APPENDIX H

Climate TAC Identification of Vulnerabilities and Adaptive Strategies

Vulnerabilities

Water Demand

- Major industries in the region requiring heating and cooling could be affected as average temperatures increase. This includes some commercial and institutional operations – hospitals, major office facilities, and industrial areas (major employment centers).
- Water use curtailment measures (water use efficiency) are effective in the CABY region when funded adequately. EID has instigated drought rates, proven to be effective in funding additional conservation outreach and education. However, 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, as is the case in many areas of the CABY region.
- Instream flow requirements in the region could be affected by climate change. Instream flows have been negotiated through relicensing agreements and other regulatory processes for controlled streams, but FERC processes, that didn't take climate change into account, may not be sufficient to protect streams, or ensure adequate flow for humans or wildlife. Naturally flowing streams may be even more vulnerable drawdown during low flows.
- Seasonal water use (primarily recreational and agricultural use) could increase due to increasing temperatures and lower summer precipitation. (Agricultural water use is not more than 50% of any one service area in the CABY region.)
- While all crops are "climate sensitive," peaches, grapes, cherries, mandarin oranges, and berries are heat-sensitive crops grown in the region that can also be susceptible to unseasonable precipitation. Greater climate variation may negatively affect production of these crops, in particular. Climate change may also make some areas more suitable for crops not yet previously grown in the region.
- Regional groundwater supplies are not a source of purveyor supply in the region, but represent a significant resource used by individuals outside water service areas for residential potable water use.
- Long, non-intensive rainfall patterns are more effective at resupplying groundwater than short, intense rainfall events. These patterns may be affected by climate change, as well.
- Local fractured geology makes groundwater resources particularly vulnerable to drying/drought.

Water Supply

- Climate change projections indicate that there will be less snowmelt to recharge streams and maintain a reliable water supply for people and wildlife through late summer and autumn, and the timing of water availability may threaten life cycles that have evolved in concert with the natural timing of snowmelt recession (Yarnell et al. 2010).
- In 2008, EID completed a Drought Preparedness Plan. During that process, EID modeled four potential future climate scenarios and an assessment of future supply reliability and projected shortages. When exposed to the range of plausible climate scenarios, there were occurrences projected when EID failed to either supply the amount of water that its customers expect under

the fluctuating drought stage, or to meet the instream flow obligations it has agreed to in recent regulatory proceedings, depending on which use is given priority.

- A multi-year drought, especially one lasting more than two years, could create problems in carryover storage capacity. Agencies have drought plans and drought rates in place to stretch supply, and generally manage a two-year supply to accommodate short drought periods. However, some smaller agencies have limited or no carryover storage and must curtail demand even during mild drought periods. The intense drought of 1976-77 created supply shortages for all major CABY region water purveyors.
- While the CABY region is a contributor to Delta flows, it does not have access to Delta or Colorado River imports for its regional supply, although there are inter-basin transfers in the region, including one from the Tahoe Basin into EID's system. Source water areas may have adequate water for in-region use, export may be questionable. Conditions in some parts of the CABY region may be such that even in-region quantities are threatened.
- 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.

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.
- As is the case throughout California, infrastructure used to manage and move water throughout the CABY region is sized and managed based on historic hydrology. The management strategies and rules in place for reservoir and other infrastructure operations are in direct relationship to this hydrologic history.
- 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.
- Projected changes expose vulnerabilities in water agencies specific to delivery capacity, the number of customers an agency can serve, financial stability and planning, and even recreational potential for current and planned facilities. It will also affect how hydroelectric power is produced, a service provided by the three major water purveyors in the CABY region (EID, PCWA, and NID).
- Aquatic invasive species are not currently a problem in CABY's water supply infrastructure, however, it is possible that they could become an issue as climate change alters the region's water temperature and chemistry (pH and TDS).

Water Quality

- Beneficial uses designated in the CABY region could be more difficult to meet with climate change altering regional hydrology. (CABY's 303(d) listed water bodies can be found in **Chapter 5 Region Description**).
- All reservoirs are in forested areas that are susceptible to fire. Catastrophic fire around reservoirs coupled with precipitation events could cause increased sedimentation. Secondarily,

hydropower facilities could face challenges with increased sediment loads through decreased capacity in reservoirs and increased levels of wear on equipment. Increased water temperature could affect aesthetics of municipal supply.

