Chapter 11
Climate Change

11.1 Introduction

The purpose of this chapter is to: 1) discuss relevant research that illustrates the region's climate setting and vulnerabilities; 2) describe the actions CABY members took in developing this chapter; 3) discuss CABY member stakeholders' participation in State and federal efforts to prepare for and mitigate climate change impacts; 4) offer adaptation strategies that CABY can undertake for an integrated, regionwide effort to respond to variations in climate and the associated impacts; 5) offer potential actions to minimize greenhouse gases generated within the region; and 6) array future plans for addressing climate within the CABY IRWM process. Table 11-4, located at the end of this chapter, illustrates the guideline-required consideration of climate change in other Plan chapters.

11.2 Process for Preparing the Updated Climate Change Chapter

CABY Planning Committee (PC) and member engagement on the issue of climate change has been consistent and reliable. The CABY Climate Change Technical Advisory Committee (TAC) was established in January 2012 to allow for member-based, technical input to the project team about how climate change should be considered within the revised (2013) CABY IRWMP. Participation recruitment for the TAC occurred at the November 2011 PC meeting and the first TAC meeting was held in January 2012.

While an expanded list of individuals received meeting information, active participants (those attending TAC meetings and submitting comments on materials) included representatives of the Bear Yuba Land Trust, Nevada Irrigation District, Placer County Water Agency, Sierra Nevada Alliance, and U.S. Forest Service. These representatives brought to the table organizational interests as well as individual qualifications ranging from biological and geological expertise to in-depth knowledge of the CABY region watershed and water system management. Each meeting of the TAC was open to the public and often accommodated call-in participants. New members were regularly invited to attend.

11.3 Climate Change Evaluation Overview

11.3.1 CABY Region – Climate Change Considerations in a Source Area

This chapter discusses the influence of a changing climate on the CABY region, and specifically on the quantity, quality, and timing of water resources available to support the needs of humans and natural systems. Climate change and related drought conditions are increasingly at the forefront of water resource management decisions around the state and throughout the CABY region. Water supply and demand, ecological processes, and fire are CABY's core issues, and it is likely that management of these issues under the projected impacts of climate change will intensify.

The historic hydrologic regime can be described as follows: During winter, snow falls high in the mountains and runs off as winter transitions to spring and summer. This runoff fills rivers, streams, reservoirs, and canals, and supports critical ecosystems, agriculture, recreation, and a vast array of other human and wildlife systems. Folsom Reservoir, a major federal reservoir that plays an integral part in Delta health and serving statewide water needs, was created by damming one of the four rivers for which the CABY region is named (American River). Three of the four primary waterways in the region flow directly into the Sacramento River (American, Bear, and Yuba Rivers), and the fourth, the Cosumnes, flows into the San Francisco Bay-Delta system. Thus, projected effects that climate may have on managing the region's water storage, flood risk, recreational and economic benefits, and watershed health are of utmost interest for both the region and the state as a whole.

The CABY region is entirely within the Sierra Nevada range, which is the source for the majority of the state's fresh water. As such, its water is under complex management by multiple agencies, and of considerable and competing value to out-of-region interests. Some CABY stakeholders maintain that policies adopted by State agencies beyond the purview of the region, (e.g., to address Sacramento Delta supply and ecological concerns in response to climate change) could have as much effect on the region's water supply and management as direct climate impacts. This situation suggests to CABY stakeholders that the best 'defense' will be to enter into robust conversations on how the region's water systems are being affected, develop an effective communication strategy, and place it at the table in decision-making processes. Some key documents and stakeholder entities addressing climate change policy and adaptation are listed and described in the relevant sections of this chapter.

Further, given constrained funding for projects, alongside the uncertainty of how specific climate effects might manifest at the greatest cost/damage, no-regrets strategies – strategies that can be employed without foreclosing future opportunities, or committing stakeholders to a single course of action – are at the forefront for consideration.

11.3.2 Current Status of CABY's Climate Change Preparedness – Trends and Projections

From the outset of the CABY IRWM planning effort in 2006, stakeholders have worked to incorporate CABY-based climate planning and projections with other regional planning. In 2007 and 2008, CABY worked with El Dorado Irrigation District to expand the Water Evaluation and Planning System (WEAP) modeling effort throughout the CABY region. Effort was also put into incorporating the findings of the El Dorado County Western Slope Drought Analysis — a planning and assessment process completed in spring 2007 with the goal of preparing South Fork American River water users for extreme drought. Currently, the staffs of each member water agency work within their respective systems to project the effects of drought and climate change on specific service area infrastructure and water demand patterns. The four major water providers in the CABY Region, El Dorado Irrigation District, Placer County Water Agency, Georgetown Divide Public Utility District, and Nevada Irrigation District (EID, PCWA, GDPUD, and NID), all have different modeling frameworks for operations. These models have been used for variable periods of time between the agencies, but all represent significant financial commitment in terms of purchasing the software and getting individual systems described in the respective model. None of these operational models is capable of predicting the effects of future climate scenarios; instead, they indicate how water delivery (operational) systems might work under differing climate scenarios. As such, the models could help the region to identify infrastructure-related vulnerabilities and/or preparedness for climate change.

Moreover, many members of the non-profit community are highly invested in conservation, restoration, and other activities directly aimed at mitigating projected climate change impacts. As a consequence, a substantial regional body of research on climate-change projections, effects, mitigation, and adaptation has been completed by a variety of public agencies, universities, and organizations. This research has contributed greatly to the understanding of climate change displayed in this chapter.

11.3.3 Vulnerabilities/Adaptive Management Strategies

While climate models developed by national and international organizations vary on the *amount* of warming that will occur in various regions, they agree that this region will warm by 2° to 4°F in the winter and 4° to 8°F in the summer by the end of the century.[1] Precipitation is less predictable, especially within the regions microclimates, but the increase in temperature is projected to bring about a higher level of evapotranspiration and, thus, potentially less available moisture overall, even in areas that experience increased precipitation.

Spring thaw in the central Sierra occurred 5 to 30 days earlier in 2002 than it did in 1948.[2] Along with rising temperatures, more precipitation now falls as rain than snow. This has serious implications for a region whose snowpack has historically served as a 'reservoir,' a reliable slow-melting source of water for the rest of California. As snow melts sooner and faster and combines with precipitation increasingly falling as rain rather than snow, uncertainty in water storage and release will confront water managers and hydropower producers. Flooding impacts increase with storm intensity and higher winter precipitation events, while summer streamflows are expected to diminish over the season, potentially affecting domestic and environmental water supply and quality and engendering tough choices for water managers and policy makers.

CABY water agencies have been incorporating operational and other modeling into their respective management projections for some years now, and have been responding to those projections with adaptive conservation and operational strategies as well as infrastructure upgrades and new facilities. Federal, State, and local agencies and NGOs have responded as well, with innovative responses to create climate resiliency on the ground — forest-management strategies that account for the upslope movement of species, restoration of mountain meadows to enhance the slow releases from the region's watershed, and use of alternative energy production (see Table 11-2, at the end of this chapter, for a display of the region's vulnerabilities and suggested adaptive strategies).

But both simple and complex vulnerabilities remain. CABY suffers from a lack of common knowledge about these vulnerabilities, especially among the underserved disadvantage communities. There is concern that State policies may become at odds with facets of water rights that were developed more than a century ago. Also, a lack of funds to implement projects and mitigations to climate change may limit the ability to respond to evolving understanding of the problems.

[1] Safford, H.D., M. North, and M.D. Meyer. *Chapter 3: Climate Change and the Relevance of Historical Forest Conditions*, *Managing Sierra Nevada Forests.* Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Stations. **Date:** Available from: http://www.fs.fed.us/psw/publications/documents/psw_gtr237/psw_gtr237_023.pdf

[2] Stewart, I.T.; Cayan, D.R.; Dettinger, M.D. 2005. Changes toward earlier streamflow timing across western North America. Journal of Climate. 18: 1136-1155.

11.3.4 Long-term Climate Change Program

The Climate Change TAC, with the endorsement of the PC, formulated recommendations for a long-term climate program to help assure climate resiliency for the region. The program focuses on ways to mitigate climate change effects on the region, as well as identifying the contributing factors within and outside of the region (including potential State policy and regulation) that exacerbate the impacts of climate change.

The program seeks to provide the means, under an altered climate future, for the region to continue to produce high-quality water, provide reliable water supply and carbon-free hydroelectric generation, support sustained healthy and diverse ecosystems, and reduce socioeconomic impacts under an altered climate future. The CABY stakeholders were uniform in their support in having IRWM be the organizing venue for both developing and implementing this recommended program.

The TAC, after considerable reflection and with the intent of fully implementing resource management strategies and Plan goals and objectives, formulated a climate change program to consist of eight components. These program components are: involvement in developing State policies and programs, increased knowledge sharing, increased coordination and collaboration, securing funding, monitoring the implementation of adaptive management strategies, reducing GHGs, data gathering, and investment in infrastructure and monitoring (see Section, 11.10, CABY Climate Change Program: Implementation of Adaptive Management, below).

11.4 State Climate Strategies

In preparation for evaluating potential vulnerabilities and adaptive management strategies for the CABY region, the Climate Change TAC reviewed the four primary source documents identified by DWR in the IRWM Guidelines. The results of this review informed both the process and the content of the CABY climate change evaluation. These documents included:

- *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*
- *2009 California Climate Adaptation Strategy*
- *Climate Change Scoping Plan*
- *Climate Change Handbook for Regional Water Planning*

