VII. WATER MANAGEMENT

Introduction

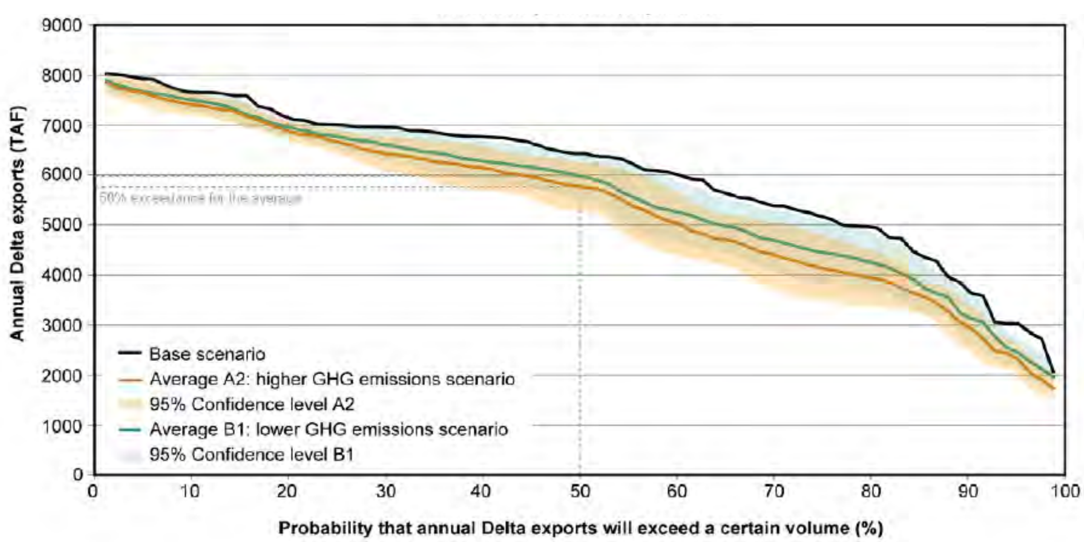
Water is the lifeblood of California's natural and human systems. For more than 200 years, California water and flood management systems have provided the foundation for the state's economic vitality, providing water supply, sanitation, electricity, recreation, and flood protection. However, the climate patterns that these systems were based upon are different now and may continue to change at an accelerated pace. These changes collectively result in significant uncertainty and peril to water supplies and quality, ecosystems, and flood protection.

Nearly 75 percent of California's available water supply originates in the northern third of the state (north of Sacramento), mainly from water stored in the Sierra Nevada snowpack. At the same time, 80 percent of the demand occurs in the southern two-thirds of the state.[1] California has been able to bridge the geographic distance between water supply and demand by building one of the most complex water storage and transport systems in the world to convey large quantities of water throughout the state.

However, drought conditions are likely to become more frequent and persistent over the 21st century due to climate change. Today, the effects of hydrologic droughts are increasingly being exacerbated by additional regulatory requirements to protect listed fish species, especially regarding water diversion from the Bay-Delta. For example, the hydrologic severity of California's present three-year drought is not remarkable in comparison to past three-year droughts, but drought impacts in the Delta export area are such that a statewide drought emergency has been proclaimed for the first time in California.

Population growth expected over the next few decades will lead to additional demand. Even without higher air temperatures and changing precipitation patterns over the next few decades, California's water supply problems would already be challenging. A portfolio of measures implemented at the local and regional level will be needed to meet these growing challenges.

Figure 13: *Using mid-century climate projections to support water resources decision making in California (Source: Chung, et al 2009)*



Future Climate Change Impacts to Water Management

The state's water supply system already faces challenges to provide water for California's growing population. Climate change is expected to exacerbate these challenges through increased temperatures and possible changes in precipitation patterns. The trends of the last century – especially increases in hydrologic variability – will likely intensify in this century. We can expect to experience more frequent and larger floods and deeper droughts. Rising sea level will threaten the Delta water conveyance system and increase salinity in near-coastal groundwater supplies. Planning for and adapting to these simultaneous changes, particularly their impacts on public safety and long-term water supply reliability, will be among the most significant challenges facing water and flood managers this century.

