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BRIEFING PACKET

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CONTENTS

15. Adapting to Rising Tides Nine County Work Program: Regional Assessment and Adaptation Project BCDC (35 pages)

16. BCDC Testimony Before the Milton Marks Commission on California State Government Organization and Economy (28 pages)

17. Bay Area Regional Adaptation Efforts to Climate Change Impacts Testimony of R. Zachary Wasserman, Chair BCDC (7 pages)

18. Preparing for Change Along Our Shores OWLS (1 page)

19. Staff Report on the California State Lands Commission Staff's Activities to Address Sea Level Rise (6 pages)

20. Sea Level Rise and Public trust Doctrine: Moving Boundaries & Emerging Issues (34 pages)

21. Climate Change: Reducing Risk Now with Nature-based Solutions (4 pages)

22. Reducing Climate Risks with Natural Infrastructure (16 pages)

23. Key Lessons for Incorporating Natural Infrastructure into Regional Climate Adaptation Planning (9 pages)

Natural Resources Agency

Safeguarding California: Reducing Climate Risk

An update to the 2009 California Climate Adaptation Strategy

July 2014

Table of Contents

PROLOGUE

As climate change shifts from a far-off concern to a present-day crisis, Californians are most vulnerable precisely where we're most fortunate. Rising seas and gathering storms threaten our justly famous coastlands, home to most of our population. Heat waves and droughts pressure farms and ranches that are among the most productive in the world. And our magnificent forests are at greater risk from wildfires that worsen in warmer weather.

Knowing what's at stake, California has become a global leader in responding to the growing climate threat. Our innovative policies are reducing greenhouse gas emissions and accelerating the transition to a clean-energy economy. At the same time, we are planning and preparing for the unavoidable risks of climate change. Our efforts fit within an integrated, three-R's strategy:

- Reducing Emissions – A centerpiece of our efforts is the Global Warming Solutions Act of 2006, which set the goal of reducing heat-trapping emissions to 1990 levels by 2020, a target we are pursuing by various means. The AB 32 Scoping Plan, updated every five years, outlines our strategies and defines our priorities for reducing emissions and driving the transition to a clean-energy economy.
- Readiness – While these efforts are essential for reducing the magnitude of climate change, they will not prevent it from occurring. Given the risks, investments are needed to protect our people, environment and economy from these inevitable impacts. The Safeguarding California Plan provides guidance for state and local decision makers in their efforts to prepare for climate-related risks and minimize economic losses.
- Research – Our approach is built on science. Research helps us to identify climate change impacts and risks, informs the development of our policies, and helps us measure progress toward our goals. Among our most recent scientific assessments are Indicators of Climate Change in California (2013) and the Third Climate Change Assessment (2012).

Over the coming decades, confronting climate change will require unprecedented collaboration across state government and involve nearly every aspect of the state's planning and investments. In recognition of this, the Governor's Environmental Goals and Policy Report serves as a broad overview for how state efforts work together on a variety of fronts to achieve long-term sustainability.

Climate change represents one of the greatest challenges of our time, but it is a challenge well-suited to California's strengths of leadership and innovation. Our policies are becoming a catalyst for further actions around the world. By embracing this role, we can avoid the worst impacts of climate change and forge a cleaner, healthier and more sustainable future for all Californians.

EXECUTIVE SUMMARY – SAFEGUARDING CALIFORNIA

California and the world's climate are changing, posing an escalated threat to health, well-being, nature, and property. Extreme weather, rising sea levels, shifting snowpack, among other impacts will touch every part of peoples' lives in the next century. Planning key actions now will help us lessen impacts and cope with changes. Many aspects of the environment face historic displacement. In government at every level, we must work together to safeguard our state. And ultimately, each and every one of us needs to take steps to reduce our own impacts and increase our resilience in the future.

The Safeguarding California Plan provides policy guidance for state decision makers, and is part of continuing efforts to reduce impacts and prepare for climate risks. This plan, which updates the 2009 California Climate Adaptation Strategy, highlights climate risks in nine sectors in California, discusses progress to date, and makes realistic sector-specific recommendations.