Table 11-1
State Plans' Influence on the Climate Change Analysis

Plan	Requirements/Focus	Impact of State Plans on the CABY Climate Change Analysis
Climate Change Scoping Plan	Recommends specific strategies with a goal of cutting 15 percent from today's GHG emission levels	Two of the 18 Emissions Reduction Measures were identified to have the highest degree of relevance to the CABY IRWMP, including #16, (sustainable forests) and #17, (water). Agricultural reduction measures will have a modest degree of relevance. ▪ The forest management component includes strategies that reduce the risk of catastrophic wildfire and the avoidance of land use changes that reduce carbon storage. See Appendix G: Fire and Fuels - A CABY Climate Change Case Study. ▪ Five of the six water-related strategies are being implemented in the CABY region. See Table 11-3. These strategies are also being considered by CABY Governance members and other stakeholders as part of issue identification, evaluation of applicable resource management strategies, development of goals and objectives, and project development and integration process. ▪ Agricultural strategies will have minor influences on fuel efficiency of on-farm equipment, water-use efficiency, and carbon sequestration from restoration of riparian and forested areas.
Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water	Presents 10 strategies for adaptation measures	CABY has embraced three of the ten strategies presented in the report: ▪ Strategy 1: *Provide Sustainable Funding for Statewide and Integrated Regional Water Management:* In the past, four CABY region water agencies have stepped up to fund the ongoing efforts of the CABY Planning Committee and the RWMG. Beyond this, members are strategizing for the future, as they are interested in seeing CABY persist as an active entity. The Climate Change TAC has specifically identified enhancing funding streams and identifying new funding as an adaptive management strategy. ▪ Strategy 2: *Fully Develop the Potential of Integrated Regional Water Management*: CABY represents the first IRWM model the State had in 2007-2008 for full and consistent member inclusion without requiring dues or other form of payment. This IRWMP goes on to specifically develop adaptation strategies that would help realize IRWM potential. ▪ *Aggressively Increase Water Use Efficiency:* Four of the CABY regions water agencies' 2010 Urban Water Management Plans have Water Use Efficiency as an element. Two of these agencies are in full compliance with the California Urban Water Conservation Council's Best Management Practices.
2009 California Climate Adaptation Strategy	Discusses how to assess vulnerabilities and outlines adaptation strategies	The document is guided by a set of principles, including the identification of specific and cross-sector strategies, the development of a method for and list of prioritized strategies, and the need for additional education of the public regarding climate change risks and how adaptation can positively affect those risks. Members of CABY and RWMG share these principles and values, and have incorporated much the same ethic throughout both the implementation work done in the region as well as the IRWMP.
Climate Change Handbook for Regional Water Planning	Offers an outline for how to assess vulnerabilities and adaptation strategies	CABY Climate Change TAC specifically identified vulnerabilities by using the questions in the Handbook's Appendix B - Vulnerability Assessment Checklist, as a primary resource. Guidance was also taken from suggested adaptation strategies having relevance in the region. See Appendix H for the TAC analysis.

11.5 Current Climate Trends

The region's climate is characterized by mild, wet winters and hot, dry summers, but varies greatly by topography and elevation. Precipitation generally increases with elevation in the CABY region and average annual precipitation ranges from 22.5 inches in the lowest, most western elevations of the planning region to 85 inches in the highest elevations. Snow levels are generally near 3,500 feet in the winter and rarely reach as low as the valley floor. Average temperatures generally decrease from west to east with elevation; in the summer months, temperatures tend to be warmer in the lower elevations (70°-85°F) and cooler at the higher elevations (60°-70°F). The winter months are mild at the lower elevations (45°-60°F), and cooler at the higher elevations (30°-40°F). A wide variety of micro-climatic variations also exist due to local topography and air flow.

Alongside east-west gradient of precipitation, the northern portion of the CABY region receives proportionally more precipitation than the southern portion. Much of the precipitation in the higher elevations is in the form of snow. Runoff from precipitation released from the reservoirs of snow, forest soils, and constructed lakes provides a major source of water for the region and for the state during the dry summer months. A majority of the rainfall occurs between November and April.

Models project varying patterns of precipitation and warming within the CABY region, including more or less precipitation and varying degrees of warming. This is, in part, because the area exists between grid squares on several major climate models and the resolution of the models is presently too coarse to be predictive for the region. The central expectation of these models, though, is that winter precipitation in the region will increasingly arrive in the form of rain instead of snow. Earlier snowmelt is also occurring and projected to increase. Both increased rain versus snow and earlier snowmelt have significant implications for seasonal water supply and storage.

Streamflow trend projections on portions of the North Yuba show significant decreases that may imply significant adaptations for supply and hydropower generation starting in about 2025.[3]

The effects of climate change are already manifesting in the CABY region, suggesting the need to identify vulnerabilities and related impacts to public safety, natural systems, water supplies, power generation, and recreation. Since any climate effects are potentially exacerbated or diminished by population trends, the following discussion is provided.

Population trends, as discussed in Chapter 5, Region Description (5.3.2 Economic Conditions and Trends), suggest that the growing metropolitan population in the Sacramento area is spreading into the CABY region, fueling demand for water and other natural resources. Population centers are mostly in the foothills of the Sierra Nevada and along the major Sierra highways (Highways 50 and 80), and regional growth trends over recent decades indicate increased population growth into the future. Thus, any of the trends and vulnerabilities, discussed below, could be affected to a greater or lesser degree when correlated with overall population growth, and specific patterns of growth.

[3] Freeman, Gary J. 2010. *Tracking the impact of climate change on central and northern California's spring snowmelt subbasin runoff*. Paper presented at the Western Snow Conference 2010.

11.5.1 Regional Climatic Projections

Increased Air Temperature

- Higher air temperatures are predicted for warmer seasons, generally resulting in less available water overall (McKenzie, 2004; Miller, 1999; Taylor, 2009). In the Sierra, average temperature is predicted to increase by 2° to 4°F in the winter and 4° to 8°F in the summer by the end of the century.[4]

Earlier Spring Melt

- Across the larger Sierra Nevada and Intermountain West, regional models predict a 30 to 70 percent decrease in spring snowpack by 2100 under moderate climate change scenarios (Hayhoe et al., 2004). These impacts are already being felt; the start of the spring snowmelt recession in the northern and central Sierra Nevada occurs one to three weeks earlier than in it did 60 years ago (Peterson et al., 2008), largely due to warming air temperatures (Miller, 2009; Taylor, 2009).
- The Sierra Nevada is considered one of the most vulnerable regions to climate variability in the continental U.S. due to its relatively warm snowpack. The Sierra snowpack acts as an enormous natural water storage system, accumulating precipitation over the winter and slowly releasing it in spring and early summer. The 1,000-plus dams in the Sierra were designed to take advantage of this predictable and manageable inflow of water to ultimately provide over 60 percent of California's water supply.[5] However, several observers have documented that the Sierra precipitation is arriving ever more often as rain rather than snow, especially at lower elevations. Moser et al.[6] documented a 23 percent decrease in the April-July annual runoff within the Sacramento basin within the recent past. PG&E's water management team has documented a "*…significant reduction in the low- to mid-elevation April 1 snowpack during the second half of the 20th century. This appears to be most noticeable within the PG&E headwater drainage from the Yuba River in the central Sierra north into the McCloud and Pit Rivers in the southern Cascades. This downward shift appears balanced among increased frequency of both precipitation occurring as rainfall and earlier snowmelt. The effect has been an overall shift in runoff timing and quantity from the spring into the winter period.*"[7] Freeman points out that the lower-elevation snow zone (below 6,000 feet[8]) is the most sensitive to early melt and lack of seasonal accumulation in recent years.

[4] Safford, H.D., M. North and M.D. Meyer. Chapter 3: Climate Change and the Relevance of Historical Forest Conditions, Managing Sierra Nevada Forests. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Stations. No date. Available from: http://www.fs.fed.us/psw/publications/documents/psw_gtr237/psw_gtr237_023.pdf

[5] Rothert, S. 2008. Sierra Meadows and Climate Change. Tree Rings, Journal of the Yuba Watershed Institute. 21:18-19. Available from: http://www.yubawatershedinstitute.org/documents/treerings21.pdf

[6] Moser, S., G. Franco, S. Pittiglio, W. Chou, D. Cayan. 2009. The future is now: An update on climate change science impacts and response options for California. California Climate Change Center Report CEC-500-2008-071, May 2009. California Energy Commission, Sacramento, CA.

[7] Freeman, G. J. 2003. Climate change and California's diminishing low elevation snowpack - a hydroelectric scheduling perspective. Western Snow Conference 71:39-47. Available from: http://www.westernsnowconference.org/proceedings/pdf_Proceedings/2003%20WEB/Freeman,%20G.Clmate%20Change%20and%20CA's%20Diminishing%20Low-Elevatio.pdf

[8] Freeman, G. J. 2008. Runoff impacts of climate change on northern California's watersheds as influenced by geology and elevation - a mountain hydroelectric system perspective. Western Snow Conference 76:23-34. Available from: http://www.westernsnowconference.org/proceedings/pdf_Proceedings/2008/Freeman.RunoffImpactsOfClimateChangeOnNorthernCalifornia'sWatersheds.pdf

Runoff

- Along with the early melt, the increased rainfall produces runoff at an accelerated rate compared to snowmelt, and has increased the frequency and amount of winter (as opposed to spring) runoff periods. The shift from spring to winter (November through February) runoff periods has implications for water use and management, both within the watershed and for those downstream.

Flooding

- Peak natural flows have increased on many of the state's rivers during the past 50 years. For instance, the five highest floods of record on the American River have occurred since 1950.[9]
- Increased flood potential is projected under many climate scenarios because higher temperatures cause earlier snowmelt and an increase in the ratio of precipitation arriving in the form of rainfall versus snow. Peak daily flows in winter are expected to increase even under scenarios with reduced precipitation overall.[10] Under the wettest scenarios modeled by Miller et al., 2003, highest flow volumes would increase by more than double in many Sierra Nevada rivers, resulting in greater flood risk in flood-prone areas. Miller et al. conclude that greater flood risk is likely because temperature (not precipitation) is the primary driver of peak runoff. Flooding may be further exacerbated by more extreme precipitation events, another projected outcome of climate variability. However higher-elevation snow levels may reduce the potential for winter floods because less snowpack may fall that can be mobilized.
- The entire CABY region lies outside of the part of California that has been mandated to plan for a 200-year flood. CABY is in need of a clearer definition of the flooding risk to all areas within Federal Emergency Management Administration (FEMA) mapping zones. This includes portions of most major, and many minor, cities and communities in the CABY region, including Nevada City, Auburn, and Placerville.

Storm Intensity

- Along with reductions in snowpack and accelerated snowmelt, greater storm intensity and weather extremes have been documented elsewhere in California.[11] Records show there have been 69 severe weather incidents affecting Nevada County in the period from 1960 to 2000.[12] Twenty-eight were incidents related to high wind; 8 to freeze or extreme cold; lightning was the issue in 5 incidents; 21 incidents were reported as heavy rain; and 24 related to winter storm or snow. Some included more than one cited cause. Several of the counties now have Hazard Mitigation Plans that chronicle extreme events and estimate their costs to taxpayers. It is not

[9] California Department of Water Resources. Managing An Uncertain Future: Climate change adaptation strategies for California's water. Sacramento, CA, State of California. October 2008. Available from: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf

[10] Miller, N.L.; Bashford, K.E.; Strem, E. 2003. Potential impacts of climate change on California hydrology. Journal of the American Water Resources Association. 39:771-784.

[11] California Department of Water Resources. Managing An Uncertain Future: Climate change adaptation strategies for California's water. Sacramento, CA, State of California. October 2008. Available from: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf

[12] Nevada County. Local Hazard Mitigation Plan for Nevada County. Nevada County, CA. 2011. Available from: http://www.mynevadacounty.com/nc/igs/oes/docs/Multi%20Jurisdiction,%20Multi-Hazard%20Mitigation%20Plan%20for%20Nevada%20County/2011%20Local%20Hazard%20Mitigation%20Plan%20DraftRev8.pdf.

known whether there is an increasing trend from these statistics, but they will provide a baseline for future IRWMP updates.