WATER MANAGEMENT IMPACTS DUE TO WARMING

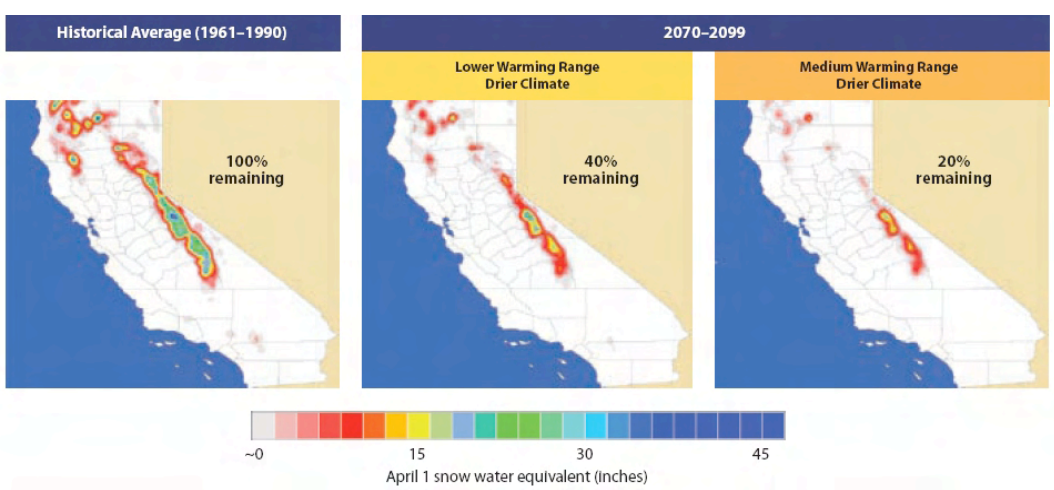
- Reduced Water Supply from the Sierra Snowpack
- Changes in Water Quality
- Increased Evapotranspiration Rates from Plants, Soils and Open Water Surfaces
- Moisture Deficits in Non-irrigated Agriculture, Landscaped Areas and Natural Systems
- Increased Irrigation Needs
- Increased Agricultural Water Demands Due to a Longer Growing Season.
- Increased Urban Water Use, at Possible Expense of Agriculture Water.

A. Increased Temperature and Extreme Events

Increasing average temperatures may have several impacts on water supply and demand, affecting California's farms, municipalities, and ecosystems.

First, increasing winter and early spring temperatures will cause earlier melting of the Sierra Nevada snowpack – the most important seasonal surface reservoir of water in California. Historically this snowpack has released about 15 million acre-feet slowly over the warming spring and summer months (one acre-foot provides the annual water needs of one to two families).[2] California's water storage and conveyance infrastructure gathers this melting snow in the spring and delivers it for use during the drier summer and fall months. This same infrastructure is also used for flood control in the winter and early spring by keeping lower reservoir levels. With earlier snowmelt and heavy winter/spring rains possibly coinciding, difficult tradeoffs may need to be made between water storage and flood protection.

Figure 14: *California historical and projected decrease in April snowpack, 1961-2099 (Source: Cayan et al 2006).*



Increased underground storage of surface waters and increased groundwater withdrawal may potentially be used to ensure that future water supplies meet growing demands. However, groundwater balances in California are generally not well documented, with many aquifers contaminated, necessitating further study to assess the more widespread feasibility of groundwater storage.

In addition, climate change may make preservation and restoration of habitat more difficult. The ecological requirements of cold-water fishes provide an example. Climate change may warm rivers and streams, with less water available for ecosystem flow and temperature needs in spring and summer. In many low- and middle-elevation streams today, summer temperatures often approach the upper tolerance limits for salmon and trout; higher air and water temperatures will exacerbate this problem. Thus, climate change might require dedication of more water, especially cold water stored behind reservoirs, to simply maintain existing fish habitat. Climate change is also expected to raise sea level. As this happens, the brackish and fresh aquatic habitats of the Sacramento-San Joaquin estuary that are critical to many at-risk species will shift upstream and inland. Growing urbanization on the eastern edge of the Delta will limit opportunities to acquire or restore lands that would provide suitable habitat. Threatened and endangered species could be increasingly squeezed between the inland sea and the encroaching cities. Higher water temperatures also can accelerate biological and chemical processes that increase growth of algae and microorganisms, thereby creating an additional demand for oxygen in the water.[3]