- Water quality shifts occur in the CABY Region during extreme storm events, and these can sometimes affect treatment facility operation. Some treatment facilities are built to manage turbid storm waters, but not every facility is built in this way. By way of example, the City of Grass Valley's system is not designed to handle stormwater, but it is so old that millions of gallons of stormwater infiltrate the water treatment system with big storms, which has resulted in the City releasing partially treated sewage into Wolf Creek annually.
- Both sediment and increased acid mine pollutant release can be challenging pollutants for treatment facilities.
- Low flows' effect on diluting pollutants (assimilative capacity) is difficult to measure. There is a high level of streamflow augmentation and variation throughout the CABY region and many flow regimes mandated in the CABY Region are water-year-dependent**.**
- Increased water temperatures could increase levels of mercury methylation throughout the CABY region. This effect has not yet been studied but has been identified by the CABY PC as an issue for further investigation and potential modeling.
- Eutrophication can increase in summer and especially if exacerbated by low flows and higher water temperature.

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 vs 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 exists throughout the CABY region and beyond.
- CABY is in need of a clearer definition of the flooding risk to all areas within 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. Many communities were developed during the Gold Rush, and so are situated close to rivers and in canyons.
- Extreme events could have a massive negative effect on the aging infrastructure throughout the region, including water supply, transportation, hydropower, recreation, and water treatment facilities.
- Catastrophic wildfires could result in devastating mass wasting events (connected with flood events) similar to the massive landslide that closed Highway 50 for 4 weeks in 1997. This landslide was a result of a fire event in the previous fire season combined with a historically high and intense rainfall event that winter. Similar events have occurred on the Middle Fork and North Fork of the Yuba River.
- More reliable gauging and telemetry on streams is needed to provide a few hours advance notice to developed areas in flood-prone zones.

Ecosystems and Habitats

- The Sierra Nevada is identified in its entirety as important refugia and vulnerable to climate change by the Endangered Species Coalition. This means that the region is particularly vulnerable to climate change, and represents a significant bio-region for plant and animal species survival. Timing of melt and water availability is just as important for habitats and species as it is for water supply for humans. This can have an effect on the blossom timing and may conflict with pollinator availability.
- Sedimentation vulnerability could increase with the higher potential for shorter, more intense storms. This could affect frog and fish reproductive cycles and habitat availability.
- Imperiled species, some of which only exist locally, could be affected by climate change. .
- Climate-sensitive populations of flora and fauna in the CABY 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.
- Quantified environmental flows are ubiquitous throughout the CABY Region. While these are mandated flow levels, extreme drought could still negatively affect stream habitats. In most cases, drought flows are defined in the mandate or license, but an extreme long-term drought could persist in lowering those flows past the defined levels. Increasing conflicts between human and environmental needs during drought and low-flow conditions brought on by climate change could further degrade wetland and riparian habitat, and in turn, species viability.
- Riparian and wetland communities, seeps and springs are often dependent upon groundwater resources. The geology of the area influences the groundwater level; habitats no longer having access to groundwater could diminish or disappear.
- Increasing temperatures overall, and especially higher temperatures at night and in winter, are expected to increase the population and distribution of bark beetle, increased occurrences of *phytophthora ramorum*, canker diseases, dwarf mistletoe, and root diseases (Kliejunas, 2011). It is likely that this will have a negative effect on the fire cycles within the forests of the CABY Region.
- Habitat is fragmented throughout the CABY Region: in the lower elevations by transportation corridors and urban development, and in the higher elevations primarily by highways 80 and 50.

Recreation

- The region depends upon defined aquatic conditions for some recreational activities, including whitewater rafting and boating on reservoirs. 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.

Hydropower

- PG&E has conducted an extensive study on changes in timing and type of precipitation to better predict the effect that these climate variations would have on hydroelectric generation. Freeman discusses current planning by PG&E to incorporate adaptive water management

strategies with the assumption that climate impacts on snowpack and early melt will "…*likely accelerate change in annual snowpack* [into the future]."[1]

- Reduced snowmelt from other sub-basins that cumulatively feed its northern and central California generation system cause PG&E[2] to anticipate that, "…*if climate change impacts on the diminishing snowpack continue, associated impacts of climate change to hydroelectric operations are likely to eventually occur and must be planned for in terms of developing additional adaptation alternatives.*"
- 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.
- Hydropower represents a significant source of electricity in the CABY region. As seasonal river flows shift, hydropower generation patterns may be affected. In addition, larger flows from more variable events and/or increased sedimentation could damage infrastructure, limiting availability for power production.