Streamflow

- In 2008, EID worked with a large public stakeholder group to complete a Drought Preparedness Plan. In the introductory section on climate change, that Plan states: "[*l*]*ate season runoff constituted 44 percent of total runoff in the early 1900s, decreasing to 33 percent by the early 2000s. Melted Sierra Nevada mountain snowpack is the source for the majority of late season runoff for EID.*"
- Mehta et al.[13] found by using an integrated river basin management model for the CABY region (WEAP model), that under climate warming scenarios, all four watersheds responded with "*increases in wet season flows, decreases in dry season flows, and a net annual decrease [in flows]*."
- In a 2012 study, PG&E examined possible side effects of climate change on runoff by comparing two consecutive 35-year periods (1942-1976 and 1977-2011).[14] The company maintains daily runoff records for 100+ locations in the Sierra, southern Cascade, and Coastal Ranges of California. This study showed that out of the 13 rivers studied, the Yuba River at Smartville has experienced the third highest reduction in unimpaired runoff between these two periods (-3.4%), behind only the Klamath River at Orleans (-10.6%) and the Feather River at Oroville Dam (-4.5%). **[Please note that this recent study is only one snapshot in time and may be more a recent analysis than those used in regional operational models. Also note that the author intends to update this trend analysis frequently where trends indicate the greatest decreases in streamflows.]**

  When comparing the two 35-year periods, PG&E also found that the standard deviation in runoff (higher variability in flow) on the Yuba changed by 30 percent for the unimpaired water year during the second period. While it is fairly normal for rivers flowing over exposed granite (such as the Yuba) to have a large variance in flows, what was observed during this comparison was that an even greater standard deviation occurred over the second period. Further, it was found that a large portion of the April through June runoff has shifted into the March and even February period, corroborating the studies mentioned above. By percentage shift, the Yuba is second only to the Feather River (of the 13 regional rivers studied) in this trend.

  PG&E has been a leader in analyzing trends in runoff for the Sierra Nevada because this region feeds nearly 100 reservoirs that the company manages for hydropower generation, and because it has recognized a relatively rapid change in runoff within the region since 1970. The company also is keenly aware that Sierra drainages differ greatly in topography, geology, soil porosity, aquifer storage, runoff recovery efficiency, as well as other parameters. For purposes of understanding runoff trends, a simplified trends forecast has been designed for relatively small subbasins, including the North and South Yuba and subbasins of the American. The tool is based on past trends extrapolated into the future, rather than downscaled climate models. PG&E's previous and current trend analyses indicate that the Feather and Yuba river basins are

[13] Mehta, V.K.; D. E. Rheinheiimer; D.Y. Yates; D.R. Purkey; J.H. Viers, C.A. Young; and J.F. Mount. 2011. Potential impacts on hydrology and hydropower production under climate warming of the Sierra Nevada. Journal of Water and Climate Change. 02.1 2011.

[14] Freeman, G. J. Analyzing the Impact of Climate Change on Monthly River Flows in California's Sierra Nevada and Southern Cascade Mountain Ranges. Western Snow Conference 2012. Available from: http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2012Freeman.pdf

experiencing the highest end of timing changes in runoff and loss of low elevation snowpack from climate change.[15]

Starting with the year 1964, a 30-year moving average in runoff was applied to subbasins. Projections made from these trends were divided into three categories indicating runoff losses between April through June of: green (<20%), amber (20% to 40%), and red (>40%). In 2009, spring runoff in the North Yuba at Slate Creek had already diminished by 28 percent over the previous 30-year average. By 2025, five of seven tributaries analyzed are in the amber to red runoff-loss categories, and Slate Creek is projected to go dry during this period by 2075.

The South Yuba and Bear subbasins are projected to fare better: Two of four tracked water bodies in those drainages are projected to be in the amber loss categories – Lake Spaulding at a 38 percent loss, and the Bear River at Rollins at a 24 percent loss by 2100. The American and Rubicon are projected to increase in flow at French Meadows – 13 percent by 2100, but to drop into the amber category with a decrease in flow by 25 percent at Hell Hole.

PG&E intends to re-examine these trend analyses annually, focusing on subbasins most likely to approach the red (40% loss) category. Therefore, following these annual analyses will be valuable for regional water planning purposes.

Of additional note: most modeling shows sustained increases in the rain:snow ratio, with decreased snowpack (up to 50% by 2100) and earlier runoff dates.[16] PG&E suggests that at the current rate of decline, low-elevation subbasins such as the Feather and Yuba may lose virtually all their snowpack except at highest elevations by century's end.[17] Elevation and aspect play a substantive role in this differing characteristic in snowpack; from the Yuba River north, the Sierra is lower in elevation and less steep.

Groundwater

- Establishing an *annual* tie between groundwater elevations and climate in the CABY watershed is difficult because of localized factors of drawdown, geology/recharge, and tapping into groundwater subbasins by others beyond the watershed. However, PG&E's long-term studies of streamflow fed by underground aquifers have indicated a correlation between long-term drought and decreased groundwater elevations.

Water Quality

- Chapter 6, Water Quality, addresses specific water-quality concerns within the watershed; this climate section addresses only those concerns that may be exacerbated by climate variability. However, earlier snowmelt coupled with rain-on-snow events that accelerate runoff may increase erosion and raise turbidity (and resulting sedimentation), as documented elsewhere in

[15] Freeman, Gary J. 2010. Tracking the impact of climate change on central and northern California's spring snowmelt subbasin runoff. Paper presented at the Western Snow Conference 2010.
[16] Moser, S.; Franco, G.; Pittiglio, S.; Chou, W.; Cayan, D. 2009 The future is now: an update on climate change science impacts and response options for California. California Climate change Center Report CEC-500-2008-071. Sacramento, CA: California Energy Commission.
[17] Freeman, Gary J. 2012. Ibid.

California.[18] Higher water temperatures also have accelerated some biological and chemical processes, increasing growth of algae and microorganisms, the depletion of dissolved oxygen, and produced impacts to water treatment processes. If projected drying of the climate manifests, the period of seasonal low flows may be extended. Low flows reduce the assimilative abilities (dilution capability) of streams, thus reducing water quality.

More Extreme Precipitation and Other Weather Events

- Nineteen severe winter storms or extreme weather events (freezes or droughts) have been documented in the Yuba County *Multi-Jurisdictional Multi-Hazard Mitigation Plan* since 1982, which the Plan describes as an "*inordinate number of natural disasters*." (Disasters also include fires.) Again, comparing these statistics with future documented events should help indicate trends in extreme precipitation events.

11.6 Vulnerabilities and Adaptive Management Strategies

CABY affiliates and stakeholders have gained a fundamental understanding of climate vulnerabilities, both from the conduct of their operational management of respective resources, as well as from the process that they underwent to prepare this section. As demonstrated below, water agencies, NGOs, and public land management entities have formulated and are conducting adaptive strategies to bolster the region's climate resiliency. The relative sophistication and capacity of entities in the region has developed over time to deal with historic and existing natural resource challenges.

For many, restoring an ecosystem that has experienced 150 years of intensive resource extraction, including mining and timber harvest, should be a primary component of climate resiliency. In the opinion of others, restoration in the region may not provide sufficient resources to ensure the region's ability to provide for all consumptive and non-consumptive uses.

As well, some view human and political responses to climate change as the greatest vulnerability of the region. For instance, changes in State policies to solve the Sacramento Delta water quantity and quality problems could affect everything from the region's water systems management and facilities construction, to water rights that have been developed over the last century.

A further vulnerability identified during the IRWMP process is the lack of funding to conduct climate resiliency projects, even after identification and prioritization. Identification of new funding sources, creative use of sources, and cost-effective responses may, at this point, be one of the most-needed adaptive strategies to climate change.

11.6.1 Process for Identification of Vulnerabilities

As discussed above, the TAC began its process to identify vulnerabilities and adaptive strategies with a review of the four documents listed in Table 11-1. These documents identified topics for further research and consideration by the TAC. At the direction of the TAC, the project team then conducted an extensive literature and data search into climate trends, vulnerabilities, and adaptive strategies, guided by the four State primary documents. The TAC expected that this data/literature evaluation would

[18] California Department of Water Resources. Managing An Uncertain Future: Climate change adaptation strategies for California's water. Sacramento, CA, State of California. October 2008. Available from: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf

provide an historical climate trend description and offer qualitative climate projections, as well as a preliminary indication of regional vulnerabilities and adaptation strategies.

The most useful information was regionally or issue-specific, such as the California Energy Commission-funded study identifying fire danger for the central Sierra.

Participants also expressed an interest in knowing what data and/or modeling was available specific to the region. The project team brought before the TAC several potential models for consideration, including WEAP and the Soil Water Assessment Tool (SWAT). The SWAT model was developed to predict the effects of management decisions and includes consideration of hydrology, weather, sedimentation, soil temperature, crop growth, nutrients, pesticides and agricultural management, all in the context of climate change (Arnold, 2005). After consideration, no single model was identified to satisfy all of CABY's needs. The TAC discussed technical merits of available models; the use of models specifically for the CABY IRWM region; and alternative bases for making climate-change-related, water-management decisions. The MC1 vegetation model, discussed in Section 11.8, was chosen to display potential climate effects to the region's plant communities. No other modeling was agreed upon for use at this time.

A vulnerability identified during the process was the region's air quality. Air quality affects the rate and health of forest growth, the health of regional residents, and the quality of life of both residents and visitors to the region. It also can affect water quality. CABY will continue to work with city and county planning entities to ensure that planning and travel management minimizes emissions, where possible; however, the PC decided against putting significant effort into describing and identifying vulnerabilities and adaptation strategies for this issue because it was judged to be outside the sphere of the CABY PC.

Going forward with regional climate trends in mind, the TAC conducted a vulnerability assessment as outlined in the Climate Change Handbook, Appendix B. An extensive list of vulnerabilities was then assembled with a corollary list of adaptation strategies (see Table 11-2 at the end of this chapter). This included substantive measures that regional public agencies and NGOs are already implementing.

11.6.2 Prioritization of Vulnerabilities

During the synthesis of the data search and ensuing vulnerability exercise with guidance from the Climate Handbook, the TAC agreed that three key categories of vulnerability rose to the top as highest priority: water supply, water quality, and environment and habitat, each of which has a wide variety of sub-vulnerabilities. These vulnerabilities are considered 'equal' in importance to the TAC as a whole, although individual entities within the TAC and across the region would assign higher or lower 'priority' depending on interests and perspective. All other identified vulnerabilities were considered to be of secondary import, either because of the nature, or scope of, their impact. Two ancillary topics, out-of-region demands, particularly water supply for the Delta, and a lack of funding for adaptive strategies to address vulnerabilities, exacerbate issues across the board.

