Preparing for New Risks:
Addressing Climate Change in California's Urban Water Management Plans

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Acronyms

2010 Guidebook	*Guidebook to Assist Water Suppliers to Prepare a 2010 Urban Water Management Plan* (DWR)
ACWA	Association of California Water Agencies
ARB	Air Resources Board
BCDC	Bay Conservation and Development Commission
BMP	Best Management Practice
CAT	Climate Action Team
CAWWG	federal Climate change and Water Working Group
CCTAG	Climate Change Technical Advisory Group (DWR)
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CPUC	California Public Utilities Commission
CUWA	California Urban Water Agencies
DAC	disadvantaged community
DMM	demand management measure
DOST	DWR Online Submittal Tool
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
GCM	global circulation model
GHG	greenhouse gas
IEUA	Inland Empire Utilities Agency
IPCC	Intergovernmental Panel on Climate Change
IOU	investor-owned utility
IRWD	Irvine Ranch Water District
IRWM	Integrated Regional Water Management
JCSD	Jurupa Community Services District
LADWP	Los Angeles Department of Water and Power
LBWD	Long Beach Water Department
MMWD	Marin Municipal Water District
MWD	Metropolitan Water District of Southern California
NDWAC	National Drinking Water Advisory Council to the EPA
NRC	National Research Council
SAWPA	Santa Ana Watershed Project Authority
SBX7-7	Water Conservation Act of 2009
SCVWD	Santa Clara Valley Water District
SCWA	Sonoma County Water Agency
SDCWA	San Diego County Water Authority
SFPUC	San Francisco Public Utilities Commission
SWP	State Water Project
UWMP	Urban Water Management Plan
WUCA	Water Utility Climate Alliance

Executive Summary

Urban Water Management Plans (UWMPs) are a central component of California's efforts to assure reliable water supplies, particularly during drought conditions that are frequently experienced in the state. Prepared by water suppliers every five years, UWMPs include supply and demand projections for the next 20 years, and describe strategies to assure adequate supplies during average, single-year, and multi-year drought conditions. UWMPs also contain plans to implement a 20% reduction in per capita urban water use by the year 2020, as required under the Water Conservation Act of 2009 (SBX7-7).

Climate change is introducing new risks in water planning, such as increasing temperatures, reduced snowpack, changing precipitation patterns, and accelerating sea level rise, which are already being observed in the state. It is increasingly important for water suppliers to consider how these trends are impacting water supply, demand, and drought patterns. Water suppliers can also make important contributions to reducing greenhouse gas emissions (GHGs), through energy savings from water conservation as well as other measures.

In its guidance to water suppliers for preparing 2010 UWMPs, the California Department of Water Resources (DWR) included an optional section focused on consideration of climate change impacts and GHG emissions. This study assesses how water suppliers have incorporated these factors into their 2010 plans. Drawing upon a sample of 2010 UWMPs, it examines the nature and extent of climate change discussion and analysis, and assesses how climate change risks have been incorporated into water supply and demand projections. The report also provides recommendations for how DWR could improve its guidance for 2015 UWMPs to support water suppliers in addressing climate change.

All public and investor-owned utilities serving 3,000 customers or supplying at least 3,000 acre-feet of water annually are required to submit an Urban Water Management Plan to DWR every five years. Of the approximately 400 agencies submitting UWMPs, most are relatively small, with 90% serving less than 300,000 people, and 40% serving less than 50,000. Most are public entities, but some are private companies, including three investor-owned utilities with multiple service areas across the state. Large and small water suppliers tend to differ in their access to resources for planning and analysis of issues such as climate change. For many small suppliers, UWMP preparation serves as their primary long-term planning process. Suppliers also vary in the nature of their vulnerability to drought and the impacts of climate change. Larger suppliers usually have multiple sources of supply, while small suppliers are more likely to rely on a single source, especially groundwater. These small utilities are less likely to have relationships with other suppliers, thereby reducing their options for coping with severe droughts.

This study is based on an analysis of 49 individually submitted UWMPs, seven regional UWMPs, and UWMPs from three investor-owned utilities with multiple service areas across the state. The sample was stratified so that it represents water suppliers of all sizes. It

includes all large suppliers (serving 300,000 or more customers), and 10% of medium-sized and small suppliers (serving 50,000 – 300,000 and less than 50,000 customers, respectively). Each UWMP was analyzed for its content related to climate change, and classified according to the degree and focus of discussion. This report is also informed by informal consultations with representatives of water supply agencies of different sizes.

Key Findings

This review of 2010 UWMPs led to the following findings regarding the incorporation of climate change:

- **Large suppliers discussed climate change in UWMPs more frequently than did small ones.** About two-thirds of all UWMPs studied mentioned climate change in some fashion. This included 85% of all large suppliers studied, but only 36% of small suppliers. This may reflect the fact that small suppliers tend to have more limited resources and staff time to dedicate to investigating climate change impacts.

- **About forty percent of UWMPs included in this study contained a discussion of specific ways in which climate change could affect their water system, with an emphasis on risks to water supply.** While some suppliers discussed the general impacts of climate change on the state, 41% of UWMPs studied identified at least one way in which their service area would be specifically impacted. Once again, more large suppliers did this (52%) than small suppliers (21%). Three out of seven regional UWMPs discussed specific impacts, as did two out of the three investor-owned utilities with multiple service areas. In most cases, water suppliers based their discussion on existing studies of climate change impacts. Nine suppliers (15%) conducted their own studies of climate change impacts. Most discussions focused on impacts to the amount and timing of water supply. Water quality, flooding, and sea level rise received more limited attention.

- **When climate change was discussed in 2010 UWMPs, it was often integrated into required sections related to supply and demand projections.** Some suppliers followed the format outlined in DWR's 2010 guidebook for preparing UWMPs, and included climate change as a separate, optional section. However, climate change was also frequently discussed in other parts of the document, suggesting that a number of suppliers have recognized the relevance of climate change to required UWMP elements focused on water supply, demand, and supply reliability.

- **Water suppliers relying upon State Water Project (SWP) deliveries used DWR's 2009 SWP reliability report to estimate their future supplies, and in doing so, incorporated climate change into their planning.** 18 out of the 56 individual and regional UWMPs included in this study are from suppliers that rely upon SWP deliveries and used DWR's SWP reliability report to estimate their future supplies. The SWP reliability report uses downscaled climate modeling to estimate the effects of climate change on water timing, amount and quality. As a result, these

suppliers effectively adjusted their water supply expectations based on anticipated impacts of climate change.

- **Aside from SWP deliveries, most water suppliers that discussed climate change impacts did not adjust UWMP projections to account for effects on supply or demand.** Among suppliers whose UWMPs were reviewed for this study, including large suppliers that have conducted their own studies, only the Los Angeles Department of Water and Power adjusted a supply projection for a non-SWP source of water. None adjusted a demand projection based on climate change, although several studied these effects. Several UWMPs indicated that within the current planning period (2010 – 2030), climate change effects were either too uncertain or too small to include in projections. However, a few large suppliers have incorporated climate change uncertainties into their own planning processes, even though they did not specifically reflect climate change in their UWMP projections.

- **Following DWR guidance, most suppliers relied upon a three-year drought planning sequence based on historical runoff records.** Although several suppliers discussed the fact that climate change is likely to bring more frequent or severe droughts, quantitative estimates were not yet available to provide a specific basis for adjusting a drought planning sequence to account for climate change. Some suppliers used a longer historical drought period, and several others adjusted the historical record to plan for a drought that is deeper or longer than experienced in the past. These adjustments were not based on an estimate of the effect of climate change on drought patterns, but were selected to provide a factor of safety that accounts for the possibility that future droughts may be more severe than the historical record.

- **Relatively few UWMPs discussed GHG emissions reductions efforts.** Most UWMPs did not include estimates of these reductions, or much information about GHG inventories or other emissions reduction strategies. However, even though it is not reflected in their UWMPs, many large suppliers have undertaken GHG emissions inventories, and some small and medium-sized suppliers are participating in city or countywide tracking of GHG emissions.

Recommendations

The current structure of California's UWMP process has several features that help support planning for climate change. Similar to a scenario planning process, water suppliers must assess their system's performance under several possible future water availability scenarios. The process is also iterative, with a plan update required every five years. However, some effects of climate change are not fully captured within the UWMP's 20-year planning horizon. Certain decisions being made now, such as investments in new water infrastructure, may have implications for a supplier's capacity to cope with rising temperatures, greater precipitation extremes, and rising sea levels beyond this 20-year planning period.

Inclusion of a basic vulnerability assessment in the UWMP process could help ensure that water suppliers of all sizes maintain an overall awareness of how climate change may affect current operations and longer-range planning. In UWMPs, suppliers discuss two main types of strategies for reducing vulnerability to droughts: 1) plans to handle immediate water shortages and other emergencies; and 2) longer-term management strategies that reduce the likelihood and/or severity of these shortages. An understanding of climate change risks can help suppliers adjust the type and relative priority of management strategies they employ. In particular, a vulnerability assessment into the UWMP process could help urban suppliers to:

- Ensure that they are undertaking adequate drought contingency planning and preparedness for other emergencies;
- Increase attention to a range of long-term strategies to reduce vulnerabilities, such as diversifying supply, improving groundwater management, ensuring adequate water storage, conveyance and treatment capacity, and protecting watersheds; and
- Ensure that demand reduction measures being implemented in response to SBX7-7 are adequate in light of increasing temperatures and changing precipitation patterns.

Large suppliers have more capacity to analyze and respond to climate change risks than do small suppliers. However, as discussed in this study and emphasized in the report on Climate Ready Utilities by the National Drinking Water Advisory Board (NDWAC 2010), even small suppliers can benefit from a basic level of awareness of climate change risks. Any requirement to undertake a vulnerability assessment should be accompanied by technical assistance from DWR, and should offer flexibility for suppliers to choose an appropriate level and type of assessment.

With regard to climate change mitigation, water suppliers can make important contributions to reducing GHG emissions, particularly through water conservation efforts that are a key component of the UWMP process. Requiring suppliers to account for GHG emissions may be beyond the scope of the UWMP process as currently framed, but DWR could encourage voluntary reporting of these activities. If it does so, DWR should consider how this data would be used. In addition, DWR could help provide tools and support for estimating emissions reductions. Such resources could benefit small suppliers that have limited capacity in this area, but face increasing requirements to estimate GHG emissions for CEQA and other processes.

To improve how climate change is considered in 2015 UWMPs, DWR could take the following three steps:

1. **Use a vulnerability-based approach.** A qualitative assessment that identifies key areas of vulnerability is a good starting point for all suppliers. The majority of suppliers submitting UWMPs are small, and these suppliers may be using the UWMP as the primary framework for organizing their planning process. A vulnerability assessment can enable them to identify their risks qualitatively and develop

priorities for further study. It will also be useful for large suppliers, which can be encouraged to undertake more in-depth climate change analyses. As this report shows, some large suppliers are already doing so. There is growing experience in California with the use of vulnerability assessments. For example, all IRWM plans are now required to, at a minimum, conduct a qualitative vulnerability assessment, prioritize key vulnerabilities, and develop a methodology for further analysis. Taking a similar approach would encourage greater synergies between the IRWM and UWMP processes.

2. **Integrate climate change into all UWMP elements.** Given the relevance of climate patterns to the required elements of UWMPs – projecting supply and demand, and assessing reliability under drought conditions – it makes sense to include discussion of the implications of climate change directly in these sections of the report. This would encourage water suppliers to focus on understanding how climate change might affect their standard assumptions for supply and demand projections and their drought planning sequence. In keeping with a vulnerability-based approach, DWR's guidance related to climate change could include a few specific questions in relevant UWMP sections in order to help suppliers identify whether climate change is a significant factor in a particular aspect of planning.

3. **Provide additional assistance to suppliers in addressing climate change.** DWR plays a critical role in providing water suppliers, particularly small ones, with appropriate knowledge, data, and tools for preparing their UWMPs. In 2015, DWR could increase its support related to climate change by including updated resources on the topic in the UWMP Guidebook, conducting workshops and webinars focused on climate change, and offering individual consultation with DWR staff, including with DWR's regional climate change specialists.

   To further support consideration of climate change in 2015 UWMPs, DWR could undertake the following efforts, some of which may require additional funding:

   - Continue to support the Integrated Regional Water Management process, which can offer water suppliers, especially small ones, opportunities to build partnerships and access funding for strategies to reduce drought vulnerability;
   - Periodically review and update DWR's approach to incorporating climate change into the State Water Project Reliability Report, upon which a number of agencies rely for UWMP water supply projections;
   - Conduct or support research on critical questions facing water suppliers, such as how to account for climate change in selecting a drought planning sequence. DWR's Climate Change Technical Advisory Group (CCTAG) could provide valuable guidance in such research;
   - Conduct pilot studies in collaboration with water suppliers to test new tools, such as vulnerability assessments or methods for incorporating a factor of safety to hedge against increased likelihood of severe droughts; and
   - Provide assistance to water suppliers in estimating GHG emissions reductions associated with water supply, treatment and demand management

1. Introduction

Urban Water Management Plans (UWMPs) are a central component of California's efforts to assure reliable water supplies, particularly during drought conditions that are frequently experienced in the state. Under the Urban Water Management Planning Act, water suppliers prepare a plan every five years that projects water supply and demand over a 20-year period and describes efforts to ensure adequate supplies under average, single-year and multi-year drought conditions. Reducing urban water demand is a core element of these plans, especially since the passage of the Water Conservation Act of 2009 (SBX7-7), which established the goal of a 20% reduction in per capita water use by the year 2020.

Climate change is an increasingly important consideration for water planners. Rising temperatures, reduced snowpack, changing precipitation patterns, and accelerating sea level rise are already being observed in California, and are projected to intensify in the coming decades (Moser et al. 2012). Further, some recent research anticipates a decrease in annual average precipitation in the central and southern parts of the state, including an increase in the frequency of dry years (Cayan et al. 2012). In light of these risks, the California Department of Water Resources (DWR) and other entities involved in managing the state's water resources have been considering climate change in water planning (DWR 2009). This includes local agencies, which manage a large portion of California's water supply. For example, following legislation in 2008, Integrated Regional Water Management plans, which are jointly developed by local agencies, must now address climate change (DWR 2012a).

The analysis contained in UWMPs is intended to assist water suppliers in identifying appropriate strategies for reducing vulnerability to drought, and developing contingency plans for droughts once they occur. The effects of climate change on water supply, demand, and drought patterns are an important consideration in selecting and designing such strategies. However, this requires a shift from long-standing water management practice that has relied upon the assumption that future climate patterns will be similar to those of the past (Milly et al. 2008). Assessing impacts on particular water systems can be a challenging endeavor, due to uncertainties associated with climate change projections at small scales and the difficulty of distinguishing the effects of climate change from other factors such as demographic or land use change (Hirsch et al. 2011). Water suppliers in California vary greatly in size and type, and have very different levels of capacity to conduct such analyses and undertake adaptation measures.

In its guidance to water suppliers for preparing 2010 UWMPs, DWR included an optional section focused on consideration of climate change impacts and GHG emissions. This study assesses how water suppliers have incorporated these factors into their 2010 plans, and provides recommendations for how 2015 guidance might be improved to help water suppliers address climate change in their planning. The analysis is based on a sample of 2010 UWMPs from suppliers of varying sizes and types.

This report begins with an overview of DWR's guidance for preparing 2010 UWMPs, and background about water suppliers in California that submit these plans to DWR. This is followed by a description of the methods used for this study. Section 4 discusses how climate change impacts have been analyzed and accounted for in UWMPs, and Section 5 examines the types of strategies discussed in UWMPs that reduce drought vulnerability, and how they might be informed by an analysis of climate change impacts. Section 6 describes how greenhouse gas emissions reductions are addressed. Finally, Section 7 summarizes key findings, assesses the appropriate role for UWMPs in climate change adaptation and mitigation, and offers recommendations for how DWR might improve guidance and support to urban water suppliers in 2015 UWMPs.

2. Background

2.1. UWMP Process Overview

First enacted in 1983, the Urban Water Management Planning Act (California Water Code §10610-10656) is "intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water," (§10610.2 (a)). It requires every water supplier serving over 3,000 customers or supplying more than 3,000 acre-feet of water per year to prepare an Urban Water Management Plan (UWMP) every five years, in years ending in 0 and 5. The Act allows water suppliers to work together to submit a "regional UWMP" (§10620(d)(1)). DWR provides guidance to water suppliers regarding the required contents of UWMPs, and reviews plans for completeness. Water suppliers must submit UWMPs in order to remain eligible for water management grants or loans from DWR, the State Water Resources Control Board, or the Delta Stewardship Council (DWR 2010a, p. xiii).

UWMPs require suppliers to project water supply and demand over a 20-year period, and to assess reliability of supplies under three possible future hydrologic conditions: a normal year, a single-year drought, and a multi-year drought of at least three years. Suppliers must describe the steps they are taking to assure adequate supplies. UWMPs are also important tools to advance strategies to reduce water demand, as emphasized in the UWMP Act (§10610.4), and the Water Conservation Act of 2009 (SBX7-7). This legislation required water suppliers, beginning with 2010 UWMPs, to calculate per capita baselines for water use and describe plans to accomplish a 20% reduction in water demand by 2020 (DWR 2012b, p. 5).