Higher temperatures – especially in the summer growing season – increase evapotranspiration rates from plants, soils and open water surfaces. In a study conducted for the 2008 California climate impacts assessment, net evaporation from reservoirs was projected to increase by 37 percent in a warmer-drier climate, but only by 15 percent in a warmer-only scenario, reducing available supplies accordingly.[4]

While higher temperatures increase the water demand and use by plants, soil moisture decreases and reservoirs and/or groundwater reserves are reduced. Non-irrigated agriculture and landscaped areas, as well as natural systems, will suffer moisture deficits if natural water supplies are limited, and the risk of wildfires will increase. Elsewhere, irrigation will need to be increased if crop losses are to be avoided.[5] During extreme heat events livestock will require more water for drinking and cooling.

Finally, higher average temperatures extending over longer periods of the year will lengthen the growing season, thereby increasing the amount of water needed for non-irrigated plant growth, environmental water needs, and for the irrigation of crops and landscaped areas.[6] A recent study on water demand in California estimated agricultural and urban water demands under both a warmer-only and a warmer-drier climate change scenario using the CALVIN (California Value Integrated Network) model – a statewide model of the economic and engineering aspects of California's interconnected water supply system. Using these scenarios, the study found that agricultural water use would decrease by nearly 15 percent (4,070 thousand acre feet [TAF]/year) between 2020 and 2050 as urban demand increases and overall supply decreases by 7 percent.[7] Even assuming the implementation of water conservation and water efficiency measures to partially compensate for the expected reduction in supply, urban water demand is expected to increase by more than 10 percent (1,606 TAF/year) between 2020 and 2050.[8] The study also concluded that the agricultural sector is more vulnerable to water shortages than the urban sector; thus, water supplies to agriculture may be 20 percent below demand targets under the warmer-only climate scenario and 23 percent below demand under the warmer-drier scenario.[9]

B. Precipitation Changes and Extreme Events

Climate change can potentially alter California's historical precipitation patterns. While the state is expected to retain its Mediterranean pattern of dry summers and wet winters, along with significant year-to-year variability in total precipitation, some projections of the future involve worrisome changes for the state's water supplies. Global climate models vary considerably in projecting precipitation patterns into the future. For planning purposes, eleven of the twelve simulations selected for the 2008 California Climate Change Impacts Assessment deliberately project a future marginally to considerably drier by mid-century, while only one simulation projects a slightly wetter future. In addition to the warming trend and the snowline moving higher, scientists expect that a growing proportion of winter precipitation to fall as rain instead of as snow, significantly reducing snow accumulation on April 1 (an important date in the hydrological calendar).[10]

The expected reduction in the Sierra snowpack is particularly troublesome for California water supplies, as it essentially functions as California's largest surface water reservoir. The state's agriculture, industrial and municipal users, and a wide variety of ecosystem functions, depend heavily on the stored water being released in the early dry months of the year.

Existing storage and conveyance facilities have been built and operated based on historical patterns of rain and snowfall. Over the last century, the average early spring snowpack runoff has decreased by about 10 percent, a loss of 1.5 million acre-feet of water. Using historical data in conjunction with climate and hydrologic models, the Department of Water Resources projects that the Sierra Nevada snowpack may be further reduced from its mid-20th century average by 25 to 40 percent by 2050.[11]

Water supplies originating from outside of the state are also important. Rising temperatures and drier conditions have led to projections of decreasing volumes of water in another one of California's water sources, the Colorado River basin. Studies underway by the Western Water Assessment of the University of Colorado are seeking to reconcile the wide range of estimates in possible decreases – from -6 percent to -50 percent - in Colorado River flow by mid-century or later.[12] In late 2007, the Secretary of the Interior signed an historic Record of Decision for *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* that allows for more efficient operation of the reservoir system to reduce the potential frequency and magnitude of shortages. Through 2025, the period covered in the interim guidelines, the estimated risk of shortage to California is very small, thanks to the large volume of storage in the river basin, the high elevation of the runoff generating region of the upper basin, and the relative seniority of California water rights. Estimating the risk of shortages beyond that date is complicated by the uncertainties of future reservoir operations strategies and the disparate projections of runoff impacts.[13]