After careful consideration, the TAC identified fire danger and management as a major topic (sub-vulnerability of environment and habitat) for in-depth research. The TAC decided to complete a case study of fire and fuels now, with research on the other issues as funds become available (see Section 11.8, below).

11.7 Adaptive Management Strategies

Following identification and prioritization of regional vulnerabilities, the TAC identified and evaluated adaptive management strategies. Adaptive management strategies were identified without consideration to cost, feasibility, or impact of implementation (see Table 11-2 at the end of this chapter).

The TAC investigated three primary sources/bodies of work to address adaptation approaches for the CABY region: 1) existing strategies employed by entities, agencies, and NGOs; 2) state-generated adaptation strategies that help fulfill water planning goals and mandates; and 3) strategies identified during the extensive literature and data search.

CABY stakeholders are already implementing many of the strategies identified in Table 11-2. For example, the U.S. Forest Service is giving significant effort through its Institute for Forest Genetics in Placerville, CA, to preserving biodiversity and minimizing the effects of invasive species, as well as the functioning and modeling of ecosystem response to changes in temperature, precipitation, and historic land use practices. The Eldorado National Forest has developed a program to identify areas at risk of mass slumping and remediate those through reforestation and other stabilization techniques, and the American River Conservancy has made it a practice to identify imperiled habitats and prioritize those areas for conservation.

Water agencies have conducted climate projections and incorporated findings into their respective plans, incorporated water-efficiency measures into system operations, installed solar panels at facilities, and promote conservation measures among employees. EDCWA began to pursue additional water rights in 2009 for EID and other smaller agencies in El Dorado County. This water rights application leans heavily on the county's need as identified in several agency documents, including El Dorado County's General Plan. It also is an application based on the Area of Origin rights statutes.[19]

It also is the first water rights application in the state that will test the California Water Code's Area of Origin rights statute.[20]

Suggested strategies identified in the reference documents within the guidelines (see Table 11-1), confirmed strategies that the region is already using and provided additional guidance and specific approaches not previously considered. The extensive literature search served the same purpose of confirming and informing stakeholders about adaptive strategies. Use of a wide variety of source documents ensured that the TAC was fully informed by the most current applicable thinking. Effort was made to identify at least one adaptation strategy for each identified vulnerability.

Because the CABY region's water delivery system is so complex and intertied, variable and, in some cases, limited capacity exists for adaptive management to address projected climate change impacts. Adaptive management usually requires flexible infrastructure and flexible management policies and approaches.

[19] Area-of-Origin water rights are rights to the amount of water a county will need in the future as it grows. There are a number of statutes that, individually and collectively, protect those rights from infringement by projects exporting water from the watershed.

11.7.1 Integrated Adaptive Strategies

In addition to the adaptive management strategies developed for specific topics, the TAC developed several integrative strategies, listed below.

- Integrate terrestrial and aquatic objectives and urban-area objectives to better develop (and then address) opportunities for synergistic solutions as suggested by Reiman, 2010.
- Diversify and examine/analyze finance options for funding watershed programs and projects that implement adaptive strategies.
- Recognize that water management is only part of a comprehensive response to climate change and implement Integrated Resource Management by integrating land use, transportation, human health, education, environmental, and economic-focused interests into CABY more fully, perhaps at an annual forum.

11.8 Fire and Fuels – A CABY Case Study

The TAC identified fire and fuels as a topic for further study, as it touches on issues of water quality, carbon sequestration, biomass preservation, land use and recreation activities, and habitat connectivity (a core concern of the CABY PC), among other concerns. Its social and economic costs have also become increasingly evident in recent years as California's fire season extends at each end. While water supply may have been the obvious choice, the TAC confirmed that water management agencies were already far along in their water assessments/planning, had consulted or generated much of the existing hydrologic information, and were already enacting adaptive management.

The importance of fire and fuels adaptations to stakeholders of all interests can be seen in the number and variety of fuels management projects submitted in this round of CABY project development (see Chapter 12, Project Review Process). The linkage of this issue to the rest of California cannot be overstated: the quality of recreation space, water and air quality, and overall water supply for the state are all dependent upon the ecological health and robust and resilient nature of the Sierra Nevada watersheds. Moreover, participants felt that the variability projected with all climate change assessments in the Sierra indicated that a 'no regrets' strategy was necessary for habitat protection and connectivity, and reducing stressors to endangered species. Managing wildfire risk will be important to the CABY region no matter what the future climate brings, so identifying management strategies, adaptation measures, and mitigation action are all value-added. As identified in the California Air Resources Board's Climate Change Scoping Plan, watershed investment would be an excellent use of State investment for addressing climate change effects in California.

To pursue its in-depth analysis of this topic, a more rigorous document review was performed. This work resulted in a list of articles dealing with topics ranging from the occurrence and severity of fires in the central Sierra to nutrient cycling and habitat refugia. Members of the TAC made a special request that the analysis look further into the issue of carbon sequestration and fuels management. This topic is sometimes controversial and there are strong feelings on both sides of the issue: one side believes that more greenhouse gas emissions occur with the occurrence of a catastrophic wildfire, and the other side believes that the mechanized harvest, transport, and (often) burning results in greater emissions.

The document review was then supplemented by a vegetation modeling exercise to help determine how vegetation might respond to climate alteration. The TAC chose the Forest Service's MC1 model for two main reasons: 1) it would build on information already collected regarding fire occurrence and vegetation change within the CABY region; and 2) large-scale vegetation change can be analyzed from a general perspective, allowing diverse stakeholders to talk about overarching management and adaptation strategies. The MC1 model also created a clear nexus with the Climate Change TAC's priority of understanding how biomass and fuel loading might be modified by climate.

The future scenarios modeled for the TAC showed an increase in and general upslope movement of the warm temperate/subtropical mixed forest (regional examples include Douglas Fir-Tanoak forest, Ponderosa Pine-Black Oak forest, and Tanoak-Madrone-Oak forest). This is largely displacing the boreal conifer forest, less tolerant of heat and drought. The temperate mixed xeromorphic woodland moved upslope from the foothills just outside of the western edge of the CABY region, further into the region (displacing the warm temperate/subtropical mixed forest upslope). The vegetation communities at the highest elevations in the region became more complex and varied, and generally drier, moving to temperate arid and/or Mediterranean shrubland, expanded xeomorphic woodland, and grasslands.[21] All future scenarios projected an increase in the number and severity of fires, but the change became more significant toward the end of the century (Lenihan, 2008). See Appendix G for further discussion of the MC1 modeling.

Extensive and very specific (and sometimes conflicting) vulnerabilities were documented along with adaptive management strategies for managing fire and fuels and the secondary consequences of fire. A synopsis is displayed in Table 11-2, while full results of the case study are contained in Appendix G.

11.9 Climate Change Mitigation/Greenhouse Gas Reduction

The CABY region does not host major industrial facilities (e.g., power plants) that typically produce substantial, single-source GHG emissions. Instead, The CABY region has significant hydroelectric capacity, developed many decades ago, that is a very low carbon source of electric generation. The three primary sources of regional GHG production are related to residential and commercial development (building lighting, heating, and cooling), transportation, and wildfires.

Counties are the relevant entities to address GHG reduction in relation to regional development and transportation, and their efforts in this regard are discussed below. Regional water agencies have also recognized their role in reducing GHGs and have undertaken substantive efforts to limit production of GHG emissions.

Research on fire and fuels conducted for this Plan showed that greater occurrence of fires feeds a negative feedback loop, putting greater amounts of carbon and particulates into the atmosphere (Westerling, 2006). By way of example, the *Sacramento Bee* reported that the 2008 Moonlight fire, that burned across Plumas County north of Quincy, pumped an estimated five million tons of carbon dioxide into the air, equivalent to the annual emissions of 970,000 vehicles, or one coal-fired power plant.[22] Therefore, management of sustainable forests and curtailment of catastrophic fire may offer the greatest opportunities for GHG reductions by the PC and other regional stakeholders (see Adaptive Management Strategies).

---

[21] Perennial grasses can be classified as either C3 or C4 plants. These terms refer to the different pathways that plants use to capture carbon dioxide during photosynthesis. These differences are important because the two pathways are also associated with different growth requirements: C3 plants are adapted to cool season establishment and growth in either wet or dry environments, and C4 plants are more adapted to warm or hot seasonal conditions under moist or dry environments. C3 species also tend to generate less bulk than C4 species, but the C3 feed quality is often higher.

[22] Sierra Nevada Conservancy. 2009. The Climate Action Plan of the Sierra Nevada: A Regional Approach to Address Climate Change. Version 1.0. December 2009. Available from: www.sierranevada.ca.gov

11.9.1 Mitigation Strategies

Governor Schwarzenegger's Executive Order (EO) S-3-05 established GHG emissions reduction goals for the State of California. The final target of 80 percent below 1990 levels is in line with the international reductions target essential to address long-term climate stabilization. These concepts were considered in the development of CABY's objectives (see Chapter 9, Issues and Objectives). As such, they are integrated into project conceptualization, development, and implementation. Further, as directed by SB97, CNRA adopted Amendments to the CEQA Guidelines for greenhouse gas emissions, effective on March 18, 2010. These called for lead agencies to determine baseline conditions and levels of significance and to evaluate mitigation measures. As the guidelines do not identify a threshold of significance or prescribe methodologies for doing this, lead agencies need to establish these levels of significance.

Accordingly, climate mitigation strategies and greenhouse gas (GHG) reduction methods are also required as part of an IRWMP. California has developed a wide body of work looking at the possible sources of greenhouse gases, effects of those gases in the atmosphere, and of a warming climate on a variety of state resources. The primary document addressing GHGs was AB32, passed in 2006. This legislation mandated a reduction in overall GHG emissions, and required CARB to develop a Climate Change Scoping Plan (December 2012) for achieving the maximum technologically feasible and cost-effective reductions in GHG emissions by 2020 (California Health and Safety Code §38561). The scoping plan provides for actions to reduce GHGs in California and indicates how these emission reductions will be achieved via regulations, market mechanisms, and voluntary measures.