Socioeconomics

- 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.
- CABY Region agriculture is primarily conducted on a smaller scale when compared with larger San Joaquin Valley or Monterey County farms. This niche market contributes a substantial portion to regional economies, but also provides for a valuable agro-tourism economy. The *California Adaptation Strategy* doesn't recognize agricultural commodities coming out of the CABY Region (such as wine grapes and apples in El Dorado County and mandarins in Placer County), but does comment in general terms on the temperature and precipitation changes that will most likely have an effect on agricultural outputs of all kinds throughout the CABY Region.
- 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.

[1] Freeman, G. J. 2010. Tracking the impact of climate change on central and northern California's spring snowmelt subbasin runoff. Western Snow Conference 78:107:118. Available from: http://www.sierrainstitute.us/ALMANOR/Freeman_Climate_Change_and_Snowmelt.pdf

[2] 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.Climate Change and CA's Diminishing Low-Elevatio.pdf

- Insufficient flows for boating and whitewater rafting due to climatic shifts could have serious financial effects for regional business interests and local economies**.**
- 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, encroached into, or overwhelm all local communities.

Sea Level Rise

- Sea level rise is not a direct issue for the CABY region, but the indirect effect of a population influx from coastal areas affected by sea level rise (environmental refugees) could have an effect on regional land use patterns and requirements for potable water. Additionally, there is potential for the region to become a refuge for wildlife if other suitable habitat is lost to sea-level rise.
- 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 demands on water rights in the CABY region because of the Delta's vulnerability to environmental change and water transfer capability.

General Adaptation Strategies

Water Demand

- Examine environmental needs in the face of a changed hydrologic regime
- Pursue sharing supplies across the CABY region
- Identify opportunities for conjunctive use
- Invest in upgrading infrastructure to maximize efficiency and reduce waste
- 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.
- 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 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.
- Locate water "service stations" in areas where residential wells are likely to go dry

Water Supply

- Recruit and support 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.
- Invest in improved efficiency of existing water conveyance, distribution and storage systems
- Increase levels of water conservation among customers and the general public
- Continue to monitor water systems for aquatic invasive species (AIS)
- Educate small water-rights holders on potential effects of climate change and how the region might collaboratively respond
- 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.
- Continue to evaluate options for enhanced water storage
- Explore and support opportunities for conjunctive use.
- - Where not already implemented, provide fee incentives for customers who meet residential conservation objectives
- - Implement 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.

Infrastructure

- 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.
- Invest in upgrading infrastructure to maximize efficiency and reduce waste
- Invest in distribution system interties and replacement of aged pipelines to maximize efficiency and reduce waste
- Research and implement strategies to manage increased sedimentation rates in reservoirs
- Implement regional stormwater control infrastructure
- Expand treated and raw water infrastructure to underserved areas.
- Add infrastructure to facilitate conjunctive use
- 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.

Water Quality

- Increase the capacity of the landscape to absorb and filter water
- Implement a more intensive network of real-time water quality and water level tracking in order to identify when storm flows may be testing water treatment capacity and/or infrastructure

- Preserve and/or restore, where appropriate, riparian vegetation in order 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 affected agencies to develop management strategies and identify improvement projects/actions that address near-term and future impacts.
- Identify places where the assimilative (dilution of contaminants) capacity of streams and rivers may be at risk and monitor those areas
- Implement regional storm water control infrastructure

Socioeconomics

- Climate change will need to be adapted to on an individual agricultural operator basis. On a policy level, protecting the agricultural land base and preserving a portion of the water supply to be dedicated to agriculture, no matter what the urban needs in the region, is important to provide farmers with the assurance that 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
- 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.
- 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 region-wide.
- Use integrated pest management on terrestrial noxious weed species, grazing treatments; revegetation; and monitoring to improve water quality and habitat
- Continue to explore environmentally acceptable and economically feasible ways of producing and using power from biomass.
- Participate in statewide pest detection programs. While the dispersed growing area does not provide an easy way for invasive and destructive pests to migrate, it is close to the State border and hosts two major national freeways going east-west across the Sierra Nevada.

Sea Level Rise

- Actively participate in regional discussions focused on modifications of source-water systems that may be proposed to protect the Delta from the impacts of t sea-level rise.
- Monitor changes in development patterns and water use from areas affected by sea level rise to prepare for potential impacts to the CABY region over time.