2.2. 2010 UWMP Guidance

DWR's *Guidebook to Assist Water Suppliers to Prepare a 2010 Urban Water Management Plan* (DWR 2010a, hereafter referred to as the "2010 Guidebook") outlines required and optional elements that water suppliers should include in their plans. DWR provides additional assistance to water suppliers through workshops, webinars, and individual consultation with DWR staff.

2.2.1. Required UWMP Elements

The 2010 Guidebook provides an outline of topics that must be covered in an UWMP, and a proposed format for organizing the document. The following is a summary of these key elements, highlighting how information about climate patterns is relevant to each. In practice, some suppliers structure their UWMPs differently, and many project supply and demand through 2035 instead of 2030.

- Section 1, Plan Preparation: suppliers describe the process used to develop the UWMP, including agencies involved and public participation.
- Section 2, System Description: this section describes the service area, its population and its climate. The description of climate, required by the Act under §10631(a), usually includes tables or graphs illustrating the seasonal rainfall and temperature patterns in the service area, often relying upon data from the Western Climate Data Center.
- Section 3, System Demands: this section includes the calculation of water use baselines for the purposes of assessing demand reductions required by 2020, projections of demand through 2030, and plans for water use reduction. As discussed in Section 4.4.1 of this report, some water suppliers include seasonal weather patterns in their water demand projections, accounting for the fact that water demand typically increases during hot or dry periods.
- Section 4, System Supplies: this section contains a description of a supplier's surface and groundwater sources and projections for each through 2030, a discussion of opportunities for water transfers and developing desalinated and recycled water supplies, and future water supply projects. The projection of supplies involves assumptions about future temperature and precipitation patterns.
- Section 5, Water Supply Reliability and Water Shortage Contingency Planning: this section requires suppliers to identify an average year, a single-year drought and a multi-year drought of at least 3 years, using historical runoff records. The supplier determines water supply reliability by comparing water demand and supply projections for the next 20 years under each of these conditions.[1] The supplier must also discuss its plans to manage water sources that "may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors," (§10631(c)(2)). Suppliers describe their water shortage contingency plans, as well as their plans to address catastrophic interruptions in supply.
- Section 6, Demand Management Measures: suppliers describe water conservation programs in this section and their use of best management practices (BMPs) for demand management. This includes specific plans to meet their identified per capita water use targets.

[1] Specifically, the guidelines request suppliers to project supply and demand under normal, single-dry year, and multiple-dry year (a minimum of 3 years) conditions for the years 2010, 2015, 2020, 2025, and 2030 (2035 is optional). The 3-year drought sequence is to begin in years ending in 0 and 5 (DWR 2010a, p. 5-5).

2.2.2. Optional Climate Change Element

The 2010 Handbook includes climate change as an optional element (Section 7). The instructions state, "DWR suggests that an urban water supplier consider in its 2010 UWMP potential water supply and demand effects related to climate change," (p. 7-1). While noting that the UWMP Act and the Water Conservation Act of 2009 do not contain specific climate change requirements, DWR indicates, "inclusion of potential climate change impacts in a water supply planning document is consistent with other water supply programs and environmental requirements being implemented in California. Potential climate change impacts could also start to be observed and impacting water suppliers within the planning horizon of this document," (p. 7-1).

More specific guidance on climate change is contained in Part II, Section G of the 2010 Guidebook. This guidance describes some of the impacts of climate change being observed or anticipated in California. It notes that "these potential changes include a more variable climate with risks of extreme events more severe than those in the recent historical record" and emphasizes that "these changes are very likely to intensify within the 20-year UWMP planning horizon," (p. G-2). DWR does not propose specific methods to assess these impacts. Both mitigation and adaptation responses are discussed. With regard to mitigation, the guidance encourages suppliers to calculate GHGs not emitted as a side benefit of demand management measures. With regard to adaptation, suppliers are encouraged to consider climate change effects on: 1) water demand; 2) water supply and quality; 3) sea level rise, with respect to flooding and storm surges, and 4) disasters, including more extreme droughts and floods. Suppliers are encouraged to include in their UWMP a summary of on-going efforts to assess climate change impacts. Finally, the guidance summarizes requirements to include climate change in Integrated Regional Water Management (IRWM) plans and the California Environmental Quality Act (CEQA) analyses. It notes the opportunity to connect climate change analysis efforts in UWMPs and IRWM plans, and that the analysis of GHG reductions from demand management measures could be used in CEQA analyses for future projects.

2.3. Water suppliers in California

The requirement to submit an UWMP applies to public and investor-owned entities that serve at least 3,000 customers or supply at least 3,000 acre-feet of water annually. DWR is aware of at least 448 such agencies in California, of which 381 had submitted UWMPs by April 2012 (DWR 2012b).[2] Most submitted individual UMWPs, with only 27 agencies participating in a total of seven regional plans. These water agencies vary greatly in their size, organizational type, and water supply sources. These differences have important implications for how water suppliers understand and plan for climate change.

DWR's Online Submittal Tool (DOST), an internal database through which many suppliers submit their UWMPs, contains data on the populations served by suppliers in 2010, as reported by suppliers. At the time of this report's analysis, data from 206 plans had been

[2] A large number of very small suppliers serving less than 3,000 customers exist in California. They are not required to submit UWMPs, and therefore are not discussed in this report.

entered into DOST. Of these UWMPs, almost 90% serve less than 300,000 people, and 42% serve less than 50,000 people (see Table 1). A small number are very large water suppliers, the largest of which is the Metropolitan Water District of Southern California (MWD), a wholesaler serving over 18 million people.

Table 1. Population served by water suppliers submitting UWMPs.

2010 Population Served	UWMPs in DOST†	Percent of total
Less than 50,000	87	42%
50,000 – 300,000	97	47%
More than 300,000	22	11%
Total	206	100%

† Data from 2010 UWMP Table 2 (Current and Projected Population) in DWR's Online Submittal Tool (DOST) as of May 29, 2012. The number of UWMPs in DOST has since increased. See Section 3.2.1 for details.

In general, suppliers that serve smaller populations have smaller revenues and staff size, although other factors also play a role. Data specific to California were not available, but the nationwide *2006 Community Water System Survey* provides a reference point (EPA 2006a, b). Based on a sample of the nation's estimated 49,000 community water systems, the average revenue for suppliers serving between 3,301 – 10,000 people was $543,000, while suppliers serving over 500,000 had an average revenue of $132 million (EPA 2006b, Table 58). Staff size obviously varies greatly across these agencies. Informally gathered information suggests that a supplier serving 50,000 or less people may employ approximately 20-30 people, while MWD, the largest supplier, employs several thousand (personal communications; see list in Appendix B). The preparation of UWMPs can involve a significant amount of staff time. Suppliers often hire consulting firms to prepare UWMPs, and small suppliers are even more likely to do so. Among UWMPs analyzed for this report, 33% of those from suppliers serving more than 300,000 people were prepared by a consulting firm. For UWMPs from suppliers serving less than 300,000 people, the figure was 68%.[3] All of this suggests that suppliers serving smaller populations are likely to have less financial resources and in-house staff time to dedicate to water management planning, including assessing climate change risks.

The majority of water suppliers submitting UWMPs are public entities, including water departments of cities and counties, water districts, community service districts, or joint powers authorities. Water supply may not be the only service provided by these organizations; some also have mandates for flood control, sanitation, power, or other services.[4] Some water suppliers are private companies, also referred to as investor-owned utilities (IOUs), whose activities are regulated by the California Public Utilities Commission. Among the 206 UWMPs for which data was available, there are seven IOUs serving single service areas, and three IOUs providing water in multiple service areas: California Water Service Company, California American Water Company, and Golden State Water Company.

[3] Based on a count of UWMPs that indicated the name of a consulting firm assisting in its preparation. See Section 4 for information about the sample of UWMPs used.

[4] This is another factor affecting revenue and staff size.

Based on population data available from UWMPs in DOST, together these multi-site IOUs serve approximately 2.5 million people (see Section 4 and Table A3, Appendix A).

Some water suppliers submitting UWMPs are wholesale suppliers, which obtain and sell water to retail suppliers that sell directly to customers. Of the 381 UWMPs submitted to DWR as of April 2012, 34 were wholesale suppliers (DWR 2012b), although this number does not include some suppliers that are both wholesale and retail, such as the San Francisco Public Utilities Commission (SFPUC). Most wholesalers sell surface water, often importing it from other regions, and serve large populations through retailers. In the preparation of UWMPs, retailers and wholesalers share information with each other, including projections about future water demand (prepared by retailers) and future water supply (prepared by wholesalers). As will be discussed later in this report, this information sharing is important with respect to understanding and planning for the impacts of climate change on water supply and demand. Some wholesalers and retailers collaborate quite closely in developing an UWMP, and a few have elected to submit a single "regional" UWMP, as permitted in the UWMP Act. Of the seven 2010 regional UWMPs, six involved collaborations between a wholesaler and its retail suppliers (see Table A2, Appendix A).

In general, large suppliers tend to rely upon more diverse types of supply, which may include imported or local surface water and groundwater, as well as small but growing amounts of recycled or desalinated water. Small suppliers, on the other hand, are more likely to rely primarily upon a single source of supply, especially groundwater. Among suppliers whose UWMPs were reviewed for this study, 50% of suppliers serving 50,000 people or less relied primarily or only on groundwater, while none of those serving 300,000 or more did so (see Table 9 in Section 5.3 of this report).[5] Suppliers that rely upon groundwater usually pump their own water, and therefore do not have a relationship with a wholesaler. Reliance on a single water source and limited relationships with other suppliers may limit the options available to some small suppliers for coping with climate change impacts. The Association of California Water Agencies (ACWA) makes note of this in its recent groundwater policy framework document, stating: "Small community water systems, including many that serve disadvantaged populations, can face unique management challenges not shared by their larger counterparts. Such systems that are dependent on groundwater and/or private wells are especially vulnerable to drought and the effects of climate change because they are typically located in isolated areas with few opportunities for interconnections with other systems, water transfers, or emergency relief," (ACWA 2011, p. 18).

Finally, the UWMP process may play a different role in planning for large and small suppliers. Many of the largest suppliers have their own long-range planning processes and programs in place, which are the primary basis for their investment decisions. Examples include MWD's Integrated Resources Plan (2010a), East Bay Municipal Utility District's Water Supply Management Program 2040 (EBMUD 2012a), and Santa Clara Valley Water

[5] This is consistent with nationwide patterns. The *Community Water System Survey* indicates that 55% of systems serving between 3,301 – 50,000 people rely completely or primarily upon groundwater, while only 13% of suppliers serving over 500,000 people do so (EPA 2006b, Table 2).

District's Comprehensive Water Resources Management Plan (SCVWD 2012). These processes may overlap somewhat with UWMP requirements, but often use a different structure and planning time period. For small suppliers, on the other hand, the UWMP process is often the primary framework for water supply planning.

2.4. Incorporating climate change into urban water supply planning

Awareness is growing among urban water suppliers about the potential impacts of climate change, and a number of agencies in California have already taken steps to integrate climate change into their planning. The Water Utility Climate Alliance (WUCA) is a group of ten water suppliers nationwide, including the Metropolitan Water District of Southern California (MWD), the San Diego County Water Authority (SDCWA), and the San Francisco Public Utilities Commission (SFPUC). WUCA members have worked together to identify the research needs of water suppliers, and conduct research and pilot studies regarding decision methods that account for climate change and other uncertainties (WUCA 2010, 2009). Others, such as the East Bay Municipal Utility District (EBMUD), have been involved with U.S. Environmental Protection Agency (EPA)'s Climate Ready Water Utilities initiative, which has led to the development of resources to support utilities in assessing impacts and developing adaptation strategies (EPA 2011a). The California Urban Water Agencies (CUWA), a group of 11 agencies supplying water to two-thirds of the state's population, published a report in 2007 documenting their climate change adaptation and mitigation efforts (CUWA 2007). DWR, which supplies water to a number of urban water suppliers via the State Water Project, has incorporated climate change into its reliability estimates for this supply for 2007, 2009 and 2011 (DWR 2012c, 2010b). DWR has also included climate change in the 1998, 2005, and 2009 updates to the California Water Plan, as well as in other plans and projects (DWR 2009, Khan and Schwarz 2010).

Some large suppliers have responded by adjusting their planning processes to incorporate climate change as one among many uncertain factors affecting future water supply and demand. Two approaches that have gained recognition as ways to incorporate climate change uncertainties are robust decision-making and scenario planning. Robust decision-making involves creating a large number of simulations of possible future conditions based on different assumptions about the climate, population growth, and other factors, and using statistical methods to identify water management strategies that perform well under a range of these scenarios (WUCA 2010, p. 56, Groves et al. 2008). Scenario planning involves creating a limited number of possible future scenarios, and evaluating the performance of water strategies under these conditions (WUCA 2010, p. 4). Both approaches acknowledge the uncertainty associated with future scenarios, but robust decision-making addresses this uncertainty more quantitatively.

In general, the UWMP process follows the logic of scenario planning, since it requires suppliers to select three scenarios (normal, single dry, and multiple dry year runoff) under which to assess future water supply and demand. However, unlike scenario planning efforts that incorporate climate change, UWMP scenarios are based on the historical record and are not adjusted to account for the effects of climate change. In addition, the UWMP's 20-year planning period is short compared to the timeframes of many climate change

models, which project the effects of increased GHG emissions over the next 50-100 years. Water suppliers that have conducted climate change impact analyses have mostly done so using multiple time periods, typically one of approximately 30 years for planning and operations, and 50 years or more for infrastructure planning (EPA 2010, p. 14). As will be seen in this report, some suppliers have concluded that within the UWMP's 20-year timeframe, climate change impacts are either too uncertain or small to make a difference in their planning.

While there has been considerable progress in developing methods and tools to incorporate climate change into water planning, many challenges still remain. A standard set of practices has not yet emerged, particularly for handling uncertainties associated with future projections (EPA 2011b, 2010). This is especially true for smaller water supply agencies. While a number of large suppliers have hired staff and consultants with specific expertise in climate change, smaller agencies often do not have sufficient resources to do this (EPA 2010, p. 9). A recent study by the National Drinking Water Advisory Council to the EPA confirms that as small and medium-sized suppliers struggle to cope with aging infrastructure and other immediate issues, they have less capacity to analyze and act upon climate change risks (NDWAC 2010, p. 3). However, the report suggests that small suppliers still need a basic awareness of how climate change may affect their operations, and that state and federal agencies should provide support to enable this (p. 33). As already noted, the majority of UWMPs are submitted by relatively small suppliers.[6] An important question addressed in this report is what steps would be appropriate and feasible for these smaller water suppliers to incorporate climate change in their UWMPs, and what support DWR could provide to help them do so.

In California, new resources have recently become available that may help provide such support. The Climate Change Handbook for Regional Water Planning (EPA/DWR 2011), developed by DWR in partnership with the EPA, the US Army Corps of Engineers and the Resources Legacy Fund, guides water managers through the steps involved in addressing climate change in water planning and provides access to key resources and tools. This resource was developed in part to help water planners meet the requirement to consider climate change in Integrated Regional Water Management (IRWM) plans. These regional planning processes, organized through 48 Regional Water Management Groups across the state, involve many urban water suppliers. The Climate Change Handbook and updated IRWM plans were not available at the time of 2010 UWMP preparation, but in the future these may be important resources for understanding climate change impacts in a particular region. Finally, many small and medium-sized suppliers are part of city and county governments, some of which have prepared Climate Action Plans that set targets for GHG emissions reductions and discuss potential impacts of climate change. These plans may also serve as a resource for these suppliers to integrate climate change into their UWMPs.

[6] Section 3 describes how large, medium-sized and small suppliers are defined for the purposes of this report.

3. Research Questions and Methods

The overall purpose of this study is to assess how climate change was considered in 2010 UWMPs and provide recommendations on how DWR's guidance to water suppliers might be improved for 2015 UWMPs. The study design is based on the expectation that the attention given to climate change depends in part upon the degree of capacity of a water supplier, as determined by factors such as resources, staffing, and climate-related information and expertise. In order to help inform DWR's future climate change guidance for UWMP preparation, it is also important to understand the relevant types of management strategies discussed in UWMPs, and how these strategies might be informed by analysis of climate change impacts. Although reducing greenhouse gas emissions (GHGs) is not the primary objective of the UWMP process, GHG reductions are an important benefit of the water conservation measures discussed in UWMPs, and are also considered.

3.1. Research Questions

Guided by these considerations, this study sought to answer the following specific questions:

1. How have climate change impacts been analyzed and accounted for in 2010 UWMPs from water suppliers of different sizes and types?
2. What strategies for reducing drought vulnerability are discussed in UWMPs, and how might the analysis of climate change impacts inform decisions about these strategies?
3. To what degree are efforts to reduce greenhouse gas emissions discussed in 2010 UWMPs?
4. How might DWR's guidance and support for water suppliers in preparing UWMPs be improved with regard to climate change?