The CARB 'recommended actions' relating to sustainable forests, water supply, and agriculture may hold the most promise locally and are embodied in the objectives and projects proposed in this Plan. CARB's proposed sustainable forest actions most applicable to the region are carbon sequestration through sustainable forestry practices and prevention of widespread and intense forest fires. Several forestry and fuels management projects, and restoration that stabilize mountain meadows and forest ecosystems help address maintenance of California as a 'carbon sink,' in other words, more carbon is removed from the atmosphere in California at present than is generated from processes, such as wildfires and forest land conversion. Fuels reduction projects also help assure that frequent widespread fires do not shift this carbon sink balance. Biomass processing from forest residue also has been a potential project suggested under this Plan. Planting trees now will result in a maximum sequestration capacity in 20 to 50 years. Near-term investments in these activities will play a role in reaching California's 2050 goals. Suggested and implemented adaptive strategies for forest health address both carbon sequestration and sustainable forestry.

Improvements in water delivery, treatment, and use are another area of regional relevance addressed under the CARB strategies. IRWM Guidelines state that GHG emissions are associated with all aspects of water management, including: habitat management; recreation; domestic, municipal, industrial and agricultural water supply; hydroelectric power production; and flood control. Since activities related to water management result in significant amounts of GHG emissions (on a statewide average, 19% of the electricity and 30% of the non-power-plant natural gas of the state's energy consumption are spent on water-related activities, although a disproportionate amount occurs outside the CABY region), several State mandates and strategies are aimed at reducing GHG contributions from this sector of energy use.

The Scoping Plan recommends six actions that, if implemented throughout the state, could reduce GHGs (in CO_2 equivalent[1]) by almost five million metric tons (MMT). CABY water management agencies are already implementing five of these actions, and the specific details of this are described in Table 11-3.

Table 11-3
California Climate Change Scoping Plan Recommendations for Water Management Being Implemented in the CABY Region.

Climate Change Scoping Plan Actions	*Nevada Irrigation District*	*Placer County Water Agency*	*El Dorado Irrigation District*
W-1: Water Use Efficiency	Complying fully with California's 20% by 2020 mandate (see 2010 Urban Water Management Plan)	Complying fully with California's 20% by 2020 mandate (see 2010 Urban Water Management Plan)	Complying fully with California's 20% by 2020 mandate (see 2010 Urban Water Management Plan)
W-2: Water Recycling	Investigating efforts to reuse treated effluent for agricultural uses		Recycled water delivery currently makes up 7% of total water deliveries
W-3: Water System Energy Efficiency	Delivers raw water to users wherever feasible and appropriate, saving energy in the treatment process and chemical production Replacing pumps as appropriate with energy efficient models Use built-in system gravity feed effectively	Delivers raw water to users wherever feasible and appropriate, saving energy in the treatment process and chemical production Replacing pumps as appropriate with energy efficient models Use built-in system gravity feed effectively	Replacing pumps as appropriate with energy efficient models Use built-in system gravity feed effectively Employs electrical load management by shifting loads to off-peak schedules
W-4: Reuse Urban Runoff	Reducing urban runoff is a component of the agency's 20x2020 compliance; reuse is not currently a strategy	Reducing urban runoff is a component of the agency's 20x2020 compliance; reuse is not currently a strategy.	
W-5: Increase Renewable Energy Production	Looking for ways to incorporate in-pipe and in-system micro-hydro facilities Improving efficiency of existing low-carbon hydroelectric power generation	Looking for ways to incorporate in-pipe and in-system micro-hydro facilities Improving efficiency of existing low-carbon hydroelectric power generation Installed solar panels at several PCWA facilities	Looking for ways to incorporate in-conduit hydro facilities Installed a one-megawatt solar plant to aid in powering a wastewater treatment plant
W-6: Public Goods Charge	Not implementable on an individual-agency basis	Not implementable on an individual-agency basis	Not implementable on an individual-agency basis

Of note, PCWA has emerged as a leader among California water agencies regarding reduction of GHG emissions and energy efficiency. In 2009, PCWA completed its *Energy and Greenhouse Gas Benchmark Study* to better understand cost of delivery, cost containment, and related energy efficiencies, in the context of climate change. It has voluntarily reported its GHG emissions, starting with the year 2006, to the Climate Action Registry that tracks and inventories such emissions for North America.

The Scoping Plan also includes strategies that would influence water management on a secondary basis, including fuel economy standards, efficiency regulations for light-duty and heavy-duty vehicles and equipment, a green building strategy, and suggestions for recycling and waste management such as mandatory commercial recycling. PCWA already maintains a fuel-efficient vehicle fleet and, for heavy equipment implements, an idling reduction program, and installs automatic idle shutoffs. The agency also has established a conservation awareness program and installed solar panels to help reduce electrical use at its many facilities.

CARB strategies associated with agriculture typical of this region include improving fuel efficiency of on-farm equipment, water-use efficiency, and carbon sequestration from restoration of riparian and forested areas. Objectives and projects in this Plan address the latter two actions; the IRWMP can address improving on-farm fuel efficiency via future objectives to develop and share BMPs and through stewardship outreach with local watershed groups.

Regional NGOs, in cooperation with the Forest Service, have also played a substantive role in stabilizing regional ecosystems that help capture carbon and thus reduce GHGs. American River Conservancy, South Yuba River Citizens League, and Sierra Streams Institute have accomplished important mountain meadow and forest restoration and protection projects relevant to this issue.

11.9.2 Further Opportunities for Greenhouse Gas Reduction

While CABY agencies and NGOs have come a long way in addressing GHG reduction, stakeholders recognize the urgency of this issue and anticipate emerging technologies that may aid in further regional GHG mitigations. Stakeholders identified some of those future opportunities, below.

11.9.2.1 Opportunities for Carbon Sequestration

Three categories of forest management can help in decreasing the amount of carbon in the atmosphere:

- Carbon sequestration (through reforestation and restoration of degraded lands, improved silvicultural techniques to increase growth rates, and implementation of agroforestry practices)
- Carbon conservation (through conservation of biomass and soil carbon in existing forests, improved harvesting practices, and fire protection)
- Carbon substitution (increased conversion of forest biomass into durable wood products for use in place of energy-intensive materials, increased use of biofuels, and enhanced utilization of harvesting waste as feedstock) (Montagnini, 2004)

All of these practices have been recognized in public management of forests in the CABY region and coordination with private forestry interests over these issues has been suggested as an adaptation strategy that could help reduce carbon emissions. Portions of the Tahoe National Forest are serving as pilot study areas to determine the potential for sequestration within the forest resulting from diverse management strategies. Outreach to the private forest industry to assess current management practices supporting carbon sequestration has been identified as a priority by CABY.

11.9.2.2 Actions Proposed or Underway by Counties

In keeping with the integrated, regional approach embodied in this Plan, it is important to recognize the role counties and others will play in reducing GHGs, in concert with the RWMG. While none of the counties has adopted a Climate Action Plan, plans are beginning to be drafted. It is expected that consideration of land use patterns to encourage energy efficiencies, community incentives for conservation, and altered design standards may all be part of the counties' CAP mix that will help reduce GHGs.

11.9.2.3 GHG Reduction Considerations for Project Design

The Project Team conducted GHG emissions calculations for Tier 1 ready-to-proceed projects recommended in this Plan. (Please see Chapter 15, Technical Analysis, for the methodology used to undertake these emissions calculations, and Appendix I for these individual analyses.) These calculations are a requirement for projects seeking DWR funding and future projects submitted to DWR will offer mitigations to reduce project-related emissions.

IRWM Guidelines suggest that common emissions sources from projects are related to:

- Operations of construction equipment
- Passenger vehicle trips during construction and operation
- Transportation of construction materials and equipment
- Transportation of material inputs for O&M
- Transportation of material outputs or production
- Generation of electricity used for operation of projects
- Waste generation and disposal of materials during construction and operation

Reduction strategies during project design and project mitigations under CEQA/NEPA review could include any of the applicable measures listed below:

Project construction-related transportation

- Offer local contractor preference and local purchase of construction materials where possible to reduce transportation-related emissions
- Encourage or require carpooling within construction contracts
- Encourage use of B20 fuels in construction equipment and other diesel machinery
- Manage OHV use, particularly in sensitive or restored areas where project investments have been made

Project construction-related emissions

- Encourage or require recycling of construction waste, such as brick, concrete, lumber, metal, and dry wall
- Pursue projects in this Plan that would use biomass from fuels reduction projects
- Capture sequestration opportunities with forest, sage-steppe, riparian, and grassland revegetation, stabilization, and restoration projects

Water supply and water efficiency improvements

- Select project components and upgrades, such as pumps, based on energy efficiency
- Schedule pumping to reduce peak hour (12:00 to 5:00, highest carbon output) energy use
- Select projects that offer the best water conservation options among project choices (e.g., greatest reuse/recycling, greatest reduction in leakage or evaporation per mile)
- Install solar generation equipment for pumping and other energy-generation needs to reduce both emissions and long-term O&M costs
- Increase conservation/reduce water use (and thus the energy and emissions related to its delivery) with increased metering, favorable rate incentives for conservation, and education within utility bills

11.9.2.4 Environmental Compliance

CABY will need to document through its project review process that: 1) emissions from a proposed project have been determined, 2) GHG mitigations have been incorporated into the project, 3) the project may help in adapting to climate change over the 20-year planning horizon, and 4) a determination of significance has been made.

In the near term (within one year) CABY will provide a venue to help water agencies (generally the CEQA lead agency) to develop consistent regional significance criteria for its CEQA reviews. It may be a qualitative, quantitative, or performance level of a particular environmental effect above which impacts will normally be considered significant. Three basic strategies have been formulated to date: 1) a net-zero threshold, 2) a non-zero significance threshold based in compliance with AB32 (falls beneath a reporting requirement for 25,000 metric tons of $C0_2$ per year), or 3) other established GHG reduction strategies. IRWM Guidelines suggest considering the following questions in developing non-zero threshold significance criteria:

1) Does the project implement or fund its fair share of a climate mitigation strategy (perhaps as suggested from the list above, under GHG reduction strategies)?
2) A brief description of how and in what ways the project moves California toward a lower carbon future.
3) How closely does the project's overall GHG emissions balance approach net zero?
4) Are there process improvements or efficiencies gained by implementing the project?

11.10 CABY Climate Change Program: Implementation of Adaptive Management

The purpose of the CABY climate program is to begin a systematic and purposeful response to assist the region in its ability to adapt to climate change. The program attempts to mitigate climate change effects on the region, as well as the contributing factors within and outside of the region (including potential State policy and regulation) that exacerbate the impacts of climate change.

The program seeks to assure, under an altered climate future, that the region continues to produce high quality water, reliable water supply and hydroelectric (clean energy) generation, sustained healthy and diverse ecosystems, and reduces socioeconomic impacts under an altered climate future. The CABY stakeholders were uniform in their support in having IRWM be the organizing venue for both developing and implementing this program.