California is a leader in the global effort to fight climate change. The state is pursuing a broad, integrated strategy to reduce greenhouse gas emissions and build the foundation for a new clean energy economy. While these efforts will reduce the magnitude and impact of climate change, they will not prevent it from occurring. Given the potential impacts and the long-term nature of effective planning, it is only prudent to begin preparing for these impacts. Actions needed to meet these challenges will not be cheap, but will cost far less than taking no action. Every step that we take today helps save valuable resources in the future. To that end, the plan details 11 current efforts already underway.

Right now, more extreme fires, storms, and heat waves are costing lives and property damage. State of the art modeling shows that a single extreme winter storm in California could cost on the order of $725 billion – with total direct property losses of nearly $400 billion and devastating impacts to California's people, economy and natural resources. The health and fiscal consequences are dire. Climate change poses a threat not just to lives and health, but the financial resources of governments and the insurance industry.

More broadly – and likely more costly – are rising seas that threaten our coast, while disappearing snowpack in the Sierra Nevada presents new challenges for our state's water management. In the near term, we must take practical, affordable steps to maintain our water, power, and transportation infrastructure, and plan for longer term actions as well.

Below are the nine broad areas impacted by climate change, with real-world, realistic recommendations for actions that we can take today to ensure a better future. In addition, we have included seven strategies that cut across each one of these nine broad areas that can be realistically implemented to help safeguard California.

Safeguarding our Everyday Lives from Climate Change:

- A Changing Water Future: Develop an urban water use plan that reduces reliance on distant, unpredictable sources.
- Keeping the Lights On: Promote development of smart grids that are connected, but localized.
- Cooling California: Promote strategies to keep Californians cool and guard against longer, more frequent heat weaves, which are already responsible for a growing number of hospitalizations and deaths.
- Do Better Today, Live Better Tomorrow: By reducing our carbon output today, we can lessen the extent of impacts in the future.

Safeguarding our Natural World:

- Nature Moves with the Climate: As climate patterns shift, so will nature. Providing habitat connectivity and chances for adaptation will help allow species and habitats to survive.
- Help Nature Protect Herself: Improve forest and other habitat resilience.

Safeguarding California – What Science and Lawmakers Can Do:

- Knowing the Real Impacts: Sound science will highlight risks, and help provide a path to solutions.
- Help is on the Way: Assess adequacy of emergency responders.
- Better Together: Collaborate with federal and local government.

Seven Strategies to Safeguard California: Cross Sector Themes

These nine areas touch every part of modern life for people and nature: 1) Agriculture, 2) Biodiversity and Habitat, 3) Emergency Management, 4) Energy, 5) Forestry, 6) Ocean and Coastal Ecosystems and Resources, 7) Public Health, 8) Transportation, and 9) Water. For these nine areas, common themes were identified during the development of the plan. This important identification resulted in identifying seven strategies that cut across all areas that can be acted upon.

- All core functions of government must make the risks Californians face from a changing climate an integral part of their activities.
- Provide risk reduction measures for California's most vulnerable populations.

- Identify significant and sustainable funding sources for investments that reduce climate risks, human loss, and disaster spending.
- Support continued climate research and data tools to inform policy and risk reduction activities.
- Maximize returns on investments by prioritizing projects that produce multiple benefits and promote sustainable stewardship of California's resources.
- Prioritize climate risk communication, education, and outreach efforts to build understanding among all Californians.
- Promote collaborative and iterative processes for crafting and refining climate risk management strategies.