3.2. Methods

Conducted primarily during the period of July – November 2012, this study is based on an analysis of the climate change content from a sample of the 381 2010 UWMPs that had been submitted to DWR as of April 2012 (DWR 2012b). The sample was designed to identify differences in how suppliers of varying sizes and capacities have addressed climate change. Categories of large, medium-sized, and small suppliers were analyzed, and certain types of UWMPs in which suppliers were likely to have substantially different access to resources were considered separately. Specifically, regional UWMPs prepared by a group of suppliers and UWMPs from investor-owned utilities with multiple serve areas were each considered separately, since they might benefit from access to shared resources for the analysis of climate change.

While these UWMPs are the primary basis for the study's findings, a limited number of informal consultations were conducted by phone with representatives of water supply agencies of different sizes (see Appendix B for a list). These conversations provided important general background information about the relative size and capacity of these

agencies with respect to the process of preparing UWMPs and inclusion of climate change, as well as an opportunity to confirm specifics of climate change analyses. No formal surveys or interviews were undertaken.

3.2.1. Selection of UWMPs for inclusion in this study

UWMPs are public documents and are available on DWR's website and the websites of individual water suppliers. Each UWMP contains the 2010 population served by a supplier, which was used as a rough indicator of the agency's size and capacity (see Section 2.2). DWR maintains an internal database of UWMP plans, called the DWR Online Submittal Tool (DOST), which contains data from the tables in UWMPs. As of April 2012, DWR had received 381 UWMPs, but data for all of these had not yet been entered into DOST (DWR 2012b). In May 2012, DWR provided 2010 population data from the 206 UWMPs available in DOST at that time.[7] Since population data was not available in a digitized form for all UWMPs, the study's sample was selected from these 206 UWMPs. Conversations with DWR staff suggest that these are broadly representative of all UWMPs.

The set of 206 UWMPs was reviewed to identify the seven regional UWMPs, which were analyzed separately. In addition, UWMPs submitted by three investor-owned utilities (IOUs) with multiple service areas (California Water Service Company, California American Water Company, and Golden State Water Company) were identified. UWMPs submitted by a single company followed a common format and type of analysis, including for climate change, so they were also analyzed separately. This resulted in a list of 169 UWMPs from individual wholesale and retail suppliers.[8] These were classified into four groups based on 2010 population served. These groups, shown in the first column of Table 2, were defined in order to create a limited number of categories while still capturing the variation in sizes of population served.

Table 2. Sampling process for individually submitted UWMPs.

2010 Population Served	Individual UWMPs in DOST	% of UWMPs in DOST	Expected number of all individual UWMPs	Sample size (% of all individual UWMPs)
50,000 or less	74	44%	137	14 (10%)
50,000 - 300,000	38	22%	68	7 (10%)
100,000 - 300,000	36	21%	65	7 (10%)
300,000 and above	21	13%	N/A	21†
TOTAL	**169**	**100%**		**49**

†All UWMPs in DOST from suppliers serving over 300,000 people were included in this study; no random sampling was used.

[7] The data provided by DWR contained 221 entries, but some entries related to the same supplier (for example, when UWMPs used multiple sources of population data). Eliminating these duplicates led to a total of 206 UWMPs.

[8] Most are public agencies, but this list included some private companies that serve a single area.

Since it was expected that UWMPs from large suppliers would contain the most information about climate change, all 21 plans from suppliers serving over 300,000 people were included in the study. For the large number of remaining suppliers, it was anticipated that discussion of climate change would be limited. A random sample was used, representing 10% of the expected number of UWMPs for each size category. The expected number of UWMPs for each category was calculated as follows. Of the 381 UWMPs contained in the April 2012 report to the Legislature (DWR 2012b), 311 were individually submitted, and the rest were either regional UWMPs or from multi-site IOUs, and 311 was used as the total number of individual UWMPs. The percentages of UWMPs in DOST serving different population sizes (Table 2, Column 3) were assumed to be same as the percentages in the overall population of 311 UWMPs. These percentages were used to calculate the expected number of UWMPs in each size category (Column 4), and then a sample size of 10% was calculated for each category. UWMPs in each size category were then numbered sequentially and Excel's random number generator was used to select the sample.

During the analysis, it was determined that in terms of climate change content, there were few differences between UWMPs from suppliers serving 50,000 – 100,000 people and those serving 100,000 – 300,000 people. Therefore, throughout this report these UWMPs are grouped into a single category of medium-sized suppliers. Table 3 summarizes all of the categories of UWMPs included in this report. For simplicity, suppliers in the size-related categories are referred to as "large," "medium-sized" and "small."[9] The names of the suppliers whose UWMPs are included in the study appear in Tables A1, A2 and A3 of Appendix A.

Table 3. UWMPs included in this study

Category	Definition	Sample	Number of UWMPs
Large suppliers	Serving 300,000 or more	All	21
Medium suppliers	Serving 50,000 – 300,000	10%	14
Small suppliers	Serving 50,000 or less	10%	14
Regional UWMPs	Suppliers sharing one UWMP	All	7 plans representing 27 suppliers
Multi-site IOUs	California American Co., California Water Service Co., Golden State Water Co.	All	34 plans from 3 companies

3.2.2. Analysis of UWMPs

Each UWMP was reviewed for its content on climate change. To locate sections of the plan that discussed the topic, document searches were used to find instances of the terms "climate change," "global warming," "greenhouse gas," "GHG," "emissions," and "carbon dioxide." When these terms were found, those sections of the plan were reviewed, and the content was classified according to categories that capture the degree and focus of discussion. For example, plans were classified according to whether they contained no mention of climate change, discussed general statewide impacts, or identified how climate change may affect specific aspects of a water system. These categories appear in the tables

[9] In other contexts, the term "small" may refer to utilities serving less than 3,000 people. Since these suppliers are not required to submit UWMPs, they are not included in this study.

and the analysis throughout this report. Certain other information, such as the number of years in a supplier's multi-year drought sequence, was also collected from each plan and is reflected in this analysis.

For large suppliers whose UWMPs contained more substantial information about climate change, additional sources were consulted to gain a better understanding of how these suppliers incorporated climate change into their planning. These included major water planning documents besides UWMPs, such as MWD's Integrated Resources Plan (MWD 2010a), documentation of climate change analyses undertaken by these agencies, and other relevant reports. In some cases, relevant staff at these agencies were contacted by phone or email to clarify the role of climate change analyses in decision-making.

This study has several limitations. First, it is assumed that the 206 UWMPs for which population data was available are representative of the entire set of 381 UWMPs submitted to DWR as of April 2012. As noted earlier, conversations with DWR staff indicate that there is unlikely to be significant bias in the sample toward larger or smaller suppliers. Second, some patterns among small and medium-sized suppliers may not have been detected with a 10% sample size. Third, geo-referenced data was not available for water suppliers submitting UWMPs, and no analysis could be conducted on how responses to climate change varied across regions of the state.

4. Consideration of climate change impacts in UWMPs

This section examines how climate change impacts have been analyzed in UWMPs, and how these analyses have affected UWMP water supply and demand projections. Sections 4.1 and 4.2 characterize the degree and nature of climate change discussion in UWMPs. Section 4.3 provides an overview of the existing studies that UWMPs draw upon, and the specific climate change analyses that certain water suppliers have undertaken and discussed in their UWMPs. Section 4.4 examines how information about climate change impacts is taken into account in UWMP planning for water demand, supply, and quality, and in determining drought sequences. Finally, Section 4.5 provides a summary and discussion of these findings.

4.1. Extent of discussion of climate change impacts

As illustrated in Table 4, about two-thirds of all UWMPs studied mentioned the potential impacts of climate change in some manner. All regional UWMPs discussed climate change, and the UWMPs of two out of three multi-site investor-owned utilities did so. In general, large suppliers are much more likely to discuss climate change than smaller suppliers. Table 4 shows that 85% of large suppliers mention climate change impacts, while only 36% of small suppliers do so. To the extent that population size served is an indicator of the level of financial resources and staff size (as discussed in Section 2.3), this suggests that suppliers with greater access to such resources are more likely to discuss climate change impacts.

Table 4. Extent of climate change impacts discussion in 2010 UWMPs.

Supplier/UWMP type	Percent (number) of UWMPs mentioning climate change impacts
Large suppliers (21)	85% (18)
Medium suppliers (14)	64% (9)
Small suppliers (14)	36% (5)
Regional UWMPs (7)	100% (7)
Multi-site IOUs (3)†	66% (2)
All UWMPs studied (59)	69% (41)

†The UWMPs for the service areas of each these 3 companies follow the same format for considering climate change, and therefore are counted together here.

Among those discussing climate change, two broad categories emerge. First, some UWMPs mention climate change in a general manner, usually noting that climate change is anticipated to impact California's water systems, but without describing potential impacts to the service area. Some indicate that these impacts are too uncertain to consider at this time. For example, Stockton East Water District simply states that "long term affects [sic] of climate change on the Sierra snowpack are unknown at this time," (p. 8-1), and the Long Beach Water Department's climate change chapter consists of two brief paragraphs indicating that local impacts are uncertain and that "LBWD does not expect climate change to have a major impact on its local sources of water, such as groundwater and recycled water, during the time projections of this 2010 UWMP," (p. 54). Others discuss key impacts at the state level and note plans to incorporate climate change as more specific knowledge emerges. Jurupa Community Services District follows this approach, concluding that, "As DWR develops more specific assessments of the potential effects of climate change on SWP delivery reliability, local water reliability, and water demands, JCSD can update its plans accordingly," (p. 10).

Another set of UWMPs contains a discussion of specific impacts that climate change may have in a supplier's service area. The length and sophistication of the discussion may vary, but these UWMPs tend to identify these impacts by connecting general climate change trends with specific characteristics of their water systems. Some large suppliers discuss studies they have undertaken to estimate the magnitude of these impacts (see Section 4.3.2), while others discuss impacts qualitatively. For example, the UWMP from the City of Paso Robles contains a brief but specific discussion of potential climate change impacts:

> "Paso Robles does not have surface water supplies dependent on snowmelt, which is likely to be affected by global warming. Effects of global warming on local rainfall remain highly uncertain; however, it is likely that continued global warming would increase evapotranspiration losses. In other words, water demand for irrigation would increase as well as evaporation of Lake Nacimiento water. At this time, the significance of such an effect is not known but warrants continued consideration, particularly given the high summer season water demand that already has stressed the City water system capacity." (City of Paso Robles 2010 UWMP, p. 34)

Table 5 summarizes the extent of climate change discussion in the UWMPs reviewed according to these categories. It shows that 52% of large suppliers identified specific

impacts, in some cases by conducting their own studies. Fewer medium-sized and small suppliers discussed specific impacts. Among the seven regional UWMPs, three contained specific climate change discussions but none conducted their own studies. Two out of the three multi-site investor-owned utilities (IOUs) – California American Water and California Water Service Company – contain discussions of climate change impacts in UWMPs for each of their service areas. None have conducted specific studies, although California Water Service Company is planning to undertake a study of climate change impacts to its service areas in 2013, making use of the Climate Change Handbook (EPA/DWR 2011).

Table 5. Analysis of climate change impacts in UWMPs reviewed.

	No mention	**General mention**	**Specific impacts identified**	**Conducted own study†**
Large suppliers (21)	14% (3)	33% (7)	52% (11)	33% (7)
Medium suppliers (14)	36% (5)	29% (4)	36% (5)	7% (2)
Small suppliers (14)	64% (9)	14% (2)	21% (3)	0% (0)
Regional UWMPs (7)	0% (0)	57% (4)	43% (3)	0% (0)
Multi-site IOUs (3)	33% (1)	0% (0)	67% (2)	0% (0)
All UWMPs studied (59)	31% (18)	28% (17)	41% (24)	15% (9)

†UWMPs in this column are also included in the figures for UWMPs identifying specific impacts (Column 3).

4.2. Location of climate change discussion

The 2010 Guidebook includes climate change as a separate, optional section (Section 7). Some UWMPs follow this pattern and include a separate section focused on climate change, ranging in length from 2 sentences to 20 pages. However, as Table 6 shows, climate change is also discussed in other UWMP sections (and sometimes in more than one), including sections on the risks to water supply sources, or water reliability and drought planning. A few have discussed climate change in the section related to water demand. The fact that climate change has been incorporated into multiple parts of UWMP documents suggests that some water suppliers recognize the relevance of climate change to a number of required UWMP elements.

Table 6. Location of climate change impacts discussion in UWMPs reviewed.

UWMP Section†	**# of UWMPs discussing climate change in this section††**
Introduction/System Description	6
Water Demand	4
Water Supply	14
Water Reliability and Drought Planning	7
Climate Change	16
Other (describing planning process)	2

†Section names reflect DWR's 2010 UWMP Guidebook, although some UWMPs use another structure, and often combine Water Supply and Water Reliability sections. The "Other" category refers to report sections that are not included in DWR's Guidebook, and provide an overview of the supplier's planning process.
††Some UWMPs discuss climate change in more than one section.

Two UWMPs reviewed – Metropolitan Water District of Southern California (MWD) and San Diego County Water Authority (SDCWA) – included discussion of climate change when describing their own planning processes, a section not required by the UWMP guidelines. MWD discusses its use of robust decision-making, and SDCWA is employing scenario planning (see Section 2.4 of this report for a description of these two approaches). Both agencies explicitly incorporate climate change into the future scenarios they consider. They have been closely involved in WUCA, and SDCWA's UWMP notes that its participation in WUCA was pivotal in their decision to undertake scenario analysis (p. 10-1).

4.3 Climate change information and analysis

While there has been considerable study of the overall impacts of climate change on California's water resources, understanding the impacts of climate change on the operations of an individual water supplier can be challenging. This requires linking knowledge of broad-scale changes in climate patterns with knowledge about features a water system, and taking into account uncertainties associated climate change projections. There are a number of approaches to assessing impacts, requiring different levels of expertise in the use of climate models and for accounting for uncertainties in different ways (EPA/DWR 2011). While some larger suppliers are taking the lead in developing these approaches, many small and medium-sized water suppliers are limited in the time and resources they can invest in selecting and undertaking these studies. This section describes the kinds of information and analysis that water suppliers reference in their UWMPs as the basis for their discussion of climate change. Two broad categories emerge: UWMPs that draw upon existing literature or plans, and those that discuss results from a specific study of climate change impacts undertaken by the supplier.

4.3.1. Climate change discussion based on existing studies

Most UWMPs that discuss climate change impacts draw upon findings from existing studies. A number of UWMPs contain a description of the anticipated impacts of climate change at the state level, largely based on DWR documents summarizing these impacts, such as *Managing an Uncertain Future* (2008) and the 2009 Water Plan Update, along with reports from the Climate Action Team (CAT). While it is useful to understand these general trends, the key challenge for a water supplier is to understand implications of these trends for their water systems. In identifying specific climate change impacts in their UWMPs, suppliers have referenced various studies or plans, including the following:

- **DWR's State Water Project Reliability Report 2009.** This is the most widely cited study, referenced by 18 of the 49 individually submitted UWMPs reviewed, and in five out of seven regional UWMPs (see Tables A5 and A6, Appendix A). The SWP Reliability Report used downscaled climate model projections to estimate how climate change will affect the reliability of supply available to SWP contractors, and includes the anticipated impacts of sea level rise on salinity levels in its estimates (DWR 2010b). This climate change analysis is mentioned in UWMPs when suppliers relying upon SWP water discuss risks to their supply sources.
- **Studies by wholesale suppliers.** Those water suppliers that receive wholesale water may be able to draw upon a wholesaler's study of specific climate change

impacts to a region, if one has been conducted. The next section discusses the analysis involved in some of these studies. Table A5 in Appendix A illustrates the extent to which wholesaler studies are referenced in UWMPs.

- **Climate Action Plans.** Cities and counties across the United States and in other countries have been developing Climate Action Plans, some of which include an analysis of potential impacts of climate change (Tang et al. 2010). Several UWMPs submitted by cities or counties reference a Climate Action Plan, including the cities of Sacramento, Santa Rosa, Santa Monica, and Santa Cruz. These city water departments, which themselves may have limited staff time available responsible for submitting the UWMP, are able to draw upon this information gathered as part of a citywide effort. For example, the vulnerability analysis conducted by the City of Santa Cruz, and referenced in the city's UWMP, is discussed in the next section.
- **IRWM plans.** As discussed in Section 2.4, IRWM guidelines now require that IRWM plans include an assessment of the region's vulnerabilities to climate change, and most are now being updated to include this (Conrad 2012). Few UWMPs reference IRWM plans with respect to climate change, but this may be because most IRWM plans did not yet include a climate change analysis when 2010 UWMPs were prepared. The UWMPs submitted by the five service areas of California American Water Company each indicate that the climate change analysis in the relevant IRWM plan will be referenced in future UWMPs (for example, see California American's San Diego District, p. 7-1). In the future, IRWM plans may be an important resource, particularly for small suppliers that do not have the capacity to conduct substantial climate change analysis on their own (see Section 5.3).
- **Local climate data.** Although every UWMP contains a description of local precipitation and temperature patterns (in Section 1: System Description), relatively few examine trends in local data over time. Long Beach Water Department's UWMP notes that local temperatures have increased by more than one degree Fahrenheit over the last 50 years, but does not connect this trend with climate change (p. 15-16). California Water Service Company's UWMPs contain graphs of historical trends in temperature and precipitation for the relevant hydrologic region, using data from the Western Climate Data Center (for example, see Salinas District UWMP, p. 90-92).