After considerable reflection and with the intent of fully implementing resource management strategies and Plan goals and objectives, CABY formulated a climate change program to consist of eight components. These program components are: involvement in developing State policies and programs, increased knowledge sharing, increased coordination and collaboration, securing funding, monitoring the implementation of adaptive management strategies, reducing GHGs, data gathering, and investment in monitoring. These programmatic focus areas follow and, when taken together, constitute CABY's climate change program for the future. CABY will determine the measures and outcomes for these programmatic elements as they are implemented and mature.

1) Involvement in Developing State Policies and Programs: As discussed previously, human response to climate change may have equal or greater impact on the region when compared to direct climate impacts. Of particular relevance in this regard is State policy and regulation aimed at trying to assure environmental flows for the Sacramento/Bay Delta. For instance, the State Water, Parks and Wildlife Committee has introduced legislative language for a $6.5 billion water bond for the 2014 ballot. As amended August 26, 2013, the bill identifies five broad categories of programs and projects that would be allocated funding for a total bond measure of $6.5 billion. The broad categories and funding amounts include clean and safe drinking water ($1 billion); protecting rivers, lakes, streams, and watersheds ($1.5 billion); climate change preparedness for regional water security ($1.5 billion); Delta sustainability ($1 billion); and water storage for climate change ($1.5 billion continuously appropriated). The final disposition of AB1331 could affect water management and infrastructure, such as levee improvements and dams to support that management, and thereby affect the region. Another water bond bill, SB42 (Wolk), is awaiting action in the Senate Natural Resources and Water Committee. SB42 proposes a $5.6 billion water bond for the 2014 ballot that would be known as the Safe Drinking Water, Water Quality and Flood Protection Act of 2014. And these are but two of many examples.

To affect these and other policies to the benefit of the region, CABY has determined it needs to be actively involved in State-level and interregional IRWM discussions, using IRWM as an organizing principle. It needs to join with other source-water counties to be effective, and it needs to be pro-active, rather than reactive. Therefore, involvement with State water policy will be part of CABY's future climate program.

2) Increase Knowledge Sharing: CABY members have a sophisticated understanding of climate change due to their joint and individual efforts to understand the issue and its effects on both water supply and watershed health. As a result they have experience with evaluating and interpreting a wide variety of climate-related information. With this in mind, the Knowledge Sharing component is specifically aimed at ensuring that the newest and most relevant information is available to CABY.

The Knowledge Sharing element focuses on several specific activities: use of the CABY web portal and the Sacramento River Watershed Information Module (SWIM) website to post and store relevant information (as directed by the Climate Change TAC), use of two regular CABY meetings to ensure that new information (data, reports, modeling outcomes, trends analyses, results of project, and program-level monitoring) that is germane to the region will be brought forward and discussed, attendance by various CABY members at conferences and workshops focused on climate change with reports to the Climate Change TAC as an outcome, and creation on the CABY website of a set of links to various climate-change-relevant State and federal agency websites to facilitate access by both the TAC and stakeholders.

3) Increased Coordination and Collaboration: Many of the management strategies and objectives identified in this document suggest increased communication and coordination with 'outside' and 'partner' organizations. CABY already provides a venue for members to engage in formal and facilitated climate-related discussions, as does the Climate Change TAC and the various CABY Work Groups. In addition, CABY members collaborate frequently in the course of project development and integration activities.

This component of the program seeks to provide better tracking of these internal CABY coordination discussions and activities as they relate to climate change.

Additionally, several CABY members have indicated the need to work with adjacent IRWM regions (most notably though the Sierra Nevada Conservancy, Sierra Water Work Group, Mountain Counties Water Resources Association, Sierra Nevada Alliance, and Sierra Business Council) to ensure that issues of common concern with the larger Mountain Counties region (as defined in the 2013 Water Plan) are identified and the groups are actively engaged in discussion about emerging trends and available adaptive management strategies.

CABY water agencies, through decades of experience dealing with climactic and weather variations, as well as regulatory and State policy initiatives, have instituted ongoing programs to increase system efficiency, decrease water wastage and increase operational flexibility, and are engaging in de facto climate change adaptation. Likewise, the CABY region non-profit community and federal agencies are focusing on implementing projects which address watershed resiliency and sustainability. However, taken together these efforts may not be sufficient to ameliorate the worst of the predicted impacts of climate change and variability.

CABY creates a venue where most of the key stakeholders with interest in the effects of and adaptive management for climate change can meet on a regular basis and advance both discussions of the issues and also collaborative opportunities to address these issues.

4) Securing funding: In many ways, the greatest challenge associated with climate change is developing funding to support the ongoing studies, support for small hydropower and other infrastructure which increases feasibility for using renewable resources and flexibility for managing water resources in response to changing climatic conditions, evaluation of adaptive management strategies and projects, development of regional and collaboratively developed mitigations, and devising ways to increase inter-agency opportunities for water system efficiency and redundancy in the face of persistent drought.

Additionally, the ability of disadvantaged communities and less affluent water agencies and non-profits to take part in developing knowledge, collaborating regularly, understanding the strategies most appropriate to their issue, and to be included in regional strategies is very limited. Some communities rely totally on groundwater, and the potential impacts of climate change on these resources are very poorly understood. However, experience in previous drought years suggests that there will be an increasing number of ground-water dependent residences and small communities which will also need to be included in any regionally oriented solutions, yet there is no real process for funding these small-scale efforts.

Use of grants to support these myriad efforts will not be sufficient, neither is it possible to keep raising water cost to fund such activities. Therefore, the identification of suitable and sustainable funding sources will be a key focus of implementing this program component.

5) Monitoring the Implementation of Adaptive Management Strategies: CABY will specifically monitor the Plan's climate goals and objectives and implementation of projects to assure adaptive management strategies, at a minimum during the Plan's scheduled performance reviews. As well, CABY will serve as a think tank for identification of new and emerging adaptive strategies to address climate, and assure they are incorporated into Plan updates.

6) Reducing GHGs: CABY will help assess and develop a project review process that incorporates mitigation of GHGs into project design. It will monitor the outcomes of project implementation to determine if adaptive management strategies and mitigations appear effective, based on technical input from project sponsors, and if the list of project mitigations can be supplemented as guidance for project development, CABY will work with entities to develop a regionally consistent level of significance for GHG emissions.

The goal of reducing GHGs will be further targeted by supporting opportunities to employ non-carbon-based energy sources.

7) Data gathering: The CABY data-gathering effort focuses on two types of data: existing material and data that is developed over time. For existing data, the current Data Management System (DMS) (i.e., the CABY web portal) is a searchable database which contains all relevant climate change data for the region, cataloged by topic. The DMS is available to all CABY members and is maintained regularly. As new data emerges (in the form of in-region monitoring results, technical and/or scientific papers or articles, modeling by or for the region, information developed within the IRWM community) this information will be added to the database. The CABY webpage will have a Climate tab that will link to this portion of the CABY DMS and will also support program component #2, Knowledge Sharing.

8) Investment in Monitoring: Stakeholders have determined that investment in monitoring (e.g., water quality, macro benthic invertebrates) is needed to substantially affect resources management and programs in the CABY region. Monitoring will facilitate more robust science-based adaptive management and assist in detecting change in climate and hydrologic effects on the ecosystem and the human population.

Many volunteer organizations demonstrate effective support for monitoring activities of all kinds, but seed funding is often needed for lead staff and/or materials. Monitoring is rarely funded as a component of the IRWM program, yet it could save considerable time and effort spent on ineffective methods if property deployed. CABY will continue to make a case for funding of monitoring with public agencies and engaged private organizations.

Moreover, monitoring is going on throughout the region that needs only to be shared for greater impact. CABY represents an ideal forum for publicizing monitoring information through the use and application of the SWIM tool, thereby creating the synergies that are essential in further assessing and understanding data's various components. Increased diligence will be made to assure monitoring data is posted on the SWIM site.

11.11 Climate Change Discussion Elsewhere in this Plan

Climate is addressed in several other sections of this Plan, as appropriate. Please find references to those sections in the following Table 11-4.

Table 11-4 Climate Change Discussion throughout the CABY IRWMP		
Item	**Description**	**Chapter**
Region Description	Regional vulnerabilities from the effects of climate change are discussed in general in this section.	5
Plan Objectives	Two objectives and one goal address climate change. Climate change is cited throughout the descriptive text for many of the objectives as well.	9
Resource Management Strategies	Climate change is built into the consideration of each resource management strategy, as discussed in the description below each strategy.	10
Project Review Process	Climate change adaptation and mitigation was a major component of identifying project readiness to proceed in the Tier 1 project suite.	12
Local Water Planning	Climate change is part of most water management agencies' planning processes, as discussed.	8
Local Land Use Planning	Climate change is identified by several county general plans as a specific point of coordination with local water management institutions.	8
Plan Performance and Monitoring	Performance measures include many addressing and increasing system resiliency and flexibility, as well as measures to address mitigation efforts	13
Coordination	Coordination with federal, State, and local agencies about climate change is addressed in chapters covering Coordination and Plan Performance and Monitoring.	8

