)					
			Annual	10-Year Avg	5-Year Avg		Annual	10-Year Avg	5-Year Avg	2008 Baseline	2020 Target	2015 Target
1995	57,012	17,543	275			48,165				335	268	301
1996	59,895	19,721	294			50,420	349			335	268	301
1997	62,826	22,128	314			54,095	365			335	268	301
1998	69,168	19,874	257			57,745	307			335	268	301
1999	73,353	22,735	277			60,850	334			335	268	301
2000	**77,476**	**25,189**	**290**			**63,922**	**352**			**335**	**268**	**301**
2001	84,420	24,714	261			69,409	318			335	268	301
2002	90,556	28,360	280			74,192	341			335	268	301
2003	96,618	28,779	266		258	78,757	326		316	335	268	301
2004	102,451	30,234	263	278	258	83,816	322	335	316	335	268	301
2005	106,983	29,473	246	275	253	87,425	301	332	310	335	268	301
2006	108,043	30,643	253	271		88,304	310	328	302	335	268	301
2007	109,324	32,286	264	266		89,174	323	323	293	335	268	301
2008	110,443	32,420	262	266		90,026	321	325	284	335	268	301
2009	111,876	30,027	240	263		90,925	295	321	279	335	268	301
2010		**27,268**				**92,851**	**262**	**312**	**275**	**335**	**268**	**301**
2011		27,759				93,765	264			335	268	301
2012		29,595				94,888	278			335	268	301
2013		31,608				95,687	295			335	268	301

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-11) and updated by Maddaus Water Management, November 2014
2. Grey-shaded cells represent adjusted values after population assessment.
3. Annual water use consistent with 2010 UWMP values.
4. Targets are based on Method 1 (20x2020).
5. Excludes VWC's recycled water use.

Los Angeles County Water District Daily Per Capita Water Use

Year	Distribution System Population	Annual System Gross Water Use (AFY)	Daily Per Capita Water Use (GPCD)			Adjusted after Population Assessment			
						Distribution System Population	Daily Per Capita Water Use (GPCD)		
			Annual	10-Year Avg	5-Year Avg		Annual	10-Year Avg	5-Year Avg
1995	-	477				0			
1996	-	533			228	0			
1997	-	785			233	0			
1998	-	578			231	0			
1999	-	666			231	0			
2000	**2,965**	**758**	**228**		**235**	**3,512**	**193**		
2001	3,393	907	239		236	3,989	203		
2002	4,232	1,071	226		238	4,285	223		
2003	4,508	1,164	231		246	4,556	228		240
2004	4,600	1,302	253	235	252	4,680	248	219	243
2005	4,624	1,204	232	235	248	4,755	226	220	238
2006	4,660	1,289	247	237	243	4,830	238	223	233
2007	4,681	1,406	268	240		4,879	257	227	227
2008	4,688	1,353	258	242		4,942	244	229	220
2009	4,684	1,243	237	242		4,982	223	228	217
2010	**4,947**	**1,140**	**206**	**240**		**5,046**	**202**	**229**	**215**
2011		1,172				5,042	208	230	219
2012		1,266				5,059	223	230	225
2013		1,297				5,090	227	230	227

Notes: 1. Data supplied by retail agency (2010 UWMP Table 2-11) and updated by Maddaus Water Management, November 2014

2. Grey-shaded cells represent adjusted values after population assessment.

3. Annual water use consistent with 2010 UWMP values.

4. Los Angeles County Water District does not serve 3,000 AF or have 3,000 connections, therefore SB X7-7 targets do not apply and no GPCD target analysis was completed.