4.3.2. Climate change analyses by water suppliers

Nine water suppliers included in this study conducted their own analyses of climate change impacts and reported this in their UWMPs, as summarized in Table 7. These large and medium-sized suppliers have worked with university researchers, the U.S. Geological Survey, the Water Utility Climate Alliance (WUCA), and consulting firms to study the potential impacts on regional and local sources of surface and groundwater, regional water demand, and the potential effects of changing drought patterns. In most cases, these studies have been used to assess how climate change is likely to affect water supply or demand. As will be discussed in greater detail in Section 4.4, a number of suppliers have concluded that these effects are not significant enough to be incorporated into projections for the current 20-year UWMP planning period. However, a few large suppliers, particularly MWD and San Diego County Water Authority (SDCWA), incorporate knowledge from a climate change analysis directly in their own planning processes as one of multiple factors affecting future supply and demand.

Table 7. Climate change impact analyses undertaken by water supply agencies.

Type of analysis	Supplier	Partners	Focus of study	Integration into planning
GCM-based impacts analysis	Metropolitan Water District of Southern CA	Water Utility Climate Alliance, RAND Corporation	Water supply, demand	Use in robust decision-making
	Los Angeles Department of Water and Power	TetraTech, Scripps Institute of Oceanography at University of California San Diego	1) Effects on amount and timing of supply from the LA Aqueduct; 2) water demand, local runoff and groundwater in the LADWP service area	Adjusted supply projection for LA Aqueduct, resulting in a 10,000 acre-feet reduction in supply from 2010-2035.
	San Diego County Water Authority	Scripps Institute of Oceanography, UC San Diego	Effects on demand in SDCWA area, and supply from Sierra Nevada and Colorado River Basin	Concluded that effects of climate change demand through 2035 not significant enough to include in current projections.
	Inland Empire Utilities Agency	RAND Corporation	Water supply, demand	Use in robust decision-making
	Sonoma County Water Agency	USGS	Streamflow, runoff and groundwater changes as a result of climate change	Study is underway and will inform 2015 UWMP.
	Marin Municipal Water District	USGS, Pepperwood Institute	effects on runoff timing, dry season length, water demand	Study is underway and will inform 2015 UWMP.
Sensitivity analysis	San Francisco Public Utilities Commission	Water Utility Climate Alliance	Effects on runoff amount and timing from Hetch Hetchy Reservoir through 2025, assuming a 1.5 degree C increase in temperature and no precipitation change. Study is continuing under additional scenarios.	Concluded that the impacts on runoff patterns (7% would shift from summer to winter) are within current planning ranges. Further analysis now underway to study the effects of a broader range of variables.
	East Bay Municipal Utility District	Lawrence Livermore National Labs, Climate Ready Water Utilities Working Group	Effects of climate change on runoff volumnes from Mokolumne River, water demand, water temperature (leading to water quality and ecosystem impacts)	Climate Monitoring and Response Plan guides on-going assessments of system vulnerability, lending support to long-term strategies for system interties, groundwater recharge
Qualitative impacts assessment	San Diego County Water Authority	Water Utility Climate Alliance	Characterization of climate change as one of six scenarios considered in formulating water management strategies	Inclusion of climate change in scenario planning provided support for consideration of wider range of possible future conditions.
	City of Santa Cruz	UC Santa Cruz	Climate change impacts on all city operations. UWMP references changes in surface runoff, and rising water table with potential flooding of wastewater treatment plant.	Incorporated into city-wide Adaptation Plan, leading to recommendations water planning to be considered by City Council.

Table 7 highlights the different types of analysis used to assess climate impacts. Three broad approaches are represented, with a few suppliers employing more than one approach.

- **Incorporation of downscaled global circulation models (GCMs) into a model of a water system to quantify impacts.** These studies seek to quantify the specific effects of climate change on a water system and estimate their likelihood, by combining outputs from multiple GCMs under different global greenhouse gas emissions scenarios, such as A2 (high emissions) and B1 (moderate emissions). These climate model outputs are used to adjust temperature and precipitation variables in a water system model over the next 20-100 years. This type of study can provide a quantitative estimate of climate change impacts and the uncertainty associated with them. LADWP used this approach to estimate a reduction in supply from the Los Angeles Aqueduct due to climate change (see Section 4.4.2). However, this requires significant expertise in the use of climate models, and analysis results must be carefully interpreted given the uncertainties associated with downscaled GCMs at relatively small temporal and spatial scales. In addition to LADWP, several other suppliers discuss GCM-based analyses in their UWMPs, including San Diego County Water Authority, Sonoma County Water Agency and the Marin Municipal Water District. MWD and Inland Empire Utilities Agency (IEUA) discuss their use of downscaled GCMs to implement robust decision-making, which involves running many simulations of a water model under multiple scenarios, and using statistical methods to identify water management strategies that perform well under a range of possible future conditions (WUCA 2010, p. 56, Groves et al. 2008).

- **Sensitivity analysis to identify how changes in particular factors affect a water system.** This approach involves testing how changes in specific variables in a water system model affect system performance (DWR 2009, p. 5-12). These studies do not seek to estimate the likelihood of future impacts using GCMs, but instead test the effects of changes that are plausible based on other studies. For example, EBMUD used this type of analysis to test how its water supply from the Mokelumne River and its water demand would change as a result of increased temperatures and precipitation changes. These sensitivity analyses were not discussed in detail in the 2010 UWMP, but are described elsewhere (Wallis et al., 2008). SFPUC has so far followed a similar approach. Its 2010 UWMP reports upon a preliminary assessment it undertook to understand how flows into the Hetch Hetchy Reservoir might change under a 1.5 °C temperature increase by 2025. This temperature increase was based on a consensus among scientists at the time that a 3 °C temperature increase by 2050 was likely (SFPUC UWMP, p. 91). The UWMP indicates that SFPUC would undertake a more in-depth sensitivity analysis, testing the effects of a wider range of changes in climate-related variables, which the agency has since completed (D. Behar, personal communication, Nov. 6, 2012).

- **Qualitative analysis of vulnerabilities.** This approach combines results from existing studies about the general effects of climate change with specific knowledge of a water system to identify which elements of a system may be most significantly

impacted (EPA 2010, EPA/DWR 2011). Vulnerability assessments are commonly undertaken as a preliminary step to identify specific impacts in need of further study, but they may also directly inform decision-making processes in some circumstances. Table 7 includes two examples of this. San Diego County Water Authority (SDCWA) used a qualitative analysis of climate change impacts, drawing upon impacts discussed in DWR's *Managing an Uncertain Future* (2008), to develop a climate change scenario for its scenario planning process (SDCWA UWMP, p. 10-9). The City of Santa Cruz commissioned a study by two researchers at UC Santa Cruz to assess citywide impacts of climate change (City of Santa Cruz UWMP; final study published as Griggs and Haddad 2011). The study synthesizes findings from existing studies of the effects of climate change in the Santa Cruz region and identifies specific impacts to water supply, including potential water shortages due to decreased local runoff, and risks to the city's water treatment plant due to sea level rise (City of Santa Cruz 2010 UWMP, p. 9-3). This study provided the basis for adaptation recommendations, which are now being considered by the City Council (p. 9-4).

Other UWMPs include very basic forms of vulnerability assessment. For example, UWMPs for California American Water Company's service areas each include a table describing the specific vulnerabilities of a service area with respect to sea level rise and water quality, reduced snowpack, Delta flooding, and increased temperature and water demand (for example, see California American's Ventura County District UWMP, p. 7-10).

4.4. Accounting for climate change impacts in UWMPs

This section discusses how water suppliers have used their understanding of climate change impacts in projecting water supply and demand, and choosing drought planning sequences. In the vast majority of cases, including large suppliers that have conducted their own studies, climate change effects are not explicitly included in projections of supply and demand, with the exception of LADWP and those suppliers making use of the State Water Project Reliability Report. A number of suppliers appear to have concluded either that knowledge is too uncertain, or the potential impacts are too small, to adjust projections for this 20-year UWMP planning period. A few suppliers have considered the possibility of adjusting their drought planning sequences in response to the finding that climate change may lead to more extreme droughts, but so far none have done so explicitly.

4.4.1. Water demand

While population growth and changes in per capita water use are the most significant variables affecting water demand, temperature and rainfall patterns also play a role, particularly for outdoor water use. This is noted in a number of UWMPs. For example, Long Beach Water Department's UWMP states, "Weather impacts how much water people use, especially how much water is needed for landscape irrigation. The primary weather impacts are summer temperature and winter rainfall," (p. 15). Thus, as climate change leads to increased temperatures and changes in precipitation patterns, impacts on water demand can be expected. The 2009 Water Plan Update considers how climate change may

affect urban water demand statewide under three plausible future growth scenarios. It finds that although the effect of climate change is smaller than that of population growth, it is still significant, potentially amounting to as much as 750,000 acre-feet per year (DWR 2009, p. 5-32). A recent study by the Pacific Institute finds that under high GHG emissions scenarios, climate change may lead to an additional one million acre-feet per year in urban water demand by 2100 (Christian-Smith et al., 2012).

Estimating future water demand is a crucial element of UWMPs, particularly given the focus on demand management in order to comply with SBX7-7's 20% per capita reduction in urban water demand by 2020. In their water demand projections for 2010-2030, suppliers make differing assumptions regarding conservation measures and weather patterns. Most UWMPs assume that conservation measures will be used in all years in order to achieve 20% demand reductions by 2020. Many UWMPs also assume that these measures will be more aggressive in dry years, sufficient to counteract the effects of dry weather. For example, the Stockton East Water District assumes urban demand decreases to 90% of normal in the second of three consecutive dry years, and to 80% in the third, fourth and fifth such dry years (p. 8-1). Some suppliers, on the other hand, assume that dry weather will increase water demand. For example, Los Angeles Water District 29's UWMP states, "During multiple dry year periods, the overall demand is estimated to increase by 4% over normal year demand during the first year, 4.5% over normal year demand during the second year, and 5% over normal year demand during the third year to account for anticipated progressive increases in irrigation needs during each multiple dry year period," (p. 22). Temperature effects on demand are also considered in some models. For example, MWD's demand model uses statistical analysis of weather and demand data to quantify how demand has been affected by dry or hot periods in the past, and uses this in its projections of future demand, along with estimates of the degree to which conservation measures may counteract these effects (MWD 2010b).

The above are illustrations of how water suppliers typically estimate the effects of dry and hot periods on water demand. Accounting for climate change would require adjusting assumptions about how frequent or intense these dry or hot periods are. Some UWMPs mention the potential for climate change to affect these patterns, mostly in a general manner. For example, the Antelope Valley regional UWMP states, "Historically, both agricultural and urban water usage have increased in dry weather. However, in recent years, conservation efforts have limited increases in demand due to higher temperatures and often have resulted in reduced overall demand. Further effects due to global warming may also begin to influence future water usage and planning efforts," (p. 29). A few large suppliers, including SDCWA, EBMUD, and LADWP, have studied these effects in detail. SDCWA's analysis found that climate change would increase water demand by between 0.63 – 1.8% by 2035. SDCWA discusses this result in its UWMP, but does not include it in official demand projections, stating that "the relatively small increase in 2035 demand under all climate scenarios suggests that significant water demand impacts associated with the forecasted trend toward warmer and drier climate conditions may occur on a time-step beyond the 2010 Plan planning horizon," (p. 2-13). EBMUD's analysis showed that a 4 °C increase in temperature (viewed as a worst-case scenario) would lead to a 3.6% increase in demand by the year 2040 (EBMUD 2012b, p. 19), but this was not incorporated into the

agency's UWMP demand projection. Similarly, LADWP has studied the effects of climate change on demand but did not include this in its 2010 UWMP (S. Hsu, personal communication, August 1, 2012).

4.4.2. Water supply

Impacts on water supply are the most frequently discussed effect of climate change in UWMPs, and are often included in the "Water Supply" section of UWMPs (see Table 4). In addition to the climate change guidance in the 2010 Guidebook that encourages consideration of effects on supply, the UWMP Planning Act requires that, "for any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable," (§10631(c)(2)).

Suppliers that receive deliveries from the State Water Project have incorporated climate change into their supply planning by using the projections provided in DWR's 2009 SWP Reliability Report (DWR 2010b). In this report, DWR used downscaled climate models to estimate the impact of climate change on SWP water deliveries, including impacts related to temperature increases and risks due to sea level rise. Specifically, the effect of climate change on the reliability of SWP deliveries for 2029 was estimated by selecting a single climate model projection that represented the central tendency of 12 projections assembled by the Climate Action Team (DWR 2010b, p. 30). Of the individually submitted UWMPs studied here, 18 receive water from the State Water Project, as do participants in five out of seven regional UWMPs (see tables A5 and A6, Appendix A). All of these suppliers used the 2009 report to estimate the amount of water they could expect from this source during the planning period, and in doing so they incorporated climate change into their supply projections.

The Los Angeles Department of Water and Power (LADWP) is the only supplier that explicitly accounted for climate change in its UWMP supply projection for a non-SWP water source. With assistance from a team of consultants and researchers, LADWP conducted a study of how climate change would affect water imported from the Eastern Sierra via the Los Angeles Aqueduct. The study used 16 GCMs under B1 (moderate emissions) and A2 (high emissions) scenarios over the period 2010-2099, and found an overall decrease in runoff and changes in timing that would increase extremes in runoff amounts (Roy et al. 2009). Based on these findings, LADWP reduced its supply projection for the LA Aqueduct by 0.1652% per year (LADWP UWMP, p. 20). This amounts to gradual reduction from a current 254,000 acre-feet per year to 244,000 acre-feet per year in 2035 (p. 223). This figure was arrived at by dividing the total projected decrease in supply through 2099, as determined in their climate change study, equally across all years to come up with an estimated reduction per year (D. Kwan, personal communication, July 31, 2012).

Suppliers that receive water from wholesalers sometimes reference wholesaler analyses of impacts on water supply (see Table A5, Appendix A). In doing so, they rely upon the wholesaler's efforts to take climate change into account. For example, the City of San Diego's UWMP notes that the city receives 85-90% of its supplies through SDCWA, which in

turn receives its supplies from MWD. After describing how climate change may affect runoff and water exports in California, the City's UWMP states, "MWD and SDCWA have established long-term supply and facility plans for implementing regional projects and water transfers to mitigate and adapt to the reduced and less reliable water supplies impacted by climate change. Therefore, the wholesale supply impacts to the City are expected to be less than indicated by the projections of reductions in runoff and exports," (p. 4-19). Although SDCWA and MWD have not explicitly adjusted their UWMP supply projections, their own planning processes account for climate change through the use of robust decision-making (MWD) and scenario planning (SDCWA), as discussed earlier in this report.

Some wholesalers – including several that undertook their own studies of climate change impacts in their service areas – have concluded that within the current 20-year UWMP planning period, the effects of climate change are not significant enough, or are too uncertain, to explicitly include them in estimates of supply. For example, the San Francisco Public Utilities Commission's preliminary assessment found that climate change impacts on inflows into the Hetch Hetchy Reservoir were within the range of current variability, which SFPUC already takes into account (p. 91). As interpreted by Alameda County, which receives supply from the SFPUC, "The SFPUC has stated that based on this preliminary analysis, the potential impacts of climate change are not expected to affect the water supply available from the San Francisco Regional Water System (RWS) or the overall operation of the RWS through 2030," (p. 3-14). Irvine Ranch Water District (IRWD), which did not undertake its own climate change study, indicated that "potential climate change impacts on state, regional, and local water supplies and relevant information for the Orange County hydrologic basin and Santa Ana Watershed have not been sufficiently developed at this time to permit IRWD to assess and quantify the effect of any such impact on its water supplies," (p. 70).

As discussed earlier (see Tables 4 and 5), most small suppliers do not discuss the impacts of climate change on supply. However, for those that do, impacts on groundwater supplies are the main focus. In fact, the three small suppliers that discuss specific impacts of climate change (City of Morgan Hill, City of Paso Robles, and Scotts Valley Water District) rely in part or wholly on groundwater supplies (see Tables A4 and A5, Appendix A). These three suppliers have already experienced shortages in their groundwater supplies during drought years. On the other hand, a number of other small suppliers that do not discuss climate change, such as Sweetwater Springs, the City of Blythe, and Indian Wells Valley Water District, have not experienced water shortages and do not anticipate their groundwater levels to be affected by drought in the future.