Table 11-2
Climate Vulnerabilities and Strategies to Increase Climate Resiliency

	Summary of Modeling Results and Relevant Studies		Vulnerabilities Identified by Stakeholder Group	Existing and Future Strategies to Address Vulnerabilities	Examples Of Existing and Proposed Projects That Can Help the Watershed Increase Climate
Potentially Affected Natural Resources	**Forest and Rangeland Vegetation**	Future vegetation modeled scenarios show an increase in and general upslope movement of warm temperate/subtropical mixed forest, largely displacing boreal conifer forest, less tolerant of heat and drought. Vegetation communities at the highest elevations in the region become more complex in variety and generally more drought tolerant. An increase in future biomass is also projected. Increased fire severity and intensity is predicted for the Sierra Nevada by the latter part of the century, with more frequent fires and more area consumed by fires (Lenihan 2008; Westerling 2008). Catastrophic wildfire in particular is projected to become more frequent and more severe in coming decades. Future regional climate is likely to favor certain invasive species, such as cheat grass. Additional invasive species act as stressors on native species that, when combined with lower flows, or erratic flow regimes more likely with greater climate variability, can cause decreased viability for desired species.	-Poor habitat condition of some forest habitat and areas of rangeland in the watershed make them more susceptible to increased fire risk under potentially hotter and drier climate conditions, and make habitat less resilient in supporting native wildlife species. -Increased fire severity will both amplify and accelerate the ecological impacts of climatic change (Flannigan 2000). -Decreased species variability within natural systems could result in degraded habitat for native species and economic losses for agricultural producers and recreation-related businesses. -Invasive species expansion often results in a higher, more flammable fuel load (Brooks, 2004) and often more shallow-rooted and quick-lived, a contributing factor to mass wasting events and excessive sedimentation in general (TetraTech EC, Inc. 2007).	-Enact strategic forest management: It increases resiliency to longer fire seasons and bark beetle outbreaks (Flannigan 2000). In stand improvement projects and revegetation efforts, Tahoe National Forest (TNF) considers favoring or planting different species and species mixes. Where appropriate and based on anticipated changes, white fir could be favored over red fir, pines would be preferentially harvested at high elevations over fir, and species would be shifted upslope. -TNF is strategically managing for process rather than structure or composition in proposed projects (e.g., those involving succession after fires, where novel mixes of species and spacing may reflect natural dynamic processes of adaptation). -Implement fuels management/reduction in watersheds where a high vulnerability exists to critical water sources. Where possible, mix selective harvest and prescribed fire to best mimic natural forest management (Schwilk 2009). -Maintaining a forest at full ecological function recharges groundwater and provides for more resiliencies regionwide. -Use integrated pest management on terrestrial noxious weed species, including: prioritization of most effective strategies; mechanical, chemical, and grazing treatments; revegetation; and monitoring to improve water quality and habitat condition. -Participate in statewide pest detection programs. The region is close to the state border and hosts two major national freeways going east-west across the Sierra Nevada.	-Coordinate between and within management agencies to better address clear management goals (Reiman 2010). Steps to more successfully integrate the management of forests, fires, watersheds, and native fishes into regional and project-scale planning should include communication among disciplinary scientists with a clear definition of management goals. -Strategies implemented to reduce fuels and minimize chances of catastrophic fires are increasing the adaptability and resilience of the Tahoe National Forest (TNF). For example, the Western Nevada County Community Defense Project is strategically located on the landscape near Grass Valley, Nevada City, and other small communities to reduce small-diameter fuels and surface fuels that will decrease the impacts from wildfire. The second project phase would treat fuels over a broader geographical area.

Potentially Affected Natural Resources	**Species and Habitat**	The Sierra Nevada is identified in its entirety as an important climate refugia by the Endangered Species Coalition. The region is particularly vulnerable to climate change, and represents a significant bio-region for plant and animal species survival. The region is also host to myriad species of special concern that may be climate-sensitive (e.g., are wetland-dependent, or occupy elevational niches projected to be affected). Climate-sensitive populations of flora and fauna in the region include: whitebark pine, vernal-pool-dependent rare plant populations, and wetlands or small ponds (such as the Pierce Wetland Area on the Tahoe National Forest) and pika, alpine chipmunks, Lahontan cutthroat trout. Habitat is currently fragmented in lower elevations by roads and urban development, and in the higher elevations primarily by Highways 80 and 50.	-Sedimentation associated with higher potential for intense storms could affect aquatic species' reproductive cycles and habitat quality. Imperiled species confronted by other stressors could be particularly affected by climate change. -While quantified environmental surface flows exist throughout the region, extreme drought could negatively affect riparian habitats, species viability, and increase conflicts between human and environmental needs. -Drought and/or growing demand coupled with climate variation could dry up or fragment these biologically productive wetland habitats. -Increased nighttime and winter temperatures are expected to increase the population and distribution of bark beetle, canker diseases, dwarf mistletoe, and root diseases (Kliejunas 2011). It is likely that this will also have a negative effect on regional fire cycles by increasing the fuel load from dead trees. -The timing of water availability will threaten life cycles that have evolved with the natural timing of snowmelt recession (Yarnell et al. 2010). -Climate-induced changes in fire behavior and frequency will affect species distribution, migration, and extinction (Flannigan 2000). -Animals and plants dependent upon boreal forests will likely become more vulnerable because the warming trend will force them higher in elevation where habitat may be less suitable. -The region may offer refugia for wildlife if other suitable habitat is lost to sea-level rise.	-Maintain/enhance species and structural diversity and the redundancy of ecosystem types across a landscape Maintain/create refugia, for at-risk populations or unique sites. -Reduce existing stressors (e.g.: unhealthy levels of sedimentation or invasive species). -Sustain and promote fundamental ecological forest functions/services (e.g.: soil quality and nutrient cycling, hydrologic cycling, and riparian zones). -Identify and prioritize habitat corridors essential to wildlife migration. -Prioritize needs for aquatic habitat connectivity; provide in-steam barriers to invasive species, where appropriate; prioritize wetland, vernal pool, and riparian restoration; maintain healthy aquatic systems or create water developments to support key species; promote activities that increase stream shading and flow attenuation, such as meadow restoration; adopt best management practices that reduce channel alteration and sedimentation; and determine where infrastructure replacements can be most meaningful (e.g., culvert and bridge projects that increase connectivity, reduce barriers). Enhance genetic diversity, potentially including introduction or enhancement of genotypes better adapted to future conditions (such as trees with higher levels of oleoresin). -Work with major transportation providers throughout the region to ensure adequate ecosystem permeability and wildlife passage of major roadways – particularly four-lane roadways.	-Create a list of all climate-sensitive populations of flora and fauna in the CABY region and identify potential adaptation strategies that stakeholders could help to implement; assess those strategies for cost, risk, and benefit and prioritize based on the outcome. -Restore wet meadow and/or spring habitats to improve shallow groundwater storage, increase summer base flows, improve in-stream-habitat diversity, and create a vegetation community within the meadow dominated by species adapted to moist soil conditions. -Monitor spring melt dates, bud burst dates, and pollinator availability. -Monitor and quantify the rate of mercury methylation.

Potentially Affected Communities	**Flooding**	Increased flood potential is projected under many climate scenarios because higher temperatures cause earlier snowmelt and an increase in the ratio of precipitation arriving in the form of rainfall versus snow. However, higher-elevation snow levels may reduce the potential for winter floods because less snowpack may fall that can be mobilized. Peak daily flows are expected to increase even under scenarios with reduced precipitation overall.	-A lack of coordinated approach to flooding management and response may compound flood impacts and increase risk to public safety. -Need exists for a clearer definition of flooding risk to all areas within FEMA mapping zones. -Extreme flood events could have substantial negative effects on aging infrastructure, including water supply, transportation, hydropower, and water treatment facilities. -Increased risk of wildfires could result in mass wasting events (connected with flood events) similar to the massive landslide that closed Highway 50 for four weeks in 1997. -More reliable gauging and telemetry on streams is needed to provide advance notice to developed areas in flood-prone zones.	-Prepare and coordinate management response for extreme weather events at greater frequency. -Work within the CABY region membership as well as with relevant State agencies to identify better flood management practices, including data tracking and communication and updated land use policies (development patterns, attenuation, and infiltration). -Identify risk areas for mass slumping and target fuels management efforts. -Update flood maps for communities in the region as updated information becomes available. -Increase infiltration rates in urban areas to combat localized flooding and Improve or decommission roads to reduce flooding impacts.	-Improve the reliability and accessibility of gauging and telemetry on streams and rivers upstream from flood-prone areas during flood events. -Implement low- impact design principles to reduce flooding within proposed development.

Potentially Affected Communities	**Water Demand**	Projected population growth, especially in the foothills of the Sierra Nevada and along the major Sierra highways (Highways 50 and 80) exceeds average growth rates for the Bay Area and California as a whole, fueling demand for water and other natural resources. Vulnerabilities could be affected to a greater or lesser degree when correlated with overall population growth, and specific patterns of growth. Regional groundwater supplies represent a significant resource used by individuals outside water service areas for residential potable water use. Agricultural water demands are expected to increase overall with gradual warming, increased evapotranspiration, and decreased soil moisture.	-Major industries and institutions requiring heating and cooling could be affected as average temperatures increase, both economically and by potential losses of power. -As California's 20x2020 demand reduction targets are achieved, water use curtailment will be more difficult especially in areas that have already installed meters and implemented tiered commodity rate structures. -In-stream flow requirements could be affected, especially where FERC relicensing processes didn't account for the effects of climate change. -Naturally flowing streams (without in-stream flow reservations) may be even more vulnerable to drawdown during low flows. -Regional groundwater levels may decrease with warming and drying conditions. -Agricultural use could increase due to increasing temperatures and lower summer precipitation. -Groundwater is used for potable supply outside water service areas. Local fractured geology makes groundwater resources particularly vulnerable to drying/drought.	-Examine environmental needs in the face of a changed hydrologic regime. -Pursue sharing supplies across the CABY region. -Identify opportunities for conjunctive use. -Identify opportunities to sell water in or outside the CABY region in years where local supply exceeds local demand, for additional funds to be used within the CABY region. -Identify alternative crops that will grow well in a changed hydrologic cycle and temperature regime, consider use of drip irrigation, and recycled water. -Invest in upgrading infrastructure to maximize efficiency and flexibility and to reduce waste. -Locate water 'service stations' in areas where residential wells are likely to go dry.	-Peak use can be lowered by using pricing strategies – this has been successful for water purveyors throughout the CABY region using a conservative baseline for indoor use and ascending block rates for outdoor use. -Invest in distribution system interties and replacement of aged pipelines to maximize efficiency and reduce waste. -Water agencies provide efficiency services to domestic, municipal, and agricultural customers. -Resource Conservation District programs to upgrade efficiency of irrigation systems.

Potentially Affected Communities	**Water Supply**	Warming temperatures, earlier snowmelt, greater rain:snow ratio, relatively stable projected regional precipitation, and more intense storm events could affect surface water supply. Establishing an *annual* tie between groundwater elevations and climate in the region is difficult because of localized factors of drawdown, geology/recharge, and tapping into groundwater subbasins by others beyond the watershed. However, PG&E's and PCWA's long-term studies of streamflow fed by underground aquifers have indicated a correlation between long-term drought and decreased groundwater elevations.	-Reduced reliable water supply for people and wildlife through late summer and autumn, especially in areas of projected population growth. -Potential inability for water agencies to meet in-stream flow obligations. -Potential for reduced carryover storage capacity, especially during multi-year drought. Some smaller water agencies have limited or no carryover storage and must curtail demand even during mild drought periods. -The CABY region is a contributor to Delta flows with no reciprocal access to Delta supplies. The negotiated outcome of Delta sustainability and management may have an effect on the way water is managed and may reduce supply in the CABY region. -Area-of-Origin water rights are an important supply cornerstone for CABY stakeholders and will be important as the region looks at climate change effects throughout the state. -Reduced growing-season irrigation supplies for area agriculture.	-Recruit more complete information on snowpack and hydrology, including real-time data tracking. -Examine forest management strategies to increase snowpack/water retention -Increase the capacity of the landscape to retain water, replacing, in part, a decreased snowpack (e.g., meadow restoration and soil conservation). -Diversify storage opportunities to add system flexibility – think of 'storage' as a network including snowpack, forest soils and constructed infrastructure. -Continue to explore opportunities to enhance storage. -Conduct leak detection, pipeline repair/ replacement and meter calibration. -Many CABY water agencies are participating in the USBR Sacramento-San Joaquin River Basin studies to evaluate storage needs and sites in the region, based on climate. -Pursue additional water rights. -Explore and support opportunities for conjunctive use. -Invest in improved efficiency of water conveyance and distribution systems. -Increase levels of water conservation among customers and the general public. -Continue to monitor water systems for aquatic invasive species (AIS).	-Where not already implemented, provide fee incentives for customers who meet residential conservation objectives. - mplement groundwater management plan objectives. -Consider changes in reservoir operations. -Add capacity to existing dams. -Invest with partner interests in improved hydrologic and meteorological monitoring of CABY watersheds. -Educate small water-rights holders on potential effects of climate change and how the region might collaboratively respond.