Flooding

- Prepare and coordinate for events that happen (traditionally every 5-20 years) in order to be ready to manage and respond to these events at greater frequency

- Improve the reliability and accessibility of gauging and telemetry on streams and rivers upstream from flood-prone areas during flood events.
- Work within the CABY region membership (water and land use agencies) 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
- Continue to update flood maps for communities in the region as additional management strategies are implemented and more updated information becomes available
- Work with agencies to identify infrastructure at risk from extreme events, gauge the storm event which would cause catastrophe, and identify probabilities associated with those events; prioritize repairs and armoring based on this information
- Increase infiltration rates in urban areas to combat localized flooding (implement low impact design principles)
- Improve or decommission roads to reduce flooding impacts during large storms

Ecosystem and Habitat Vulnerability

- Reduce the impact of existing stressors (e.g.: unhealthy levels of sedimentation or invasive species)
- Maintain/improve resiliency of the forest
- Sustain and promote fundamental ecological functions/services (e.g.: soil quality and nutrient cycling, hydrologic cycling, and riparian zones)
- Maintain/enhance species and structural diversity and the redundancy of ecosystem types across a landscape
- 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
- Maintain/create refugia, for at-risk populations or unique sites
- Enhance genetic diversity, potentially including an introduction or enhancement of genotypes better adapted to future conditions (such as trees with higher levels of oleoresin)
- Monitor the spring melt dates, bud burst dates, and pollinator availability
- Identify and prioritize habitat corridors essential to wildlife migration
- Work with major transportation providers throughout the region to ensure adequate ecosystem permeability and wildlife passage of major roadways – particularly 4-lane roadways
- Monitor and quantify the rate of mercury methylation
- Plant trees for carbon storage

Recreation

- 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

Hydropower and Alternative Energy Development

- Identify the opportunities for the 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 which have little or no negative instream consequences
- Invest in continued efficiencies in hydropower generation by upgrading equipment and operations.
- Explore and fund small hydropower generation opportunities in existing water and wastewater conveyance systems.
- Hydrogeneration managers may increase storage in the winter in anticipation of critical summer needs and to add flexibility to operational capability.

General

- Integrate terrestrial and aquatic objectives, habitat and urban-area objectives, and management agencies from all parts of the CABY region to better develop (and then address) quantifiable objectives and opportunities for synergistic solutions (Reiman, 2010)
- Diversify and examine/analyze finance options for funding effective watershed management
- Recognize that water management is only part of a comprehensive response to climate change and implement Integrated Resource Management by communicating regularly with land use, transportation, human health, education, environmental, and economic-focused agencies
- Increase the CABY region's ability to act as a carbon sink by implementing more active forest management with the goal of sequestration

Additional Models and Climate Guidance

WEAP Modeling and Status

WEAP has been used as a water management modeling system. However, some stakeholders use different models. In the CABY Region some initial reticence to WEAP arose because it was felt that the model did not robustly model the stream flow with impoundments in the system. As with all models, working with the model is necessary to make the adjustments necessary to get closer to accuracy. In addition to model tweaks, there is some reluctance on the part of agencies using alternative modeling (primarily water agencies) to address another modeling project. Through conversation within the TAC and the PC, these stakeholders agree that a region-wide model would be helpful in assessing general regional effects of climate change and looking at adaptation strategies as a region. However, continued work with the WEAP model will necessitate a robust discussion within the CABY membership regarding the costs, benefits, and potential options as far as modeling opportunities go.

The Bureau of Reclamation

The Bureau of Reclamation has completed substantial work on the topic of climate change and water management. Their 2009 document, "Addressing Climate Change in Long-Term Planning and Management" (published by the US Army Corps of Engineers (USACE), describes contemporary (2009) perspectives of Reclamation and USACE on their technical capabilities for incorporating climate change information into longer-term water resources planning. It also outlines and discusses planning capability gaps as they relate to the planning frameworks, and how those gaps might be bridged. This work includes consideration of infrastructure safety and flood risk reduction, demand estimates based on climate projections (including temperature and overall changes in precipitation), and operational constraints (such as infrastructure capacity). Much of this work does not affect the CABY Region directly, but the way in which the Bureau moves in developing its response (adaptation) to climate change will likely have an effect on the water management and policies affecting the region.