4.4.3. Water quality

In general, most UWMPs do not include extensive analysis of water quality issues, although some discussion of the topic is required in the UWMP section on water reliability planning (DWR 2010a, p. 5-3). Climate change impacts on water quality are discussed less frequently and in less detail than are impacts on water supply. Among the 11 large utilities in this study that discussed specific climate impacts, five mention potential water quality impacts, and only two medium-sized suppliers did so. Saltwater intrusion due to sea level rise is the

most frequently cited concern, noted by the City of Sacramento, two Bay Area suppliers, and LADWP (City of Sacramento UWMP, p. 7-1, Santa Clara Valley UWMP, Ch. 9, p. 2, and Alameda County, p. 3-13, LADWP UWMP, p. 254). LADWP's UWMP also notes the potential effects on water quality from an increase in fire events (p. 254). The effects of more extreme precipitation events are acknowledged indirectly in the City of San Diego's UWMP, which notes potential changes in water quality related to "increased solids, turbidity, taste and odor issues" that may lead to increased treatment costs (p. 4-20). Finally, the City of Santa Cruz's UWMP notes that the city's wastewater treatment plant may be impacted as the water table rises due to sea level rise (p. 9-3). Among all the UWMPs reviewed, this is the only instance in which flooding risks to water infrastructure is mentioned.

Risks to water quality are accounted for in UWMP planning through adjustments to projections of water supply that meets certain water quality standards. Because DWR's SWP Reliability Report incorporates potential changes in salinity due to climate change, water suppliers that rely upon SWP deliveries have effectively incorporated this factor in their planning. Aside from this, adjustments have not been made in UWMP plans as a result of concerns about climate impacts on water quality.

4.4.4. Drought planning sequences

As described in Section 2 of this report, a "Drought Planning" element is required in each UWMP, which includes an assessment of the reliability of supply to customers in "normal," "single dry" and "multiple dry" water years. The 2010 Guidebook specifies that the runoff conditions in these years should be defined according to historical runoff records for a given water source. An "average" year is the median runoff for the previous 30 years; a "single dry" year is defined by the lowest annual runoff since 1903, and a "multiple dry" year is the lowest runoff for at least three consecutive years in the record since 1903 (2010 Guidebook, p. 5-1 to 5-2). At the same time, guidance for the optional climate change section in the Guidebook encourages water suppliers to consider the potential for climate change to alter these drought patterns, noting that "droughts will become deeper and longer," (p. G-3). This potential for more extreme rainfall patterns is widely cited as a general impact of climate change, and some recent research indicates that the state is likely to see more extreme precipitation events and more frequent dry years (Moser et al. 2012, p. 5, Cayan et al. 2012, p. 16). However, it is still difficult to develop quantitative estimates of how extremes will change in specific locations.

Although a few UWMPs discuss the potential for climate change to increase the length or severity of droughts, no UWMPs included in this study have indicated that their drought planning sequence has been adjusted to reflect climate change. Table 8 shows that most UWMPs are based on a multiple-year drought length of three years (the minimum specified in the 2010 Guidebook), although some use longer periods. SFPUC's is the longest, at 8.5 years. Unlike most UWMP drought sequences, which are based directly on the historical record, SFPUC's planning sequence is a combination of the 1986-1992 and 1976-77 droughts, circumstances that have not occurred in the historical record (p. 50-51). SFPUC did not select this sequence in response to climate change; rather, it was adopted after the 1986-1992 drought in order to provide an extra factor of safety in planning (D. Behar, personal communication, Nov. 6, 2012).

Table 8. Length of multi-year drought planning sequences in 2010 UWMPs studied.

UWMP type	3 years	4 years	5 years	6+ years
Large supplier (21)	14	1	3	3
Medium/small supplier (28)	19	5	2	2
Regional (7)	4	2	0	1
Total (56)	**37**	**8**	**5**	**6**

In addition to adjusting the length of a planning sequence, it is also possible to plan for more extreme droughts by assuming lower runoff levels in individual years. For example, the East Bay Municipal Utility District (EBMUD) uses a 3-year sequence that includes historical records for 1976 and 1977, but replaces the record for 1978 (which was a wet year) with the much lower average of 1976-77. This is mentioned in EBMUD's 2010 UWMP (p. 3-2), and is discussed in depth in a technical memorandum associated with their Water Supply Management Program 2010 (EBMUD 2010c). This memo notes that although the 1976-77 drought was not the longest it has experienced, it was the deepest and had the greatest impact on EBMUD operations (EBMUD 2010c, p. 3-5). It also specifically considers if and how EBMUD's drought planning sequence might need to be adjusted due to climate change uncertainties. It finds that there is no standard practice among water planners in this regard, and recommends that EBMUD maintain its current drought sequence, which is conservative with respect to the historical record (p. 6-13).

Other water suppliers are also wrestling with the challenge of identifying an appropriate drought planning sequence in light of climate change. Marin Municipal Water District (MMWD) used a 3-year drought planning sequence (1976-78) in its UWMP, but also considered two others. Noting that "ongoing climate change has put into question the appropriateness of traditional methods of analyzing the reliability of water supply systems," (p. 7-2), MMWD developed two alternative drought sequences and tested how the reliability of its water supply would change under these assumptions. One was similar to EBMUD's approach, using the 1976-77 record but replaced the wet year of 1978 with an average of 1976-77. The second was a drought that represented runoff levels set equivalent to a 1 in 200-year event. MMWD found that these assumptions would result in a 10-25% reduction in system reliability (p. 7-3). The agency is supporting two studies conducted by USGS scientists to model climate impacts in the region, and plans to refine its consideration of these issues based on their findings.

4.5 Summary and Discussion

Two-thirds of the UWMPs reviewed for this study mentioned the impacts of climate change in some manner. Some include a separate section on climate change, while others discussed the issue in other sections focused on water supply, demand, or supply reliability. Large suppliers discussed climate change more often and in greater depth than smaller suppliers; this may be due in part to greater access to resources and expertise. Most of the focus was on water supply and demand, with only limited attention to water quality issues. The three small suppliers in the study that discussed specific impacts of climate change focused on how climate change might affect groundwater supplies, an important source of their

supply. Discussion of climate change in UWMPs was primarily based on existing studies, particularly DWR's SWP Reliability Report 2009, the California Water Plan, and other DWR documents. Nine large and medium-sized suppliers conducted their own analyses of climate change impacts on their water systems, either through the use of downscaled GCMs, sensitivity analyses, or qualitative vulnerability assessments.

This review indicates that for the most part, the analysis of climate change impacts has not been directly incorporated into UWMP water supply and demand projections. One important exception to this is that 18 UWMPs included in this study rely upon deliveries from the State Water Project, and have referenced DWR's SWP Reliability report, which incorporates the effects of climate change, in projecting their water deliveries. Aside from this, one other supplier included in this study - the Los Angeles Department of Water and Power (LADWP) – has adjusted its supply projection for a non-SWP water source based on an analysis of the anticipated effects of climate change. No suppliers have incorporated climate change into UWMP water demand projections, although several large suppliers have studied the issue. Some suppliers note in their UWMP that the estimates of impacts at local scales within the 20-year planning period are either too uncertain or too small to include in projections of supply and demand. A similar trend is found with regard to drought sequences. While a number of suppliers acknowledge that climate change may increase the severity of droughts in the future, they have not yet determined an appropriate method to adjust their drought planning sequences based on this knowledge.

As discussed below, these findings have several implications for how suppliers, with assistance from DWR, could improve their integration of climate change in UWMPs. In general, these findings suggest that a sole focus on the 20-year timeframe for UWMP planning can limit understanding and planning for climate change impacts. Most climate impact studies project changes over 50-100 years, largely because at shorter timescales year-to-year variability makes it more difficult to detect changes due to increased GHG emissions. Water planning decisions are often made at shorter timescales, although infrastructure-related decisions often require timeframes of 50 years or more (WUCA 2009). EPA's study of current practices among water suppliers indicates that most have analyzed climate impacts at more than one timescale, such as 30 and 50 years (2010, p. 14). The California Water Plan uses scenarios for the year 2050 (DWR 2009). Although uncertainties associated with shorter-term climate projections may decrease somewhat in the future, they will not be eliminated, and decisions still need to be made in the near-term to manage future risks (Dessai et al. 2009). As illustrated by the discussion below, successful planning for climate change may at times require a longer-term view than the UWMP's 20-year timeframe. The UWMP process could benefit from a means of encouraging awareness of critical climate change risks, including those that only become significant beyond the UWMP planning period.

The findings of this section provide the following insights regarding how consideration of climate change could be more effectively integrated into specific UWMP elements.

- **Water demand.** UWMP demand projections are the basis for planning conservation measures in order to meet the state's legally-mandated target of a 20% per capita

reduction in water demand. These demand projections are based on historical climate patterns and most suppliers also assume that during hot or dry periods, water conservation measures will overcome any increases in water demand. Climate change is already leading to increased temperatures, and this trend is expected to continue (Cayan et al. 2012). While the effects on water demand may be relatively small within the 20-year UWMP planning period, this may not be true over longer time periods. As a result, water conservation measures put in place by water suppliers will be insufficient to sustain demand reductions as the effects of climate change become more significant beyond 2020. Explicit inclusion of climate change in demand projections may be warranted, particularly for suppliers with significant outdoor water use. Tools to assist suppliers in doing this may be helpful. The Excel-based tool recently developed by the Pacific Institute is one such resource (Christian-Smith et al., 2012).

- **Water supply and quality.** Water suppliers that rely directly or indirectly on deliveries from the State Water Project are incorporating climate change into their UWMP water supply projections through their use of DWR's SWP reliability report (DWR 2010b). Given the fact that these suppliers are adjusting their expectations, it is important that DWR regularly review and update this climate change analysis to provide suppliers with the best possible reliability estimates. The approach used in 2009, which was employed again for 2011 reliability estimates, involves selecting a single climate change projection from among 12 projections developed by the Climate Action Team (DWR 2010b, 2012c). This methodology could be reviewed, and if necessary, updated in future years. In addition, it may be helpful for DWR to support further study and technical assistance related to the impacts of climate change on groundwater supplies. The effects of changes in runoff patterns on groundwater vary depending upon the basin, and so far, the impacts of climate change on groundwater resources have received relatively little study. Further, since groundwater is more heavily relied upon during drought years, climate change is likely to increase pressures on this resource (Langridge et al. 2012). Small suppliers rely more heavily upon groundwater, but often have limited resources and expertise for understanding climate change impacts. Finally, water quality impacts have received only limited attention in UWMPs, aside from salinity concerns discussed in the SWP reliability report.

- **Drought sequences.** This report shows that while water suppliers recognize that climate change may affect drought patterns, it is difficult to determine how to account for this. While DWR's current guidance on climate change urges suppliers to take into account that droughts may become "deeper and longer," any quantitative estimate of this effect would have a considerable degree of uncertainty. However, as many studies of adaptation emphasize, uncertainty does not mean that no action is possible (EPA 2010, Dessai et al. 2009). DWR's 2008 white paper, the findings of which were incorporated into the 2009 Water Plan, encourages planning that "assumes, until more accurate information is available, a 20 percent increase in the frequency and duration of future dry conditions," (DWR 2008, p. 12). In the case of some suppliers, the choice of a drought planning sequence may have significant

implications for infrastructure investments, and near-term options may be limited for pursuing these. For the time being, suppliers may need to decide on an approach that fits their particular circumstances. However, additional guidance from DWR regarding possible approaches to adjusting drought sequences would likely be useful.

5. Climate change analysis and strategies for reducing drought vulnerability

The UWMP process encourages water suppliers to consider a range of strategies to reduce their vulnerability to drought situations.[10] The purpose of accounting for climate change impacts in UWMPs is to improve the selection and design of these strategies. In general, the risks presented by climate change argue for a greater factor of safety in planning for droughts. However, the specific management strategies of a supplier will depend upon differences in their water sources and financial, technical and administrative capacity. Literature on climate change adaptation, including for the water sector, emphasizes the importance of a clear understanding of the decisions that a particular risk analysis is intended to inform (NRC 2010, CAWWG 2010). Quantitative analyses are appropriate in some circumstances, particularly when long-term infrastructure investments are being considered, and when capacity exists to implement the analysis and evaluate results in a way that takes uncertainties into account. However, some decision contexts may not require this, such as in the case of "low-regrets" strategies that can largely be justified based on other benefits (NRC, 2010, p. 153, CAWWG, 2010, Dessai et al., 2009).

This section surveys the types of management strategies discussed in UWMPs to reduce vulnerability to droughts, and assesses how an analysis of climate change risks can help inform choices. Two approaches are represented: 1) plans to handle immediate water shortages and other emergencies; and 2) management strategies that reduce the likelihood and/or severity of these shortages over the long-term.[11] Many of the strategies in this second category represent particular Resource Management Strategies described in the 2009 Update to the California Water Plan (DWR 2009, Volume II). Overall, this section suggests that a vulnerability assessment may provide a means for suppliers to identify key ways in which climate change may affect operations and long-term planning, and where further analysis may be needed. It also highlights the importance of collaboration among water agencies and other stakeholders in order to reduce drought vulnerability while taking climate change risks into account, particularly for small suppliers.

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[10] *Our Changing Climate 2012* defines vulnerability as the "susceptibility to harm," and more specifically as "the degree to which a system is exposed to, sensitive to, and unable to cope with or adapt to the adverse effects of change, including climate variability and extremes," (Moser et al. 2012, p. 3).

[11] In the context of the definition of vulnerability in footnote 10, preparation for immediate water shortages (Section 5.1) improves coping capacity, while longer-term management strategies (Section 5.2) reduce exposure and sensitivity to droughts.

5.1. Preparation for water shortages and other emergencies

All UWMPs include a "drought contingency plan" containing demand reductions and other measures that a supplier will undertake to cope with an immediate water shortage. Suppliers must also describe in an UWMP how they will cope with a "catastrophic" supply interruption due to earthquakes, flooding, power outages, or other disasters (2010 Guidebook, Section 5). Such plans are essential for all suppliers, but perhaps are even more so if climate change is increasing the possibility of severe droughts, flooding, wildfires and other disasters that may impact water supplies, as suggested by the climate change guidance included in the 2010 Handbook (p. G-3). If an assessment of climate change impacts suggests that demand or supply may be affected or that future droughts may be more severe, then a supplier may need a more extensive contingency plan, perhaps involving greater demand reductions or new sources of emergency supply. Other factors affecting water reliability would also need to be taken into account.

Sea level rise is a new consideration in emergency planning for water supply in low-lying coastal communities, with impacts such as increased flooding and storm surges that could potentially threaten water supply and treatment infrastructure. California has issued interim guidance providing estimates of sea level rise over the coming decades, which local governments are required to consider in their planning. A recent National Research Council report confirms that significant sea level rise is expected along the California coast (NRC 2012). Only one UWMP included in this review, from the City of Santa Cruz, discusses the potential impacts of sea level rise on infrastructure, referencing impacts on its wastewater treatment plant. Many suppliers are considering sea level rise through other processes, but do not discuss this in their UWMPs. For example, suppliers in the Bay Area are guided by the Bay Conservation and Development Commission's policies regarding sea level rise (BCDC 2011), and LADWP is participating in "Adapt-LA," a citywide process in the Los Angeles area to identify and address climate change impacts, including how sea level rise may affect infrastructure (City of Los Angeles, no date). The UWMP process may not be the primary forum though which planning for sea level rise will take place. However, whether or not a supplier is addressing this issue is relevant to its preparedness for a catastrophic interruption in supply. A basic vulnerability assessment conducted as part of an UWMP could help ensure that this risk is being addressed through appropriate avenues.

5.2. Strategies to reduce drought vulnerability

There are limits to the demand reductions a supplier can achieve once drought has already set in. In the context of climate change, disaster management literature has increasingly emphasized the need for long-term planning to reduce risks posted by disasters, rather than simply disaster response (IPCC 2012). UWMPs discuss a number of strategies for reducing the severity of drought impacts, including reducing water demand, diversification of supply sources, and groundwater management. Additional measures, such as improving regional and local conveyance, increasing storage, and watershed management, are noted in some UWMPs but are less widely discussed. Several of the Water Plan's Resource Management Strategies fall within these categories, as discussed below. These strategies are being undertaken for multiple reasons, and not solely in response to climate change.

However, understanding climate change impacts can help in prioritizing and designing these strategies.

- **Demand reduction.** Implementing water conservation measures may be the most important way in which the UWMP process is reducing vulnerability to drought across the state. As described in the Water Plan's Urban Water Use Efficiency Resource Management Strategy, reducing water demand addresses climate change both through adapting to its effects and in reducing GHG emissions (DWR 2009, Vol. II, p. 3-18). In a UWMP, a supplier is required to identify baseline daily per capita water use, and a target for 2020 representing a 20% reduction (2010 Guidebook, Section 3), and to describe the demand management measures that will be used to achieve it (Section 6). As described in the previous section of this report, suppliers have included demand reductions from conservation in their UWMP demand projections, but they did not explicitly take climate change into account. If rising temperatures do result in an increase in demand, then conservation measures being planned by suppliers may not be sufficient to achieve reductions. The effect on demand may be small before 2020, the date by which 20% reductions must be achieved. However, sustaining these reductions in the future may become more difficult as temperatures increase. Assessing the effects of climate change on longer-term demand may be important in order to ensure that adequate demand management measures are in place, particularly for large suppliers, and those with significant amounts of outdoor water use.