Water Management Impacts Due to Sea-Level Rise

Increased Stress on Sacramento-San Joaquin Delta Levees

Saltwater Intrusion into Estuaries, Bays, and Coastal Groundwater:

- Change Water Quality
- Transform Ecosystems
- Reduce Freshwater Supplies

Water Management Impacts Due to Precipitation Changes

- Possible Precipitation Decreases - From 12-35 Percent Compared to Historical Annual Averages
- More Winter Precipitation Falling as Rain Instead of Snow
- Intense Rainfall Events - More Frequent and/or More Extensive Flooding
- Droughts - More Frequent and Persistent
- Possible Decreasing Water Quality:
  - Longer Low-flow Conditions
  - Higher Water Temperatures
  - Higher Contaminant Concentrations

Figure 15: *View of Lake Oroville in 2005 (left) and November 2008 (right)*

Finally, California's hydroelectricity production relies on predictable water reserves. In 2007, nearly 12 percent of California's electricity was produced from large hydroelectric power plants, presently the state's largest source of renewable energy.[14] With snow falling at higher elevations, creating less snowpack, and melting earlier in the year less water is available for this source of power generation when it is most needed, during the warmer summer months. When several dry years create drought conditions, reservoir levels can be reduced to levels lower than those required for hydroelectric power generation.[15]

Extreme Rainfall and Flooding

California's current water systems are designed and operated to strike a balance between water storage for the dry months and flood protection during the winter and spring, when heavy rainstorms, runoff, and snowmelt can cause downstream flooding. While some climate models predict an overall drying of California's climate, at the same time there are also continued risks from intense rainfall events that can generate more frequent and/or more extensive runoff and flooding.[16] Additionally, periodic larger than historical floods are expected to occur, especially in the southern parts of the Sierra Nevada, where a transition from snow to more rainfall will occur.[17]

Flood peaks can increase erosion rates that results in greater sediment loads and turbidity while runoff from streets and farms can increase concentrations of pollutants.[18] Changes in temperature and precipitation could alter existing fresh water systems and an overall reduced availability of water for fish and wildlife. An increase in floods may amplify movement of pollutants and contaminants into previously pristine areas. Temperature and precipitation changes will affect a variety of aquatic species and may result in loss and degradation of sensitive aquatic ecosystems and potentially increase invasive species challenges. In addition, these changes will affect groundwater recharge and over drafting as well as hydropower and hatchery project operations, fish passage issues, and water diversion projects. Changes in composition and structure from precipitation and flow changes for riparian communities and conflicts over allocation of surface water could result in increased management conflicts between people and wildlife and will require communication and collaboration among managers.

C. Sea-Level Rise

The higher mean water levels from sea-level rise can exacerbate existing factors that threaten critical portions of the Sacramento and San Joaquin Delta levee system. This system extends over more than 700,000 acres and consists of a myriad of small natural and man-made channels bounded by levees to protect land and key infrastructure from floods.[19] If levees fail, water from San Francisco Bay would inundate agricultural land and some communities, damage infrastructure, affect ecosystems, enter California's freshwater supply, and change water quality.

Warmer storms and snowmelt may coincide and produce higher winter runoff from the watersheds, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, they increase the probability of Delta levee failures, breaking a critical link between water supply in the north and water users in the southern portions of the state.

Additionally, a drop in summer stream flows could affect the Sacramento-San Joaquin Delta water supply and ecosystems, both directly through low-flow conditions and higher stream water temperatures, and indirectly as saltwater intrudes further upstream from the Pacific Ocean. An increase in the penetration of seawater into the Delta will thus further degrade drinking and agricultural water quality and alter ecosystem conditions.[20] Holding back this salinity intrusion will require more freshwater releases from upstream reservoirs to maintain fresh water levels for municipal, industrial and agricultural uses, which in turn will further increase pressure on already scarce water resources.