Current Efforts to Prepare California for Climate Risk

Climate change impacts communities and crosses political and jurisdictional boundaries. Cooperation and coordination is essential across a wide variety of factors including: government at all levels (state, federal, tribal, local and regional), businesses, insurers, investors, non-profit organizations, foundations, community groups, and individuals. Fortunately, we already have many examples of progress, including:

- Creation of the Cal-Adapt tool allows visualization of local climate impacts in California
- 2012 California Climate Adaptation Planning Guide is designed for local and regional governments
- 2013 Climate Change Consortium for Specialty Crops sets out impacts and strategies for resilience
- Desert Renewable Energy Conservation Plan (DRECP) is an effort underway to support programmatic development of large-scale renewable energy and the co-equal objective of conservation of the California desert; approximately 22.5 million acres of federal and non-federal California desert land are in the DRECP plan area.
- The State Hazard Mitigation Plan has integrated climate risks since 2007
- Energy efficiency standards have saved Californians more than $74 billion in reduced electricity bills since 1975, and have helped to foster greater energy reliability
- Urban forestry investments reduce heat island effects and provide air and water benefits
- 2013 State of California Sea-Level Rise Guidance Document is part of California's response
- 2013 Preparing California for Extreme Heat is another part of the response
- 2013 Addressing Climate Change Adaptation in Regional Transportation Plans provides guidance for California's Municipal Planning Organizations and Regional Transportation Planning Agencies

- Construction of four coastal observatories in Eureka, Bodega Bay, Big Sur, and Santa Barbara will help improve flood watch and flood warning information for local emergency responders

Reducing climate risks protect California's people, economy, and natural resources. Investing in action now saves lives and provides long term cost savings; one study found that every dollar spent on a FEMA hazard mitigation grant produced, on average, four dollars of benefits. Implementation of this Safeguarding California Plan will help foster a vibrant and sustainable future for California.

INTRODUCTION

California is taking important steps to reduce emissions, but no matter how quickly we reduce emissions, some amount of climate change will occur due to prior and on-going emissions. Many climate impacts are already unfolding in California. This means that we must take action now to safeguard California's people, economy, infrastructure, and natural environment from climate risks. This report is an update to the state's *2009 Climate Adaptation Strategy*. Based on a series of sector-specific analyses, it identifies key actions that the state needs to undertake to advance efforts to address climate risks and to move from planning to implementation. The *Safeguarding California Plan* is the guiding document for reducing climate risk, which is one of the three pillars of the state's comprehensive climate change policy.

California's Comprehensive Approach to Climate Change

Climate change is the defining issue for the state's future. The Governor's draft Environmental Goals and Policy Report lays the groundwork for the state's continued long-term, deep greenhouse gas (GHG) emission reductions and provides strong direction on the need to prepare for climate impacts and risks already beginning to threaten California. The state's efforts on climate risk reduction are complemented by the other two pillars of the state's climate change strategy – reducing GHG emissions and supporting research on climate change vulnerabilities and strategies to reduce these risks.

California has made significant investments in responding to climate change, including one of the world's most comprehensive programs to reduce greenhouse gas (GHG) emissions. Based on the direction provided by the Global Warming Solutions Act of 2006 (Assembly Bill 32 or AB 32), the state is well on its way to reducing GHG emissions to 1990 levels by 2020. These efforts are documented in the *AB 32 First Update to the Climate Change Scoping Plan* (AB32 Scoping Plan). The state is already looking at GHG emissions reduction goals past 2020.

California has also invested significant resources and leveraged the intellectual capital of the state to maintain a robust research program on the impacts of climate change; technologies to reduce emissions; and approaches to preparing for climate risks. The state's research agenda is directly informed by the state's policy needs as articulated in the *AB 32 Scoping Plan*, *Safeguarding California Plan*, and other climate-related documents and processes; for instance, many of the research needs outlined in this document have been incorporated into the State's Climate Change Research Plan, which outlines the state's near-term climate research needs across sectors and mitigation and adaptation efforts.[1] Through an iterative process, the results of the state's research efforts are directly incorporated into policy guidance and analysis. The state's Third Climate Assessment was released in July 2012 and provides much of the basis for the sector-specific analyses featured in the *Safeguarding California Plan*. A Fourth California Climate Assessment will provide critical additional information to support decisions that will safeguard the people, economy and resources of California. Among other informational gaps about climate vulnerabilities, California still lacks critical information regarding expected climate impacts from extreme weather events. California also needs to better understand the scope, timing, cost and feasibility of various management options to address climate risks. Accurately understanding climate risks and management options will allow the state to prioritize actions and investments to safeguard the people, economy and natural resources of California. In August 2014, three public workshops will be held to solicit public comment and input on a proposed scope of work for the Fourth California Climate Assessment

Planning for Climate Risks in California

California's *2009 Climate Adaptation Strategy* (2009 CAS) was one of the nation's first multi-sectoral plans for preparing for the impacts of climate change. The *Safeguarding California Plan* is an update to the 2009 CAS, incorporating new information on climate vulnerabilities and management approaches. The *Safeguarding California Plan* is built on the most up-to-date science and sector-specific analyses of California climate risks and management strategies.