Affecting or having a potentially relevant outcome to the CABY Region include:

- During 2011, a study on the Sacramento-San Joaquin Basins was initiated that will address climate change concerns in this major river basin (more information on the basin studies can be found here: http://www.usbr.gov/climate/SECURE/factsheets/sacramento-sanjoaquin.html).
- The Bureau awarded several WaterSMART Program climate tool matching grants that will benefit climate change assessment and adaptation strategy planning capabilities. These include grants to the Desert Research Institute to develop tools to better simulate the effects of global climate changes in the Sierra Nevada region, as well as improvements in methods of quantifying agricultural water needs (more information on this research project can be found here: http://www.usbr.gov/WaterSMART/bsp/).
- Climate Risk Assessments completed throughout the western United States will establish a foundation for more in-depth analyses and the development of adaptation options through basin studies, operations planning, and other activities (more information may be found on these assessments here: http://www.usbr.gov/WaterSMART/wcra/index.html).

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). This model includes a groundwater flow component, multi-layer soil profiles, a daily time step, and is developed for basins of several thousand square miles. It was created and is run out of Texas A&M University.[1] The model has been used internationally for agricultural (both for crop water needs and for BMP implementation assessment), watershed management, and water quality management plan assessment, and applications within the US have focused on the impacts of land use change and management and climate change on water supply and water quality.

Water Utility Climate Alliance (WUCA): Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change (2009)[1]

This white paper was produced by WUCA in 2009 and reviews modeling options, weaknesses, considerations, and possible future paths for water agencies in their consideration of climate change – essentially a paper describing investment options. There is an in-depth identification of options for improving modeling with the objective of having more useful and reliable output. The paper points out that even with improvements in downscaling and GCM assumptions, however, it's likely that uncertainty will persist, emphasizing a future where agencies must increasingly adapt to changing conditions.

World Bank: Water and Climate Change: Understanding the Risks and making Climate-Smart Investments (2009)

This document reviews climate change effects specifically on water resources. It identifies evidence that climate change is already occurring and discusses uncertainties in projected change and what water managers and investors can do in response to these findings. The next steps identified for this financial institution, which could easily be applied to CABY Region member entities, include: 1) continue to strengthen the analytical foundation, 2) incorporate hydrologic variability and climate resiliency considerations into decision-making, and 3) strengthen organizational expertise regarding climate change effects on hydrology. The second step indicates a potential change in policy for entities wanting to ensure that climate resiliency is always a consideration in project implementation. All components of these recommendations indicate that record-keeping and project monitoring are an essential step in understanding what the future holds, what resiliency and adaptive management means, and ensuring successful adaptation to a changing climate.

CNRA: California Adaptation Strategy and Adaptation Planning Guide

In 2009 the CNRA put out the California Adaptation Strategy (CAS) to to provide a multi-sector mitigation and adaptation strategies. The document provides several recommendations for the state as a whole; one of them identifies a necessity for change in how the state as a whole manages its water. CABY stakeholders acknowledge that this must include the way that individual purveyors, and even individual citizens, manage their own water resources, including actions such as addressing rule curves for dams to manage changing hydrologic patterns, increasing demand- and supply-based conservation, and assessing small communities throughout the region for vulnerability to flooding. Another key finding relevant to the CABY Region is avoiding development in areas that are difficult to protect from projected effects of climate change, including those areas affected greatly by catastrophic wildfire. The CAS also identified the need to track vulnerable land and aquatic habitats and communities, something CABY stakeholders have had as a priority since 2007. Many of the strategies discussed in the CAS are incorporated into the adaptation strategies. While the Planning Guide document remains in draft form at this time, it is anticipated to provide considerable assistance to CABY members in the discussion, development, and implementation of adaptation policies.

Intergovernmental Panel on Climate Change (IPCC): Assessment Report 4 (2007)[1]

The IPCC puts out a periodic assessment of the current state of climate change knowledge and modeling advances. The most recent report, AR4, was released in 2007 (AR5 is projected to be released in 2013-2014). The document reviews the advances in modeling of atmospheric, ocean, terrestrial, and other processes, as well as an evaluation of large-scale climate variability and extreme events. The document discusses the use of models of varying complexity and their application in a variety of conditions. It suggests that lower complexity models are more appropriate on a global or continental basis (due to cost and time), even though atmospheric and oceanic GCMs (AOGCMs) currently represent the most comprehensive climate modeling. Not discussed is regional downscaling or the practicality of using these larger-scale models for smaller segments of a larger region. Chapter 8 of the document does discuss modeling extreme events, which are usually on a smaller scale and/or of shorter duration. The current GCMs are more effective at modeling temperature than precipitation – both in general and in extreme circumstances. These models will be useful for CABY to track for purposes of identifying regional trends and how the region fits into State projections as a whole.