D. Risks for Water Management

Higher temperatures, changes in precipitation patterns and sea-level rise all combine to exacerbate California's existing water supply challenges. Expected population growth alone would make it more difficult to meet growing water demands. With climate change the state's water crisis will worsen, overall increasing the risk of water shortages and flooding. To summarize the changing risks that California's water supply will face from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The resulting risk profile for California's water supply can be characterized as follows:

- Higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher, resulting in less snowpack to supply water to California users. In addition, a growing proportion of winter precipitation will fall as rain instead of as snow. Snow accumulation on April 1 will be significantly reduced, and snowmelt will run off earlier, leaving less water stored for the dry months.
- By mid-century, most climate simulations used by the 2009 CAT report project marginally to considerably drier conditions in California. Water supplies originating from outside of the state (e.g., the Colorado River Basin and the Klamath River Basin) are also decreasing.
- Intense rainfall events, periodically ones with larger than historical runoff, will continue to affect California with more frequent and/or more extensive flooding.
- Droughts are likely to become more frequent and persistent in the 21st century.
- Streams may experience longer low-flow conditions with higher temperatures and higher concentrations of contaminants.
- Higher temperatures – especially in the summer and over a longer growing season – increase evapotranspiration rates from plants, soils and open water surfaces, including water reservoirs.
- Non-irrigated agriculture and landscaped areas, as well as natural systems will suffer moisture deficits if natural water supplies are limited, and irrigation will need to be increased if crop losses are to be avoided. Even with conservation and efficiency measures, urban water use is expected to increase.

- Storms and snowmelt may coincide and produce higher winter runoff from the landward side, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, they increase the probability of levee failures in the Sacramento-San Joaquin Delta.
- Saltwater intrusion into estuaries, bays, and coastal groundwater resources will diminish water quality, transform ecosystems and reduce freshwater supplies.

Water Management Adaptation Strategies

Introduction

Concerns over the availability, quality, and distribution of water are not new to California, but these concerns are growing and solutions are becoming more complex as water managers navigate competing interests and regulations to reliably provide quality water to farms, businesses, and homes, while also protecting the environment and complying with legal and regulatory requirements. Water adaptation strategies are primarily driven by the possibility of reduced future water supplies and increased flood threat brought about by climate change. While we are unlikely to know the full scope of climate change for many decades, we do know enough now to begin taking action strategically to adapt California's water management systems.

The Department of Water Resources (DWR), in collaboration with the State Water Resources Control Board, other state agencies, and numerous stakeholders, has initiated a number of projects to begin climate change adaptation planning for the water sector. For instance, the recent incorporation of climate change impacts into the California Water Plan Update is an essential step in ensuring that all future decisions regarding water resources management address climate change. As part of the Update, in October 2009 DWR released the U.S.'s first state-level climate change adaptation strategy for water resources, and the first adaptation strategy for any sector in California. Entitled *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water,* the report details how climate change is already affecting the state's water supplies and sets forth ten adaptation strategies to help avoid or reduce climate change impacts to water resources. Because of the large role of local and regional water management, central to these adaptation efforts will be the full implementation of Integrated Regional Water Management (IRWM) plans, which address regionally appropriate management practices that incorporate climate change adaptation. These plans will evaluate and provide a comprehensive, economical and sustainable water use strategy at the watershed level for California.

North Coast Integrated Regional Water Management Plan (NCIRWMP):

Stakeholders on the North Coast are incorporating climate change into the NCIRWMP in many ways, including evaluating options for carbon sequestration, GHG emission reduction via large scale alternative energy generation and by reducing the risk of catastrophic wildfire, incorporating adaptation into local planning, water infrastructure and watershed restoration activities, and educating the public regarding the need for climate adaptation. In particular, there are substantial opportunities to incorporate climate adaptation into the NCIRWMP framework, many of which address multiple objectives of the IRWM program such as flood and stormwater management, water conservation, local planning, floodplain and habitat enhancement, and water supply reliability.

Another key adaptation approach is to aggressively increase water use efficiency. Implementing this approach will require the adoption of urban best management practices and other measures. Agricultural entities will be encouraged to apply Efficient Water Management Practices (EWMPs) to reduce water demand and improve the quality of drainage and return flows. In regions where recycled water may represent a relatively energy efficient and drought-proof water management strategy, local water agencies will be encouraged to adopt policies that promote the use of recycled water for appropriate, cost-effective uses while still protecting public health. However, not all water use efficiency activities are equally effective responses to climate change. For example, efficiencies that reduce evaporative (e.g., landscape and crop evapotranspiration), other consumptive uses, and flows to saline sinks (e.g., the ocean) are the most effective.