- **Diversifying sources of supply.** The UWMP process requires water suppliers to describe future water projects, and to specifically discuss the feasibility of developing water transfer arrangements, desalination, and recycling (2010 Guidebook Section 4). Suppliers must also discuss how they are responding to risks to current supply sources through diversifying their supply (Section 5). Although many suppliers are undertaking water transfers, desalination and recycling for reasons besides climate change, several suppliers, such as EBMUD, SDCWA, and MWD, note that climate change, among other factors, provides an additional rationale for these investments. For example, MWD's Integrated Resources Plan includes a set of "foundational actions" that will be needed if drastic or persistent changes in current conditions take place, as a result of climate change or other factors. These "foundational actions" include expanding capacity for recycled and desalinated water (MWD 2010a, Chapter 3). MWD uses a robust decision-making approach, which incorporates climate change projections, to identify critical thresholds that would "trigger" investments to expand these strategies. SDCWA includes a climate change scenario in its scenario planning process, and EBMUD uses the results of its sensitivity analysis to identify specific ways in which climate change may affect its water system, and to help prioritize its efforts to expand supply (EPA 2011b). For small suppliers, resources are often limited for maintaining existing infrastructure, let alone expanding supply sources. While climate change adds to the rationale for diversification, a detailed quantitative analysis of specific impacts may not be a high priority for an individual supplier. However, such efforts could be undertaken collaboratively, as discussed in Section 5.3.

- **Groundwater management.** Groundwater figures heavily in drought response strategies discussed in UWMPs. A number of suppliers with groundwater supplies make the assumption that during dry years, they will meet demand by pumping additional groundwater. This includes suppliers of a range of sizes, such as Sweetwater Springs Water District (serving about 7,500 people) and the East Niles Community Service District (24,000 people), the City of Chino (71,000 people), and the Stockton East Water District (330,000 people). Suppliers are required to describe their groundwater sources in their UWMPs, including a description of management arrangements, and for basins in overdraft, efforts to "eliminate the long-term overdraft conditions" (2010 Guidebook, p. 4-3). Discussion of groundwater banking and conjunctive water use, where they exist, are usually included in these descriptions. The creation of groundwater reserves has been proposed in some settings (Langridge et al. 2012), but few agencies are considering or implementing this option. Some suppliers note the potential impact of climate change on groundwater recharge (for example, Scotts Valley Water District), and a few suppliers are studying these impacts (LADWP and Marin Municipal Water District, as noted in Table 7). In addition to changes in runoff patterns on groundwater recharge, another important impact of climate change is likely to be increased rates of extraction as droughts become more frequent and/or extreme (Langridge et al. 2012). Given the crucial role that groundwater plays in coping with drought in California, it is all the more important to improve knowledge about the status of groundwater resources, and how they may be impacted by climate change. Small suppliers have limited capacity to undertake these studies themselves, but may do so in the context of regional partnerships, with state support.

- **Storage, conveyance, and treatment.** A number of UWMPs describe efforts to expand capacity to store, convey, and treat water, sometimes in the context of preparedness for climate change. For example, the Santa Clara Valley Water District's UWMP states, "Under any climate change scenario, the District may need to consider additional treatment options to respond to water quality impacts associated with increased salinity in the Delta. The District may also need to consider additional storage to take advantage of more wet-season water, additional supplies to replace reduced water supply from existing sources, and additional water transfers (depending on water market impacts)," (Ch. 9, p. 2). San Bernardino's regional UWMP also notes the potential need to modify infrastructure to handle both higher and lower local surface water flows that may occur under climate change (p. 1-31). LADWP's UWMP also notes that MWD already invested in constructing the Inland Feeder, which connects its Colorado River and SWP supplies with its major reservoir, enabling it to capture flows from more intense storms (p. 270). In most cases, these strategies involve significant investments, and will require quantitative analysis to determine the range of possible changes in streamflow or other variables, the types of infrastructure adjustments that may be needed, and the benefits and costs. Such specific analysis would not be necessary in the context of an UWMP. Rather, the UWMP analysis should help in identifying need and priority for such strategies. A vulnerability assessment, with varying degrees of

complexity depending upon the capacity of a supplier, could help in this process.

- **Watershed management.** Enhancement of watershed functions, and other related Resource Management Strategies such as ecosystem restoration, can bring benefits in terms of maintaining water supply and quality (DWR 2009, Vol. II, p. 27-9, and p. 22-8). These strategies are also increasingly recognized as crucial for coping with impacts of climate change (NDWAC 2010, p. 6). For example, ecosystem restoration can help reduce flood risks in a manner that reduces the conflict between flood protection and water supply goals of reservoirs (DWR 2009, Vol. II, p. 22-10). A few suppliers, such as Sonoma County Water Agency, are exploring ways to connect flood management and groundwater recharge goals (SCWA 2013). A few large water suppliers discuss these issues in their UWMPs, but coverage is fairly limited. Again, a vulnerability assessment could help identify contexts in which these approaches should be prioritized.

5.3. Collaboration and reducing drought vulnerability

Both drought contingency planning and long-term strategies to reduce vulnerability require collaboration. Water transfer arrangements by definition involve agreements between buyers and sellers. Significant resources are needed for investments in water recycling, desalination, and infrastructure modifications, and these can be difficult for small suppliers to obtain on their own. Ecosystem restoration efforts also require partnerships with conservation and land use organizations, which have not been typical collaborators for water supply agencies. According to the National Drinking Water Advisory Council report on Climate Ready Utilities, "Participation among all invested partners in a watershed is needed to focus on a comprehensive strategy that characterizes potential climate change effects on local hydrology/water resources and identifies collective actions necessary to adapt to those effects," (2010, p. 6). Thus, the capacity of a supplier, especially a small one, to reduce its drought vulnerability often depends upon its partnerships with others. As discussed in Section 2.2, small suppliers are more likely to depend only upon groundwater and have more limited connections with wholesale suppliers. Table 9 shows this pattern in the UWMPs reviewed for this report, with 50% of small suppliers relying primarily on groundwater. Only 43% receive wholesale supplies, as compared to over 75% of large and medium-sized suppliers.

Table 9. Dependence on groundwater and wholesale supplies among large, medium-sized and small suppliers.

	Receives wholesale water	Depends primarily on groundwater
Large suppliers (21)	76% (16)	0% (0)
Medium suppliers (14)	79% (11)	21% (3)
Small suppliers (14)	43% (6)	50% (7)

Thus, small suppliers are more likely to carry out their activities independently of other suppliers, and may need to seek out ways to partner with other agencies to access funding and undertake integrated approaches to management. Participation in Integrated Regional

Water Management (IRWM) planning may provide such opportunities. According to the 2009 Water Plan Update, "With integrated regional water management (IRWM), regions have been able to take advantage of opportunities that are not always available to individual water suppliers: reduce dependence on imported water and make better use of local supplies; enhance use of groundwater with greater ability to limit groundwater overdraft; increase supply reliability and security; and improve water quality," (DWR 2009, p. 4-48). Participation in an IRWM process may help suppliers access funding for such projects, such as under Proposition 84, and to establish partnerships to undertake strategies to reduce the likelihood or severity of water shortages. Further, since 2010, the IRWM program has particularly emphasized reaching out to disadvantaged communities (DACs), which in many cases are served by small water suppliers.[12] Finally, IRWM plans emphasize the development of projects meeting multiple water management goals, including environmental stewardship, and over time, participating in this planning process may help suppliers to incorporate ecosystem-based strategies into their project portfolios.

Overall, half of the 2010 UWMPs reviewed for this report made reference to participation in an IRWM process. As Table 10 shows, this includes almost two-thirds of large suppliers. In most cases, the IRWM process was mentioned either as a means of coordinating activities with other agencies, or as a source of funding for projects to improve water use efficiency, conjunctive water use or water recycling. Although only four out of 14 small suppliers included in this study mentioned an IRWM process, an examination of relevant IRWM plans indicates that 11 out of these 14 suppliers have actually participated in some capacity. Based on this, it appears that the IRWM process does provide an avenue through which small suppliers can develop partnerships and access funding for efforts to reduce drought vulnerability. Further, IRWM plans are now being updated to include climate change vulnerabilities as required by DWR's new guidelines. These vulnerability assessments may become an important resource for water suppliers in understanding the types of climate change impacts they face.

Table 10. Percent of UWMPs mentioning IRWM processes.

Supplier type (no. reviewed)	% (no.) of UWMPs mentioning IRWM process
Large suppliers (21)	62% (13)
Medium-sized suppliers (14)	57% (8)
Small suppliers (14)	29% (4)
Regional UWMPs (7)	86% (6)
Multi-site IOUs (3)	33% (1)

Regional UWMPs represent another opportunity to establish partnerships. A limited number of suppliers (27 in total) participated in a total of seven regional UWMPs in 2010. In six out of seven cases, these plans represent collaborations between a wholesaler and its retailers, which are required to share information in the UWMP planning process (see Table A2, Appendix). In addition to coordination, part of the rationale for undertaking a regional plan is to reduce UWMP preparation costs (as stated in the San Bernardino

[12] A "disadvantaged community" is a community with an annual median household income of less than 80% of the statewide median household income (California Water Code Section 79505.5).

regional UWMP, p. 1-3). A review of the seven regional UWMPs suggests that coordination may indeed occur between agencies surrounding drought contingency planning. For example, participants in the Castaic Lake regional UWMP have a joint plan to respond to water shortages (p. 8-1), and a similar drought response plan has been drafted for the San Bernardino's regional UWMP participants.

The discussion of collaboration between regional UWMP participants appears to focus primarily on short-term drought response measures. However, six of the seven regional UWMPs mention participation in an IRWM planning process, which may lead to more long-term strategies. For example, the Tehachapi regional UWMP (which serves only 36,300 people, the smallest population of any regional UWMP) states, "the participating agencies are submitting this regional plan to serve as a coordination effort with its local retail agencies so that the group has a better understanding of the reliability of its supplies for future Integrated Regional Water Management Plan (IRWMP) efforts," (p. 2). In other cases, existing IRWM processes have helped inform the development of regional UWMPs. For example, the drought response plan in San Bernardino's regional UWMP was initiated as part of the 2007 IRWM plan for the region, developed by the Santa Ana Watershed Project Authority or SAWPA (San Bernardino regional UWMP, p. 5-1).

6. Consideration of greenhouse gas emissions in UWMPs

6.1. Greenhouse gasses and urban water use

While the water sector is an important source of clean energy (e.g., hydroelectricity), water management activities also contribute significantly to greenhouse gas (GHG) emissions, accounting for over 19% of all of California's electricity use (CEC 2005, CPUC 2010). On average, urban water use is more energy intensive than agricultural water use, due to the additional energy used in water conveyance, treatment, distribution, and especially end use (CEC 2005, p. 15). Thus, efforts to reduce urban water demand can result in significant energy savings and reduced GHG emissions (DWR 2009, p. 4-47). The Scoping Plan to implement the 2006 California Global Warming Solution Act (AB 32) contains five recommendations for reducing emissions in the water sector, particularly through improving water use efficiency and the energy efficiency of water systems (ARB 2008, p. 66). DWR recently issued Phase 1 of its Climate Action Plan, which describes the measures it will take to reduce GHG emissions associated with DWR water management activities to 50% of 1990 levels by 2020, and 80% of 1990 levels by 2050 (DWR 2012d).

Thus, water supply agencies can make important contributions to reducing California's GHG emissions. Demand management efforts discussed in UWMPs can result in energy savings, and therefore GHG emissions reductions. At the same time, however, other measures to improve water reliability may increase energy use. A GHG inventory can help a water agency track its overall carbon footprint. A number of large suppliers have developed inventories to track GHG reductions through energy conservation and the use of renewable energy (CUWA 2007). Some medium-sized and small suppliers that are part of city governments are tracking their emissions through systems developed to meet citywide

emissions reduction goals, which are often included in municipal Climate Action Plans (Wheeler 2008).

The UWMP Act does not mention the GHG implications of demand management efforts. However, the guidance related to climate change in the 2010 Guidebook notes that demand management measures can result in energy as well as water conservation, and encourages water suppliers to calculate the energy conserved and GHGs that are not emitted as a result (p. G-2 and G-3).

6.2. Discussion of GHG reduction efforts in UWMPs

None of the UWMPs reviewed for this study included figures for the amount of GHG emissions avoided as a result of the specific water conservation measures that have been implemented or planned. The Inland Empire Utilities Agency (IEUA)'s UWMP came the closest to doing so by calculating the energy savings associated with a 10,000-acre-ft per year reduction in imported water supply, and the reductions in air pollutants, including carbon dioxide (p. 4-26 and p. 4-27). A few UWMPs from large suppliers included figures for the annual carbon footprint of their various water sources, which would enable calculations of avoided emissions from water conservation (for example, see LADWP's UWMP, p. 267).

UWMPs in this study contained some limited discussion of GHG reduction efforts, although usually without specific figures. Three main types of efforts were described: 1) energy efficiency improvements that result from water conservation; 2) use of renewable energy; and 3) development of a greenhouse gas emissions inventory. Table 11 summarizes the extent to which each of these was discussed in the 49 individually submitted UWMPs included in this study. A total of 15 UWMPs, mostly from large suppliers, mentioned energy savings from water conservation and GHG reduction benefits, and eight mentioned efforts to expand the use of renewable energy. Ten providers described their efforts to establish a GHG inventory, all of them large or medium-sized suppliers. None of the seven regional UWMPs mentioned GHG reduction efforts. One of the three multi-site IOUs – California American Water Company – provided a detailed description of their methodology for a GHG inventory in the UWMPs for each of their five service areas. The UWMPs from Golden State Water Company did not discuss efforts to track or reduce GHG emissions, and the California Water Service Company UWMPs indicated that the company plans to undertake this in 2013.

It is clear from Table 11 that only a subset of large and medium-sized suppliers mention GHG reduction efforts in their UWMPs, and that overall, discussion on this issue is much more limited than that of climate change impacts. Further, the discussion in UWMPs from large suppliers does not fully reflect the efforts these agencies are undertaking related to GHGs. For example, SFPUC, EBMUD, and Sonoma County Water Agency each have significant energy efficiency or renewable energy programs in place (CUWA 2007, SCWA 2011), but did not mention this in their 2010 UWMPs.

Table 11. Discussion of GHG emissions reduction efforts in UWMPs.

	Energy savings	Renewable energy	GHG inventory	Climate Registry?
Large suppliers (21)	43% (9)	19% (4)	29% (6)	24% (5)
Medium suppliers (14)	36% (5)	29% (4)	29% (4)	0% (0)
Small suppliers (14)	7% (1)	0% (0)	0% (0)	0% (0)

For the most part, the small and medium-sized suppliers that discussed GHGs are cities, including as Santa Rosa, Santa Cruz, and Santa Monica (see Table A8, Appendix). These UWMPs referenced citywide GHG inventories and plans for energy conservation and renewables in order to meet GHG reduction targets set by these cities' Climate Action Plans. It is likely there are more cities whose water departments or divisions are part of citywide GHG reduction efforts, but did not mention this in their UWMPs. Small suppliers, including county water agencies and special districts, may also be developing processes to account for GHGs at least at a project level, since this is now included in the CEQA process for all projects receiving state funding.

7. Summary and Recommendations

Water suppliers in California have long experience in planning for droughts. However, as climate change begins to affect patterns in temperature, precipitation, and sea level rise, drought preparedness strategies of the past may need to be revisited. Urban Water Management Plans (UWMPs) are a crucial element of California's efforts to assure reliable water supplies. For many water suppliers, particularly smaller ones, the UWMP process provides a key framework for water planning. In its guidance for preparing 2010 UWMPs, the California Department of Water Resources (DWR) included climate change as an optional section, encouraging but not requiring suppliers to consider climate change impacts and GHG emissions. This study assesses how water suppliers of varying sizes and types have responded to this optional guidance, and provides recommendations for how DWR's guidance to water suppliers might be improved for 2015 UWMPs. It is based on an analysis of 49 individually submitted UWMPs, seven regional UWMPs, and UWMPs from three investor-owned utilities with multiple service areas across the state.

This section summarizes the key findings of this study regarding the incorporation of climate change in UWMPs, discusses the role of UWMPs in adaptation and mitigation planning, and provides specific recommendations regarding how DWR could improve DWR's guidance for 2015 UWMPs with respect to climate change.

7.1 Key Findings

- **Large suppliers discussed climate change in UWMPs more frequently than did small ones.** About two-thirds of all UWMPs studied mentioned climate change in some fashion. This included 85% of all large suppliers studied, but only 36% of

small suppliers. This may reflect the fact that small suppliers tend to have more limited resources and staff time to dedicate to investigating climate change impacts.

- **About forty percent of UWMPs included in this study contained a discussion of specific ways in which climate change could affect their water system, with an emphasis on risks to water supply.** While some suppliers discussed the general impacts of climate change on the state, 41% of UWMPs studied identified at least one way in which their service area would be specifically impacted. Once again, more large suppliers did this (52%) than small suppliers (21%). Three out of seven regional UWMPs discussed specific impacts, as did two out of the three investor-owned utilities with multiple service areas. In most cases, water suppliers based their discussion on existing studies of climate change impacts. Nine suppliers (15%) conducted their own studies of climate change impacts. Most discussions focused on impacts to the amount and timing of water supply. Water quality, flooding, and sea level rise received more limited attention.