Potentially Affected Communities	**Water Quality**	Reductions in flow, timing and intensity of runoff, and heating of air temperatures associated with climate change could affect water quality. Three main water quality concerns exist in the region: 1) increases in water temperature, 2) the potential for increased organics content in municipal water sources due to vegetation, and 3) how increased water temperatures might affect the rate of mercury methylation.	-Beneficial uses designated in the CABY region could be more difficult to meet. -Water quality shifts occur during extreme storm events can affect treatment facility operation, as in the case of Grass Valley. -Increased water temperature could affect aesthetics of municipal water supply. -Sediment can negatively affect treatment facilities. Low flows may hinder dilution of pollutants. -Increased water temperatures could increase levels of mercury methylation throughout the CABY region. This has been identified by the CABY PC as an issue for further investigation and potential modeling. -Stream temperature has shown to be moderately affected increased fire activity; this may particularly affect aquatic species because of their inability to monitor body temperature, and confined, easily fragmented habitat (Isaak 2010). -Eutrophication can increase in summer and especially if exacerbated by low flows and higher water temperature.	-Increase the capacity of the landscape to absorb and filter water. -Preserve and/or restore, where appropriate, riparian vegetation to control water temperature for aquatic biota. -Identify 303(d)-listed waters that may become more challenging to manage under future climate scenarios), and work with agencies to develop management strategies and projects/actions that address impacts. -Identify places where the assimilative (dilution of contaminants) capacity of streams and rivers may be at risk and monitor those areas.	-Implement a more intensive network of real-time water quality and water level tracking to identify when storm flows may be testing water treatment capacity and/or infrastructure. -Implement regional storm water control infrastructure.

Potentially Affected Communities	**Infrastructure**	Hydrologic changes are projected to include altered flows, changes in seasonal flows (e.g., earlier runoff) and greater extremes in storm events. A greater rain:snow ratio is projected, and melt dates will likely be earlier, indicating a longer dry season. Some extreme events in the past have tested the capacity of regional infrastructure (such as near overtopping events in the floods of 1997), and it is likely that these extreme events will occur more often. Much of the region's infrastructure is either antiquated, in poor repair, or in the case of water delivery and storage and flood flows, designed for historic flow regimes.	-Historic water Infrastructure design and management coupled with rules in place for reservoir and other infrastructure operations may not adequately respond to altered flows and intense flow events. -Planning for longer-term drought is limited to historic extreme events. Extended duration of extremes due to climate is difficult to account for, which could compromise delivery capacity, customer capacity, and financial stability of water purveyors. -Aquatic invasive species could become an issue as climate change alters the region's water temperature and chemistry (pH and TDS), and thus clog or damage facilities. -All reservoirs are in forested areas susceptible to fire, and therefore at risk of damage and increased sedimentation load in the event of intense post-fire precipitation. -Hydropower facilities could be challenged by increased sediment loads/decreased reservoir capacity and increased levels of wear on equipment.	-Locate system interties where small systems and disadvantaged communities can more easily hook into a larger system's supply. -Locate water 'service stations' in areas where residential wells are likely to go dry. -Expand treated and raw water infrastructure to underserved areas. -Add infrastructure to facilitate conjunctive use. -Invest in upgrading infrastructure to maximize efficiency and reduce waste.	-Upgrade aged infrastructure to improve efficiency. -Add infrastructure to augment distribution and conveyance system efficiency and flexibility. -Increase existing water storage facility size. -Research and implement strategies to manage increased sedimentation rates in reservoirs. -Implement regional stormwater control infrastructure. -Invest in distribution system interties and replacement of aged pipelines to maximize efficiency and reduce waste.
Potentially Affected Economic Interests	**Hydropower Generation**	Hydropower represents a significant source of electricity in the CABY region. Continued change from snowfall to rainfall is anticipated to begin having a cumulative effect on hydroelectric production by about 2020 to 2025. Energy needs have decreased on a per capita basis over the last several decades due to increases in the efficiencies of appliances and conservation. However, an increasing population indicates that energy use will grow in the future.	-With less predictable runoff periods and potentially more intensive storm events, hydroelectric generation may become less reliable, and management will be more challenging and may involve competing with other storage needs, such as flood control and natural system needs. -The results of a warming scenario WEAP modeling suggested a low degree of warming is sufficient to significantly alter historical inflows into regional reservoirs, with a concomitant reduction in hydropower generation – between 5% and 20% losses, depending on the degree of warming – by the end of this century (Mehta et al. 2011).	-Identify opportunities for development of solar and wind energy projects to ensure multiple benefits to the region, and also benefit habitat, wildlife, and agricultural uses (grazing opportunities). -Increase the diversity of hydropower projects (e.g., micro-hydro, small hydro, or pumped storage), particularly those with little or no negative in-stream impacts. -Hydro generation managers may increase storage in the winter in anticipation of critical summer needs and subsequently with the need to spill in order to accommodate wet winter or intensive storm flows.	-Explore and fund small hydropower generation opportunities in existing water and wastewater conveyance systems. -Investing in continued efficiencies in hydropower generation by upgrading equipment and operations.

Potentially Affected Economic Interests	**Wood Products Industry**	Potential climatic changes are expected to shift forest types and species mixtures within the watershed.	-The changing conditions may continue to render forests susceptible to insect invasion and fire, which may in turn create a greater need for thinning.		**-**Continue to explore environmentally acceptable and economically feasible ways of producing and using power from biomass.

Potentially Affected Economic Interests	**Local Communities**	The amount of burned property (in total area and in monetary value) in Northern CA increases substantially under global climate models' high-emissions scenarios due to greater fire risk. This is highly evident in Placer County (Westerling 2008). Sea level rise is not a direct issue for the CABY region, but does pose potential indirect effects on communities.	-Costs for increases in fire occurrence and severity will need to be paid for, either through landscape-level forest/fuels management, or through fire-fighting activities. -Secondary effects of increased fire, such as loss of recreational amenities, area closures, and excessive smoke, can have serious financial effects on local economies. -Incorporated communities have sufficient infrastructure and capacity to fight fires, while rural communities typically have very limited resources. Catastrophic wildfires have the potential to surround, encroach into, or overwhelm all local communities. -Population influx from coastal areas affected by sea level rise could impact regional land use patterns and water demand and supply. -The impact of sea level rise on the Delta is forcing the state to look upstream, for solutions to water-producing regions, including CABY. This could lead to potential changes to infrastructure, operations, and water rights in the CABY region because of the Delta's vulnerability to environmental change and water transfer capability.	-Enact strategic forest management: It increases resiliency to longer fire seasons and bark beetle outbreaks (Flannigan 2000). -Implement fuels management/reduction in watersheds where a high vulnerability exists to critical water sources. Where possible, mix selective harvest and prescribed fire to best mimic natural forest management (Schwilk 2009). -Maintaining a forest at full ecological function recharges groundwater and provides for more resiliencies regionwide. -Use integrated pest management on terrestrial noxious weed species, grazing treatments; revegetation; and monitoring to improve water quality and habitat. -Monitor changes in development patterns and water use from areas affected by sea level rise to prepare for potential impacts to the region over time. -Actively participate in regional discussions focused on modifications of source-water systems that may be proposed to protect the Delta from the impacts of sea-level rise.	

Potentially Affected Economic Interests	**Agriculture**	More frequent drought, the drying effects at upper elevations from earlier snowmelt, potential variation in storm events, greater variability in temperatures, and more intense storm events could potentially affect agriculture.	-Peaches, grapes, cherries, mandarin oranges, and berries are heat-sensitive crops that can also be susceptible to unseasonable precipitation. -Non-irrigated agriculture – grazing and dryland hay – may be the most vulnerable to projected climate changes. More frost-free and growing-degree days could benefit some crop production and local agricultural profits, and could affect the current crop mix. -Reduced flows and groundwater recharge alongside increased demand in a warming climate could negatively affect agricultural water supply (Mehta et al. 2011; Regional Water Management Agency 2013). -Irrigation inefficiencies reduce overall water supply, both for agriculture and other beneficial uses.	-Protect the agricultural land base and designate a portion of the water supply to agriculture to provide farmers with the assurance they need. -Work with University of California Extension, local agricultural commissions, and farm bureaus to identify potential changes in crop patterns to adapt to potential changes in climate. -Increase efficiency of irrigation practices and systems. -Explore opportunities for conjunctive use of water supplies.	-Water agencies provide efficiency services to domestic, municipal, and agricultural customers. -Identify alternative crops that will grow well in a changed hydrologic cycle and temperature regime, consider use of drip irrigation and recycled water. -Resource Conservation District programs to upgrade efficiency of irrigation systems.
Potentially Affected Economic Interests	**Recreation**	Climate projections of potential greater storm intensity and variability may impact recreational infrastructure and fish and game species.	-Most rafting flows have been set by FERC licenses, but projected low flows may not be sufficient to sustain current-day recreational pursuits/timing. -Insufficient flows for boating and whitewater rafting due to climatic shifts could have negative financial effects on regional businesses and local economies. -Forest infrastructure such as bridges, culverts, campgrounds, and roads may be damaged by increased variation in flows, while recreational game fish species may be negatively affected by diminished water quality. -Forage for big game species may be affected by increased invasive species, but these species may benefit from milder winter temperatures and increased localized forage.	-Identify opportunities to adjust to changing hydrology, if necessary, to maintain recreational opportunities. -Identify and develop recreation enhancement plans responsive to changing conditions. -Assess public agency road inventories for hot spots of sediment delivery and correct; conduct bridge and culvert inventory to replace undersized or failing infrastructure; reassess flood risk and establish recreational facilities out of potentially elevated peak flows.	-Augment water storage infrastructure to provide recreational values while meeting other beneficial uses. -Use improved modeling, forecasting and communication tools to facilitate recreational use of water resources.