Statewide, adaptation strategies aim to fundamentally improve water and flood management systems and enhance and sustain ecosystems. Reliable water supplies and resilient flood protection depend upon ecosystem sustainability. Building adaptive capacity for both public safety and ecosystems requires that water and flood management projects maintain and enhance biological diversity and natural ecosystem processes. Water supply and flood management systems are significantly more sustainable and economical over time when they preserve, enhance and restore ecosystem functions, thereby creating integrated systems that suffer less damage from, and recover more quickly after, severe natural disruptions. By reducing existing, non-climate stressors on the environment, ecosystems will have more capacity to adapt to new stressors and uncertainties brought by climate change. Flood management will be improved by increased coordination among existing water and flood management systems. Ecosystem enhancement will include actions to restore previous connections between rivers and their historical floodplains, creating seasonal aquatic habitats and facilitating the growth of native riparian forests.

A strategy for improving management and decision-making capacity focuses on planning for and adapting to sea-level rise. This will require the establishment of an interim range of sea-level rise projections for short-term planning purposes for local, regional, and statewide projects and activities. A scientific panel of the National Research Council (NRC) will provide expert guidance regarding official long-range sea-level rise estimates and their application to specific California planning issues. The DWR, in collaboration with other state agencies and under guidance from the NRC, will develop long-range sea-level rise scenarios and response strategies for the *California Water Plan Update 2013.*

As climate change continues to unfold in the coming decades, institutions, along with infrastructure, may need to also adapt, which may require reconsidering existing agency missions, policies, regulations, and other responsibilities, as well as changes to existing resources legislation. The California Water Plan Update is one example of where such adaptation has already occurred.

Adaptation Strategies and Actions

Climate change is already affecting California's water resources as evidenced by changes in snowpack, river flows and sea levels. Impacts and vulnerability will vary by region, as will the resources available to respond to climate change, necessitating regional solutions to adaptation rather than an easily administered but comparably ineffective "one-size-fits-all" approaches. An array of adaptive water management strategies must be implemented to better address the risks and uncertainties of changing climate patterns. Fortunately, as one water stakeholder has observed, California has far more knowledge, expertise, and financial capacity to adapt its water management systems to climate change than our society had in the 1850's, when an east-coast American society abruptly found itself in a Mediterranean climate upon settlement in the West. The strategies listed below are from *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water* and the California Water Plan Update; they are cross-referenced with other sectors for contextual efficacy:[21]

Strategy 1: Provide Sustainable Funding for Statewide and Integrated Regional Water Management

Long-Term Actions:

a. **Financing Mechanisms –** A formal assessment of state and local financing mechanisms should be conducted by the state Legislature in order to provide a continuous and stable source of revenue to sustain proposed climate resiliency programs. Activities include regional water planning, inspection, maintenance, repair, and rehabilitation of flood management facilities, observational networks and water-related climate change adaptation research.

Strategy 2: Fully Develop the Potential of Integrated Regional Water Management

Near-Term Actions:

a. **Integrated Water Management Plans (IRWM) –** By 2011, all IRWM plans should identify strategies that can improve the coordination of local groundwater storage and banking with local surface storage along with other water supplies including recycled municipal water, surface runoff, flood flows, urban runoff, storm water, imported water, water transfers and desalinated groundwater and seawater.

b. **Adaptation Component –** By 2011, all IRWM plans should include specific elements for climate change adaptation.

Strategy 3: Aggressively Increase Water Use Efficiency

Near-Term Actions:

a. **Statewide Reduction in Water Use –** As directed by Governor Schwarzenegger and reinforced through legislation, Department of Water Resources (DWR) in collaboration with the Water Boards, the California Energy Commission, the California Public Utilities Commission, the California Department of Public Health (CDPH), and other agencies will implement strategies to achieve a statewide 20 percent reduction in per capita water use by 2020.

b. **Water Efficiency –** Agricultural entities should apply all feasible Efficient Water Management Practices (EWMPs) to reduce water demand and improve the quality of drainage and return flows, and report on implementation in their water management plans.

c. **Energy Efficiency –** Recycled water is a drought-proof water management strategy that may also be an energy efficient option in some regions.

d. **Water Conservation –** The State Water Resources Control Board (SWRCB) and the California Public Utilities Commission may impose water conservation measures in permitting and other proceedings to ensure water conservation efforts. It is recommended that the Legislature authorize and fund new incentive-based programs to promote the mainstream adoption of aggressive water conservation by urban and agricultural water systems and their users.