- **When climate change was discussed in 2010 UWMPs, it was often integrated into required sections related to supply and demand projections.** Some suppliers followed the format outlined in the 2010 Handbook and included climate change as an optional section in their UWMP. However, climate change was also frequently discussed in other parts of the document, suggesting that a number of suppliers have recognized the relevance of climate change to required UWMP elements focused on water supply, demand, and supply reliability.

- **Water suppliers relying upon State Water Project (SWP) deliveries used DWR's 2009 SWP reliability report to estimate their future supplies, and in doing so, incorporated climate change into their planning.** 18 out of the 56 individual and regional UWMPs included in this study are from suppliers that rely upon SWP deliveries and used DWR's SWP reliability report to estimate their future supplies. The SWP reliability report uses downscaled climate modeling to estimate the effects of climate change on water timing, amount and quality. As a result, these suppliers effectively adjusted their water supply expectations based on anticipated impacts of climate change.

- **Aside from SWP deliveries, most water suppliers that discussed climate change impacts did not adjust UWMP projections to account for effects on supply or demand.** Among suppliers whose UWMPs were reviewed for this study, including large suppliers that have conducted their own studies, only the Los Angeles Department of Water and Power adjusted a supply projection for a non-SWP source of water. None adjusted a demand projection based on climate change, although several studied these effects. Several UWMPs indicated that within the current planning period (2010 – 2030), climate change effects were either too uncertain or too small to include in projections. However, a few large suppliers have incorporated climate change uncertainties into their own planning processes, even though they did not specifically reflect climate change in their UWMP projections.

- **Following DWR guidance, most suppliers relied upon a three-year drought planning sequence based on historical runoff records.** Although several suppliers discussed the fact that climate change is likely to bring more frequent or severe droughts, quantitative estimates were not yet available to provide a specific basis for adjusting a drought planning sequence to account for climate change. Some suppliers used a longer historical drought period, and several others adjusted the historical record to plan for a drought that is deeper or longer than experienced in the past. These adjustments were not based on an estimate of the effect of climate change on drought patterns, but were selected to provide a factor of safety that accounts for the possibility that future droughts may be more severe than the historical record.

- **Relatively few UWMPs discussed GHG emissions reductions efforts.** Most UWMPs did not include estimates of these reductions, or much information about GHG inventories or other emissions reduction strategies. However, even though it is not reflected in their UWMPs, many large suppliers have undertaken GHG emissions inventories, and some small and medium-sized suppliers are participating in city or countywide tracking of GHG emissions.

7.2. Role of the UWMP process in supporting adaptation and mitigation in urban water planning

The current structure of California's UWMP process has several features that are helpful in planning for climate change. Similar to a scenario planning approach, the UWMP process requires that suppliers plan for single-year and multi-year droughts in addition to a normal year, thereby helping ensure preparedness for possible future climate extremes. The process is also iterative in that suppliers must update their plans every five years, ensuring that suppliers revisit their management strategies periodically in light of new knowledge. UWMPs emphasize water conservation, which is an important "low-regrets" adaptation strategy. Since the passage of the Water Conservation Act of 2009 (SBX7-7), UWMPs are the instrument through which suppliers comply with a requirement to reduce water consumption by 20% per capita by the year 2020. Overall, these UWMP elements provide a useful framework for enabling water suppliers to consider and plan for climate change.

One limitation of the process is its focus on a 20-year planning period. While some effects of climate change, such as temperature increases, are already being observed, the magnitude of impacts on water supply and demand may not be captured in a 20-year horizon. Other effects, such as changes in precipitation patterns, are still uncertain and require longer time periods to detect trends. Yet, some decisions being made today, particularly those related to water infrastructure, may have implications for a supplier's capacity to cope with changes that occur beyond this 20-year planning period. The UWMP process could benefit from a means of encouraging awareness of critical climate change risks, even if these may only become significant beyond the UWMP's 20-year timeframe.

If supported by technical assistance from DWR, a requirement that suppliers conduct a basic assessment of vulnerabilities as part of the UWMP process could help support overall preparedness for climate change risks to urban water supply. Accounting for GHG emissions reductions is less closely aligned with the purpose of the UWMP program, but DWR could still encourage water suppliers to report GHG inventories and emissions reduction efforts that they are already undertaking. This report's conclusions about the role of the UWMP process in promoting climate change adaptation and mitigation are described below.

7.2.1. Adaptation

The impacts of climate change are important considerations for water suppliers of all sizes, although suppliers may differ in their approaches to addressing them. For large suppliers, effects such as changing surface water runoff patterns, increased salinity, or reduced groundwater recharge have important implications for the millions of people relying upon their supply through retail and wholesale arrangements. Large agencies also tend to have the resources and partnerships necessary to conduct in-depth studies of climate change impacts. Small suppliers serve fewer people and resources, but may be highly vulnerable to droughts or other disasters since they often rely on a single source of supply without connections to neighboring suppliers (ACWA 2011, p. 18). For these suppliers, the effects of climate change may seem small in comparison to other urgent challenges such as infrastructure repair. However, as the National Drinking Water Advisory Council's report on Climate Ready Water Utilities suggests, even for suppliers with limited capacity, "integration of general climate impact awareness into typical utility management activities such as emergency response, capacity, and capital planning is important to individual utility and water sector resilience," (NDWAC 2010, p. 33). The report indicates state and federal support should be made available to enable those with limited capacity to maintain a "basic engagement" reflecting such a general awareness of how climate change may impact its operations.

Specifically, introducing a vulnerability assessment to the UWMP process could help urban water suppliers to:

- **Ensure adequate drought contingency planning and preparedness for other emergencies.** It is crucial for water suppliers to be aware that climate change may be increasing drought risks, as well as risks of events such as wildfires and flooding that may trigger service interruptions. Drought contingency planning, already required in UWMPs, remains very important. Awareness about the effects of climate change on the frequency or severity of droughts may encourage suppliers to introduce an extra factor of safety in their planning, even if drought planning sequences have not been formally adjusted. For suppliers in coastal areas, sea level rise may increase flooding risks to infrastructure. While other planning processes are more appropriate for guiding these decisions, a basic vulnerability assessment could help ensure that this issue is being addressed through appropriate avenues.

- **Increase attention to a range of long-term strategies to reduce vulnerabilities, such as diversifying supply, improving groundwater management, ensuring**

adequate water storage, conveyance and treatment capacity, and protecting watersheds. These water management strategies are already being undertaken by some suppliers for various reasons, and they are becoming even more important in the context of climate change. Depending upon the water sources and context of a particular supplier, a different combination of these strategies may be needed. An assessment of vulnerabilities may be helpful in prioritizing these strategies in order to manage climate change risks, including those that may only become significant beyond the UWMP's 20-year timeframe. More in-depth analysis may be needed in designing strategies, particularly in the case of modifications to infrastructure.

- **Ensure that demand reduction measures being implemented in response to SBX7-7 are adequate in light of increasing temperatures and changing precipitation patterns.** Implementation of the requirement to reduce statewide urban water use by 20% per capita by 2020 is one of the most significant ways in which the UWMP process helps reduce vulnerability to drought. However, current plans for reducing demand do not account for the effects of rising temperatures. These effects may be small before the year 2020, but it may become more challenging to sustain these reductions over time under higher temperatures, especially for suppliers with large amounts of outdoor water use.

As seen throughout this report, water suppliers vary greatly in the types of vulnerabilities they face and their capacity to analyze and respond to them. Furthermore, climate change is one of a number of factors that they must consider in their planning. Any requirement to undertake a vulnerability assessment should offer flexibility to choose the appropriate level and type of assessment, while providing a structure that encourages basic awareness of the types of impacts a supplier may face and how they are relevant to planning. The ability of many water suppliers to undertake such assessments and implement adaptation strategies will be enhanced by their participation in regional-level planning, particularly California's Integrated Regional Water Management (IRWM) process. Many suppliers, particularly small ones, do not have the capacity to conduct analyses of climate change impacts, nor are they able to fund and implement strategies to address these impacts on their own. IRWM plans are now required to incorporate climate change, and the analysis of climate change impacts contained in these plans will be an important resource for UWMP preparation. IRWM process also offers opportunities for new partnerships and access to funding that can help improve drought resilience.

7.2.2. Mitigation

Water suppliers can make an important contribution to reducing the state's GHG emissions, particularly through energy savings resulting from the water conservation measures discussed in UWMPs. Tracking these reductions is less clearly linked to the central objective of the UWMP process, as currently framed, than are adaptation efforts. However, some water suppliers are already participating in a GHG inventory, even though this is not always reflected in their UWMPs. This includes large suppliers, some of which are already members of The Climate Registry, as well as smaller agencies that may be participating in a city or countywide GHG inventory. Instead of adding a new GHG accounting requirement to the UWMP process, DWR could encourage water suppliers to report the GHG reduction

efforts that they are already undertaking, and provide support and access to simple tools for water suppliers seeking to initiate these activities. Guidance on participating in a GHG inventory and tools to estimate avoided emissions due to water conservation may be particularly useful, given the emphasis on demand management in the UWMP process. These resources may benefit suppliers that currently have limited capacity in this area but face increasing requirements to estimate GHG emissions for CEQA and other processes. If DWR does request suppliers to report on GHG reduction efforts in the UWMP process, consideration should be given to how DWR plans to make use of the information.

7.3. Recommendations for improving guidance and support for 2015 UWMPs

In light of the above, the following three steps are recommended for incorporating climate change into DWR's UWMP guidance and supporting suppliers in the preparation of 2015 plans: 1) use a vulnerability-based approach; 2) integrate climate change into all UWMP elements; and 3) provide additional assistance to suppliers in addressing climate change.

1. **Use a vulnerability-based approach.** As discussed in Section 4, water suppliers have used different approaches to analyzing climate change impacts and incorporating them into planning, requiring different levels of resources. Only relatively large suppliers appear to be undertaking the more resource-intensive approaches such as robust decision-making using inputs from GCMs, scenario analysis, and sensitivity analysis (see Section 4.3.2). Smaller suppliers that have discussed climate change in their UWMPs have taken a qualitative approach, identifying the basic ways in which higher temperatures or shifting precipitation patterns may affect water supply, demand and reliability in their system.

   Vulnerability assessments are studies that identify the exposure, sensitivity, and adaptive capacity of a local system to the impacts of climate change (Moser et al. 2009, p. 67, Mastrandrea et al. 2010). They can vary in complexity, but vulnerability assessments can be conducted with relatively limited resources by relying on existing studies of climate change trends, combined with knowledge of a local system (Climate Impacts Group 2007). This type of qualitative vulnerability assessment is a good starting point for all suppliers submitting UWMPs. The majority are small suppliers, which may be using the UWMP as the primary framework for organizing their planning process. A vulnerability assessment will enable them to account for risks qualitatively, and to identify priorities for further study. Small suppliers already have a detailed knowledge of their systems, and general climate change trends are relatively well studied in California, with information that is readily available in DWR's white paper *Managing an Uncertain Future*, the 2009 Water Plan Update and other DWR publications, as well as the recently released third Adaptation and Vulnerability Assessment for California (DWR 2008, 2009, Moser et al. 2012). Vulnerability assessments will also be useful for large suppliers, which can be encouraged to undertake more in-depth climate

change analyses. As this report has shown, some large suppliers are already doing so.

There is growing experience in California in the use of vulnerability assessments. All IRWM plans are now required to assess the potential impacts of climate change for a given region. The most recent version of DWR's guidance for the development of IRWM plans indicates that IRWM regions should meet this requirement by conducting a vulnerability assessment, followed by prioritizing vulnerabilities and developing a methodology for analyzing them (DWR 2012a, p. 22). The Climate Change Handbook for Regional Water Planning (EPA/DWR 2011) provides a template for a basic vulnerability assessment, consisting of a 40-question checklist based on critical features of a regional water system. IRWM plans are being updated to follow the assessment process in the Handbook, at a minimum. By 2015, these plans will be completed and can serve as resources for incorporating climate change into UWMPs.

2. **Integrate climate change considerations throughout UWMP elements.** The 2010 Guidebook includes climate change as a separate section, in which suppliers are encouraged to discuss the implications of climate change related to water supply and quality, water demand, sea level rise, and disasters, as well as to report on efforts to reduce GHGs. Some suppliers have followed this approach, but a number also addressed climate change within other required elements of UWMPs, particularly in the discussion of risks to current sources of water supply. Given the relevance of climate patterns to these required elements – projecting supply and demand, and assessing reliability under drought conditions – it makes sense to include discussion of the implications of climate change directly in these sections of the report. This would encourage a more specific focus on understanding how climate change might affect a supplier's standard assumptions in projecting supply and demand, or in selecting a drought planning sequence.

   In keeping with a vulnerability-based approach, guidance related to climate change could include a specific set of questions intended to help suppliers identify whether climate change is a significant factor in a particular aspect of planning. These questions could be similar to those found in the Vulnerability Assessment Checklist in the Climate Change Handbook (EPA/DWR 2011, Appendix B), which could be adapted for use in the UWMP process.

   The following sections may be appropriate places to incorporate an additional sub-section related to climate change:

   - **Section 1, Plan Preparation**: this section describes the agencies and public participation involved in preparing the UWMP. Guidance for this section could request suppliers to discuss how they are coordinating with their IRWM regional process, if one exists. Although UWMP and IRWM planning processes differ in important ways, there are some synergies, including in the area of climate change. Water suppliers could draw upon vulnerability assessments already

conducted for IRWM plans, and involvement in IRWM process could help generate partnerships and funding opportunities for water suppliers, particularly for small ones.

- **Section 2, System Description:** this section already requires a discussion of the service area's climate. Guidance for this section could request a brief description of any observed trends in temperature or precipitation, perhaps based on data from the Western Climate Data Center, which many UWMPs already use. A trend toward increasing temperatures has already been observed across the state (Moser et al. 2012), and this information is particularly relevant for demand management components of UWMPs.
- **Section 3, System Demands:** Suppliers could be requested to consider the effect that climate change is anticipated to have on water demand. Guidance could include specific questions related to how much water is used outdoors, or other appropriate indicators of how significant the effect of climate change might be on water demand. DWR guidance could encourage suppliers for whom effects may be significant to conduct a more in-depth assessment, and suggest relevant resources such as the Climate Change Handbook for Regional Water Planning and the Pacific Institute's Excel-based tool designed for water suppliers to estimate climate change impacts on demand. This element is particularly important for retail suppliers, since wholesale suppliers use their demand projections.
- **Section 4, System Supplies:** this section asks suppliers to describe and project their sources of supply. Specific language could be added to this section requesting consideration of climate change impacts on each source of supply. Guidance could contain specific questions to help suppliers identify the kinds of impacts that may be of concern, such as the degree of dependence on water from snowmelt or from the Delta. Guidance could include a list of key studies that could serve as references for suppliers that do not have the capacity to undertake their own analysis. Wholesalers could be particularly encouraged to conduct an analysis of impacts on their supply sources, since retail suppliers use their supply projections.
- **Section 5, Water Supply Reliability and Water Shortage Contingency Planning**. This section requests suppliers to identify the average, single year, and multi-year drought periods they will use for assessing the reliability of supply. Currently, guidance for this section instructs suppliers to use the historical record, while guidance for the climate change section indicates that climate change may bring "extreme climate events more severe than those in the recent hydrologic record," (p. G-2). Further study is likely needed before requiring suppliers to use something other than the historical record. However, DWR guidance for this section could note that while use of the historical record may still be an appropriate option for some suppliers, climate change research indicates that more severe events may occur in the future, and water suppliers may wish to consider including an additional factor of safety in light of these uncertainties. As discussed below, DWR should also undertake further research to better support suppliers in this area.

- **Section 6. Demand management.** This section discusses reduction in demand through best management practices (BMPs), which can lead to substantial avoided GHG emissions. Tracking avoided emissions, while important for meeting AB 32 emissions reduction targets, is not the primary objective of the UWMP Act, and requiring suppliers to include an estimate of avoided emissions may be beyond its scope as currently framed. However, if DWR envisions a purpose for collecting information about avoided emissions from demand management measures (DMMs), it might consider how to make this as easy as possible for suppliers, such as by creating or referencing a simple calculation tool in the guidance.

3. **Provide additional assistance to suppliers in addressing climate change.** DWR plays a critical role in providing water suppliers, particularly small ones, with appropriate knowledge, data, and tools for preparing their UWMPs. DWR currently offers this support by developing the Guidebook for UWMP Preparation (DWR 2010a) and including updated references to relevant resources, conducting workshops and webinars to assist suppliers with specific topics, and through individual consultation with DWR staff. All of these avenues should be employed with respect to climate change, especially since many suppliers have limited capacity and knowledge in this area. In particular, DWR should:

   - **Include updated resources related to climate change in the UWMP Guidebook.** In addition to recent studies on climate change effects from DWR, the California Energy Commission, and others, this would include the Climate Change Handbook, which provides a framework for analyzing climate change impacts. The guidance could also suggest local resources for understanding climate impacts, including IRWM planning processes and Climate Action Plans.
   - **Conduct workshops and webinars related to addressing climate change in UWMPs**. These could be developed in cooperation with DWR's Climate Change Program, which includes one regional climate change specialist in each of DWR's four regional offices. These specialists could also be available for individual consultation with water supply agencies to help them access appropriate resources for including climate change in an UWMP.