Strategy 4: Practice and Promote Integrated Flood Management

Near-Term Actions:

a. **Flood Management Improvements –** To reduce flood peaks, reduce sedimentation, temporarily store floodwaters, recharge aquifers and restore environmental flows, flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.

b. **System Reoperation Task Force –** The improved performance of existing water infrastructure cannot be achieved by any single agency, and will require the explicit cooperation of many. Moreover, system-wide operational coordination and cooperation must be streamlined to respond to extreme events that may result from climate change. Successful system re-operation will also require that the benefits of such actions are evident to federal and local partners. To achieve these goals, the State will establish a System Re-operation Task Force comprised of state personnel, federal agency representatives, and appropriate stakeholders.

c. **Support Decision Making –** To successfully meet the challenges posed by climate change, the federal-state Joint Operations Center (JOC) capacity should be expanded to improve tools and observations that better support decision-making for individual events, seasonal and inter-annual operations and water transfers. The JOC should be enhanced to further improve communications and coordination during emergencies such as floods and droughts.

d. **Central Valley Flood Protection Plan –** By January 1, 2012, DWR will collaboratively develop a Central Valley Flood Protection Plan that includes actions to improve integrated flood management and consider the potential impacts of climate change.

e. **Emergency Flood Preparedness –** All at-risk communities should develop, adopt, practice and regularly evaluate formal flood emergency preparedness, response, evacuation and recovery plans.

f. **Land Use Policies –** Local governments should implement land use policies that decrease flood risk.

Strategy 5: Enhance and Sustain Ecosystems

Long-Term and Near-Term Actions:

a. **Species Migration and Movement Corridors –** Water management systems should protect and reestablish contiguous habitat and migration and movement corridors for plant and animal species related to rivers and riparian or wetland ecosystems. IRWM and regional flood management plans should incorporate corridor connectivity and restoration of native aquatic and terrestrial habitats to support increased biodiversity and resilience for adapting to a changing climate.

b. **Floodplain Corridors –** Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains. Setback levees and bypasses help to retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Carbon sequestration within large, vegetated floodplain corridors may also assist the state in meeting GHG emissions reductions mandated by AB 32.

c. **Anadromous Fish –** The state should work with dam owners and operators, federal resource management agencies, and other stakeholders to evaluate opportunities to introduce or reintroduce anadromous fish to upper watersheds. Reestablishing anadromous fish, such as salmon, upstream of dams may provide flexibility in providing cold water conditions downstream, and thereby help inform system reoperation. Candidate watersheds should have sufficient habitat to support spawning and rearing of self-sustaining populations.

d. **Tidal Wetlands as Buffers –** The state should identify and strategically prioritize for protection lands at the boundaries of the San Francisco Bay and Sacramento-San Joaquin Delta that will provide the habitat range for tidal wetlands to adapt to sea-level rise. Such lands help maintain estuarine ecosystem functions and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level rise and storm surges.

e. **Reversal of Delta Island Subsidence –** The state should prioritize and expand Delta island subsidence reversal and land accretion projects to create equilibrium between land and estuary elevations along select Delta fringes and islands. Sediment-soil accretion is a cost-effective, natural process that can help sustain the Delta ecosystem and protect Delta communities from inundation.

f. **Upper Watershed Services –** The state should consider actions to protect, enhance and restore upper watershed forests and meadow systems that act as natural water and snow storage. This measure not only improves water supply reliability and protects water quality, but also safeguards significant high elevation habitats and migratory corridors.

Strategy 6: Expand Water Storage and Conjunctive Management of Surface and Groundwater Resources

Near-Term Actions:

a. **Expand Water Storage –** California should expand its available water storage for both surface and groundwater supplies. Funding for this is included in the proposed 2010 Water bond.

b. **Surface Storage Feasibility Studies –** DWR will incorporate climate change considerations as it works with the U.S. Bureau of Reclamation (Reclamation) and local agencies to complete surface storage feasibility studies.

c. **Conjunctive Use Management Plans –** State, federal, and local agencies should develop conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage.

d. **Groundwater Management Plans –** Local agencies will be encouraged to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of their IRWM plans. In addition, recently passed legislation requires that local agencies monitor the elevation of their groundwater basins.

e. **Local Ordinances –** Cities and counties will be encouraged to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

Strategy 7: Fix Delta Water Supply, Quality and Ecosystem Conditions

Near-Term Actions:

a. **Delta Adaptation Planning** – Recently passed legislation establishes the framework to achieve the co-equal goals of providing a more reliable water supply to California and enhancing the Delta ecosystem. It encourages the incorporation of adaptive responses to climate change in the development of the Bay-Delta Conservation Plan and other Delta-related efforts.

b. **Sustainable Delta Goals –** The Safe, Clean and Reliable Drinking Water Supply Act of 2010 is an $11.14 billion general obligation bond proposal that would provide funding for California's aging water infrastructure and for projects and programs to address the co-equal goals as well as statewide water projects and programs. It includes funding for drought relief, water supply reliability, Delta sustainability, statewide water system improvements, conservation and watershed protection, groundwater protection and water quality, and water recycling and conservation.

Strategy 8: Preserve, Upgrade and Increase Monitoring, Data Analysis and Management

Long-Term Actions:

a. **Climate Monitoring –** Critical for the projection of future water supply, climate change detection and consistent monitoring of critical variables such as temperature, precipitation, evapotranspiration, wind, snow level, vegetative cover, soil moisture and stream flow will be expanded at high elevations and wilderness areas to observe and track changes in the rain and snow transition zone.

b. **Atmospheric Observations –** To better project future rain and snow patterns on a regional scale, atmospheric observations are needed to define and understand the mechanisms underlying atmospheric processes that lead to California's seasonal and geographic distribution of precipitation.

c. **Water Use Feasibility Study –** The accurate measurement of water use can facilitate better water planning and management. By 2009, DWR, the state and regional Water Boards, the Department of Public Health, and the California Bay-Delta Authority will complete a feasibility study for a water use measurement database and reporting system.

d. **Water Use Accountability –** Recently passed legislation improves accounting of the location and amounts of water diverted from the Delta.

Strategy 9: Plan for and Adapt to Sea-Level Rise

Long-Term Actions:

a. **Sea-Level Rise Projections –** The state will establish an interim range of sea-level rise projections for short-term planning purposes for local, regional and statewide projects and activities.

b. **National Research Council study –**The Resources Agency, in coordination with DWR and other state agencies will convene and support a scientific panel from the National Research Council (NRC) to provide expert guidance regarding long-range sea-level rise estimates and their application to specific California planning issues.

c. **California Water Plan Update –** Based upon guidance from the NRC, DWR, in collaboration with other state agencies will develop long-range sea-level rise scenarios and response strategies to be included in the California Water Plan Update 2013.

Strategy 10: Identify and Fund Focused Climate Change Impacts and Adaptation Research and Analysis

Long-Term Actions:

a. **Research Planning and Partnerships –** In association with research institutions such as the Regional Integrated Sciences and Assessment centers, Lawrence Livermore and Berkeley National Laboratories, and the University of California, state agencies will identify research needs that provide guidance on activities to reduce California's vulnerability to climate change. The state will also explore partnerships with the federal government, other western states, and research institutions on climate change adaptation.

b. **Sensitivity Analysis –** The state's water supply and flood management agencies will perform a sensitivity analysis of preliminary planning studies, along with risk-based analyses for more advanced planning studies. For flooding, sensitivity and risk-based analyses an appropriate risk tolerance and planning horizon for each individual situation is under consideration. Selection of climate change scenarios for these analyses can be guided by recommendations of the Governor's Climate Action Team.

c. **Pilot Projects –** The sponsorship of science-based pilot projects for watershed adaptation research is needed to address climate change adaptation for water management and ecosystems. Funding for pilot projects should only be granted in those regions that have adopted IRWM plans that meet DWR's plan standards and have broad stakeholder support.

d. **California Water Plan Update –** Every five years DWR will provide revised estimates of changes to sea level, droughts, and flooding that can be expected over the following 25 years, this will be included in future versions of the California Water Plan Update.