   The following are some additional ways in which DWR could improve its support to water suppliers in the area of climate change. It should be noted that in order to implement some of these activities, DWR would likely require additional funding. Revenues from California's cap and trade program, established under the Global Warming Solutions Act (A.B. 32) may be one possibility to explore.

   - **Continue to support the IRWM process, and encourage participation by small water agencies.** As discussed earlier, the IRWM process offers opportunities for water suppliers, particularly small ones, to build partnerships and access funding resources needed to undertake strategies to reduce vulnerability to droughts. The IRWM program requires regions to reach out to disadvantaged communities (DACs), which are often served by small suppliers

that may be vulnerable to climate change impacts. DWR should continue to provide assistance to IRWM regions to help them better serve DACs. DWR should encourage suppliers to consult IRWM plans in preparing their UWMPs. Although UWMP and IRWM planning processes differ in important ways, there are some synergies. For example, IRWM plans are now required to include an assessment of climate change impacts, which can be a useful resource for small suppliers without the capacity to conduct their own assessments.

- **Periodically review and update the approach to incorporating climate change into the State Water Project Reliability Report.** Suppliers receiving water from the State Water Project, either directly as a contractor or indirectly through purchase from a wholesaler, are using supply estimates from the SWP reliability report, including DWR's assessment of the effects of climate change. In order to best support the planning of these suppliers, DWR should periodically review and update its methodology for incorporating climate change into estimates of SWP deliveries.
- **Support research on key questions relevant to water suppliers.** For example, all water suppliers face the challenge of selecting an appropriate drought planning sequence in light of the fact that the historical record may no longer be an adequate guide for the future. Climate science is unlikely to yield quantitative estimates of anticipated changes in drought patterns in the near future. Research is needed to assess the options available to water suppliers in the absence of quantitative measures of climate change effects on drought periods. This could involve an assessment of current practices in water management, and pilot studies in collaboration with water suppliers interested in testing alternative approaches. DWR's Climate Change Technical Advisory Group (CCTAG) may be able to provide valuable guidance on such research.
- **Conduct pilot studies in collaboration with water suppliers to test new tools and approaches.** Water suppliers could participate in adapting existing vulnerability assessment protocols to the needs of small water suppliers preparing UWMPs. Suppliers could also be involved in testing any tools to facilitate inclusion of climate change in water demand or supply projections, and in assessing different approaches to incorporating a factor of safety in drought planning to hedge against increased likelihood of severe droughts.
- **Consider ways to facilitate and encourage suppliers to estimate emissions reductions associated with water supply, distribution, treatment, and demand management in UWMPs.** DWR should consider whether it would use information about GHG reduction efforts if they were included in UWMPs. It should ensure that suppliers have access to user-friendly tools for assessing these emissions reductions, and consider whether any incentives could be developed to help encourage suppliers to use them. DWR could work with a few suppliers that are interested in this issue to develop appropriate tools and resources.

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Appendices

Table A1. Sample of 49 individually submitted Urban Water Management Pl
used in this report.

Category	Supplier	2010 Pop.
Large - serving 300,000 or above (21 plans)	Metropolitan Water District of S. CA	18,896,000
	Los Angeles Water and Power	4,100,260
	San Diego County Water Authority	3,200,000
	San Francisco Public Utilities Commission	2,601,387
	Municipal Water District of Orange County	2,300,021
	Santa Clara Valley Water District	1,822,000
	East Bay Municipal Utilities District	1,340,000
	San Diego, City of	1,324,305
	San Jose Water Company	946,494
	Inland Empire Utilities Agency	846,469
	Eastern Municipal Water District	695,932
	Calleguas Municipal Utility District	632,399
	Sonoma County Water Agency	602,270
	Covina Irrigating Company	566,400
	Contra Costa Water District	495,230
	Sacramento, City of	466,488
	Long Beach Water Dept.	462,257
	Anaheim, City of	364,921
	Alameda County	340,000
	Irvine Ranch Water District	337,876
	Stockton East Water District	332,299
Medium-sized - serving 50,000 - 300,000 (14 plans)	Central Coast Water Authority	291,900
	San Gabriel Valley Water Company	271,817
	Marin Municipal Water District	190,600
	City of Santa Rosa	163,436
	Sacramento County Water Agency Zone 41	154,646
	City of Daly City	110,598
	Jurupa Community Services District	101,700
	City of Westminster	94,294
	City of Santa Cruz	92,165
	City of Santa Monica	91,000
	Indio Water Authority	78,000
	City of Chino	71,506
	City of Pleasanton	69,300
	Citrus Heights Water District	67,475
Small - serving 50,000 or less (14 plans)	Delano, City of	48,957
	Morgan Hill, City of	40,807
	Calexico, City of	40,075
	Crescenta Valley Water District	35,000
	LA County Waterworks District 2, Malibu, MDR	31,229
	Indian Wells Valley Water District	31,120
	Paso Robles, City of	30,072
	Windsor, Town of	26,158
	Amador County Water Agency	25,640
	East Niles Community Services District	24,062
	Rainbow, Bonsall and Fallbrook	19,495
	Blythe, City of	13,839
	Scotts Valley Water District	10,309
	Sweetwater Springs Water District	7,493

See Section 3 for how this sample was selected.

Table A2. 2010 Regional Urban Water Management Plans

Regional UWMP	Participants	2010 Population (region)
San Bernadino Valley	8 agencies (one wholesale, 7 retail)	657,500
Kern County	2 agencies (one wholesale, one retail)	335,842
Castaic Lake	5 agencies (one wholesale, four retail)	286,750
Antelope Valley	2 agencies (retail)	279,300
Modesto	2 agencies (one wholesale, one retail)	264,174
Hollister Area	3 agencies (one wholesale, 2 retail)	40,121
Tehachapi	5 agencies (one wholesale, four retail)	36,300

Data in this table was collected from each UWMP document.

Table A3. 2010 Urban Water Management Plans from multi site investor-owned utilities (IOUs)

Investor-owned utility (IOU)	Number of UWMPs	2010 Population (total for all plans)
CA Water Service Company	24	1,716,840
California American Water	5	561,206
Golden State Water Company	5	245,221

Data in this table is based on 2010 population data available in DOST as of May 29, 2012.

Table A4. Primary water sources and connections to other agencies (individually submitted UWMPs).

		Current primary water sources (2)				
Supplier (1)	**2010 Pop.**	**Surface water - local**	**Surface water - imported**	**Groundwater**	**Receives portion of supply from wholesaler?**	**IRWM process mentioned in UWMP?**
Metropolitan Water District of S. CA	18,896,000		•		•	
Los Angeles Water and Power	4,100,260	•	•	•	•	•
San Diego County Water Authority	3,200,000	•	•		•	•
San Francisco Public Utilities Commission	2,601,387	•	•			•
Municipal Water District of Orange County	2,300,021	•	•	•	•	•
Santa Clara Valley Water District	1,822,000	•	•	•	•	
East Bay Municipal Utilities District	1,340,000	•	•			•
San Diego, City of	1,324,305	•	•		•	•
San Jose Water Company	946,494	•	•	•	•	
Inland Empire Utilities Agency	846,469	•	•	•	•	•
Eastern Municipal Water District	695,932	•	•	•	•	•
Calleguas Municipal Utility District	632,399		•	•	•	•
Sonoma County Water Agency	602,270	•		•		•
Covina Irrigating Company	566,400	•		•		
Contra Costa Water District	495,230	•	•	•	•	•
Sacramento, City of	466,488	•		•		•
Long Beach Water Dept.	462,257		•	•	•	
Anaheim, City of	364,921		•	•	•	
Alameda County	340,000	•	•	•	•	•
Irvine Ranch Water District	337,876		•	•	•	
Stockton East Water District	332,299	•		•	•	
Central Coast Water Authority	291,900		•		•	•
San Gabriel Valley Water Company	271,817			•		
Marin Municipal Water District	190,600	•			•	•
City of Santa Rosa	163,436	•		•	•	
Sacramento County Water Agency Zone 41	154,646	•	•	•	•	•
City of Daly City	110,598		•	•	•	•
Jurupa Community Services District	101,700			•	•	
City of Westminster	94,294		•	•	•	
City of Santa Cruz	92,165	•		•		•
City of Santa Monica	91,000		•	•	•	
Indio Water Authority	78,000			•		•
City of Chino	71,506		•	•	•	•
City of Pleasanton	69,300		•	•	•	
Citrus Heights Water District	67,475	•		•	•	•
Delano, City of	48,957			•		
Morgan Hill, City of	40,807			•		•
Calexico, City of	40,075		•		•	•
Crescenta Valley Water District	35,000		•	•	•	
LA County Waterworks District 29, Malibu, MDR	31,229		•		•	
Indian Wells Valley Water District	31,120			•		
Paso Robles, City of	30,072			•		
Windsor, Town of	26,158	•		•	•	
Amador County Water Agency	25,640	•		•		•
East Niles Community Services District	24,062		•	•	•	
Rainbow, Bonsall and Fallbrook	19,495		•		•	
Blythe, City of	13,839			•		
Scotts Valley Water District	10,309			•		•
Sweetwater Springs Water District	7,493			•		

1. See Section 3 for a discussion of how this sample was selected.
2. Does not include recycled or desalinated sources. Except in a few cases, this currently represents a small (but increasing) portion of supply.
3. IRWM column only includes UWMPs that mention participation in an IRWM plan.
Wholesale supply here includes water from the State Water Project (from DWR) and the Central Valley Project (USBR).

Table A5. Discussion of climate change impacts in individually-submitted 2010 UWMPs

		Climate impacts discussion (1)			Studies referenced		
Water supplier	**2010 Pop.**	**No mention**	**General mention**	**Identified impacts specific to service area**	**SWP Reliability report**	**Wholesaler study**	**Conducted own analysis**
Metropolitan Water District of S. CA	18,896,000			•	•		•
Los Angeles Water and Power	4,100,260			•	•	•	•
San Diego County Water Authority	3,200,000			•	•	•	•
San Francisco Public Utilities Commission	2,601,387			•			•
Municipal Water District of Orange County	2,300,021		•		•	•	
Santa Clara Valley Water District	1,822,000			•	•		
East Bay Municipal Utilities District	1,340,000			•			•
San Diego, City of	1,324,305			•	•	•	
San Jose Water Company	946,494	•			•		
Inland Empire Utilities Agency	846,469			•	•	•	•
Eastern Municipal Water District	695,932		•		•		
Calleguas Municipal Utility District	632,399		•				
Sonoma County Water Agency	602,270			•			•
Covina Irrigating Company	566,400	•					
Contra Costa Water District	495,230	•					
Sacramento, City of	466,488			•			
Long Beach Water Dept.	462,257		•		•	•	
Anaheim, City of	364,921		•		•	•	
Alameda County	340,000			•	•	•	
Irvine Ranch Water District	337,876		•		•	•	
Stockton East Water District	332,299		•				
Central Coast Water Authority	291,900		•		•		
San Gabriel Valley Water Company	271,817	•					
Marin Municipal Water District	190,600			•		•	•
City of Santa Rosa	163,436			•		•	
Sacramento County Water Agency Zone 41	154,646	•					
City of Daly City	110,598			•		•	
Jurupa Community Services District	101,700		•		•		
City of Westminster	94,294	•					
City of Santa Cruz	92,165			•			•
City of Santa Monica	91,000	•					
Indio Water Authority	78,000			•	•		
City of Chino	71,506		•		•	•	
City of Pleasanton	69,300		•		•	•	
Citrus Heights Water District	67,475	•					
Delano, City of	48,957		•				
Morgan Hill, City of	40,807			•			
Calexico, City of	40,075	•					
Crescenta Valley Water District	35,000		•				
LA County Waterworks District 2, Malibu, MDR	31,229	•					
Indian Wells Valley Water District	31,120	•					
Paso Robles, City of	30,072			•			
Windsor, Town of	26,158	•					
Amador County Water Agency	25,640	•					
East Niles Community Services District	24,062	•					
Rainbow, Bonsall and Fallbrook	19,495	•					
Blythe, City of	13,839	•					
Scotts Valley Water District	10,309			•			
Sweetwater Springs Water District	7,493	•					

1. See section 4.1 for a discussion of these categories.

Table A6. Discussion of climate change impacts and IRWM in 2010 Regional Urban Water Management Plans.

			Climate change impacts		
Regional UWMP	**2010 Population (region)**	**Primary water sources**	**General mention**	**Identified impacts specific to service area**	**Mentions IRWM?**
San Bernadino Valley	657,500	groundwater, imported surface water (SWP)		•	•
Kern County	335,842	groundwater, imported surface water (SWP)	•		•
Castaic Lake	286,750	groundwater, imported surface water (SWP)		•	•
Antelope Valley	279,300	groundwater, imported surface water (SWP)	•		•
Modesto	264,174	groundwater, local surface water	•		•
Hollister Area	40,121	groundwater, imported surface water (CVP)		•	
Tehachapi	36,300	groundwater, imported surface water (SWP)	•		•

Note: No regional UWMPs mention GHG reduction efforts.

Table A7. Discussion of climate change impacts, IRWM, and GHGs in 2010 UWMPs from multi-site IOUs.

			Climate change discussion				
Investor-owned utility (IOU)	**2010 Population (total for all plans)**	**Number of UWMPs**	**No mention**	**Identified impacts specific to service area**	**Conducting own study**	**Mentions IRWM?**	**Mention GHGs?**
CA Water Service Company	1,716,840	24		•	•		
California American Water	561,206	5		•		•	•
Golden State Water Company	245,221	5	•				

Note: UWMPs from the service areas of each of these companies follows a common template in addressing climate change, and therefore the plans from each company were considered together.

Table A8. Greenhouse Gas Emissions and 2010 Urban Water Management Plans

		Discussion of GHGs in UWMPs			
	Water Suppliers	**Energy savings from conservation**	**Renewable energy**	**GHG inventory plans**	**Climate Registry member?**
Large (serving more than 300,000)	Metropolitan Water District of S. CA	•	•	•	•
	Los Angeles Water and Power	•	•	•	
	San Diego County Water Authority	•	•	•	•
	San Francisco Public Utilities Commission				
	Municipal Water District of Orange County				
	Santa Clara Valley Water District	•		•	•
	East Bay Municipal Utility District				
	San Diego, City of				•
	San Jose Water Company				
	Inland Empire Utilities Agency	•			
	Eastern Municipal Water District				•
	Calleguas Municipal Utility District				
	Sonoma County Water Agency				
	Covina Irrigating Company				
	Contra Costa Water District	•			
	Sacramento, City of	•		•	
	Long Beach Water Dept.				
	Anaheim, City of	•	•		
	Alameda County				
	Irvine Ranch Water District	•		•	
	Stockton East Water District				
Medium-sized (serving 50,000 - 300,000)	Central Coast Water Authority	•			
	San Gabriel Valley Water Company				
	Marin Municipal Water District		•	•	
	City of Santa Rosa	•	•	•	
	Sacramento County Water Agency Zone 41				
	City of Daly City				
	Jurupa Community Services District				
	City of Westminster				
	City of Santa Cruz	•		•	
	City of Santa Monica	•	•	•	
	Indio Water Authority				
	City of Chino	•	•		
	City of Pleasanton				
	Citrus Heights Water District				
Small (serving 50,000 or less)	Delano, City of				
	Morgan Hill, City of	•			
	Calexico, City of				
	Crescenta Valley Water District				
	LA County Waterworks District 2, Malibu, MDR				
	Indian Wells Valley Water District				
	Paso Robles, City of				
	Windsor, Town of				
	Amador County Water Agency				
	East Niles Community Services District				
	Rainbow, Bonsall and Fallbrook				
	Blythe, City of				
	Scotts Valley Water District				
	Sweetwater Springs Water District				
TOTAL		**15**	**8**	**10**	**5**

Appendix B.

Representatives of the following water suppliers were consulted by phone or email to obtain additional information and background for this report:

Citrus Heights Water District (David Kane, November 6, 2012)
City of Paso Robles (Keith Larson, October 22, 2012)
City of Pleasanton (Rita DiCandia, October 27, 2012)
Los Angeles Department of Water and Power (Delon Kwan, July 31, 2012, Simon Hsu, August 1, 2012, Sujoy Roy, TetraTech, August 27, 2012)
Metropolitan Water District of Southern California (Brandon Goshi, October 23, 2012)
San Diego County Water Authority (Kelley Gage, August 15, 2012)
San Francisco Public Utilities Commission (David Behar, November 6, 2012)
Santa Clara Valley Water District (James O'Brien, August 6, 2012)