The *Safeguarding California Plan* is not meant to replace the 2009 CAS, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward.

The 2009 CAS was built on several guiding principles. Many of these principles are still relevant and are carried forward as updated here:

- Use the best available science to identify risks and adaptation strategies;
- Understand that an effective strategy for preparing for climate risks should evolve as new information is available;
- Involve all relevant stakeholders;
- Establish and maintain strong partnerships across all levels of government, tribes, businesses, landowners, and non-governmental organizations;
- Give priority to strategies that also achieve benefits other than climate risk reduction benefits, including additional benefits to public health, the economy, environmental justice, and conservation of natural resources; and
- Ensure that strategies to reduce climate risk are coordinated, to the extent possible, with the state's efforts to reduce GHG emissions and other local, national and international efforts.

The *Safeguarding California Plan* is designed as policy guidance for state decision makers. Climate risks often present cross-sectoral challenges, and may require cross-sectoral solutions. As a result, the Safeguarding California Plan identifies cross-sectoral linkages throughout. Each sector chapter features its own recommendations; cross-sectoral strategies are presented in the Introduction.

The *Safeguarding California Plan* is the result of cross-agency collaboration and public input that drew on the experiences and knowledge of leaders from each of the sectors represented. The sector-specific analyses that follow this introduction provide additional detail on progress to date and challenges and opportunities. The sector-specific analyses, together with the cross-sectoral themes discussed below, provide a robust discussion of necessary next steps to further safeguard California's people, economy, infrastructure and natural resources from climate risks.

Future updates of the state's multisectoral guidance to address climate risks may include expanded discussions of risks to business and labor, as well as additional recommendations with respect to coordination with local and regional governments. For more information on climate risk and business, please see [Inset 2] below.

Key Strategies to Advance Efforts to Reduce Climate Risk in California

The sector-specific analyses featured in the *Safeguarding California Plan* highlight the opportunities and challenges for implementing climate risk reduction actions. Climate impacts occur at different scales (global, national, regional and local) and impacts may vary from place to place. Because of this, many strategies to reduce climate risk must be crafted at a regional or local scale. Climate data development and tools must also be tailored to support regional and local risk reduction efforts.

Several common themes emerged during the development of the sector-specific materials featured in this Safeguarding California Plan. These common themes point to the need for cross-sectoral coordination and collaboration. Leadership and support are needed to help transition from planning for climate risks to taking action to reduce risk. The state has an important role to play in enabling efforts to reduce climate risk, helping climate risks become a mainstream policy consideration, and ensuring that all state agencies are taking climate risks into account. State agencies need to consider climate change in their normal day-to-day business and operations. In particular, the state needs to take the following actions:

1. Establish a mandate and guidelines for all state agencies to consider climate risks in their policies, planning efforts, and investments
2. Provide data, tools, and guidance to support efforts to reduce climate risks; and
3. Build the capacity to plan for and implement actions to reduce climate risk through collaboration, education, outreach and funding.

These three actions will improve clarity and direction on how to move ahead on risk reduction activities and will help support risk reduction activities across sectors at the state, regional and local scales. Further information on implementing these actions is provided below.

ESTABLISH A MANDATE AND GUIDELINES FOR ALL STATE AGENCIES TO CONSIDER CLIMATE RISKS IN THEIR POLICIES, PLANNING EFFORTS, AND INVESTMENTS

California is already experiencing the effects of a changing climate. Over the coming decades, as global average temperatures continue to increase and sea levels rise, these effects will become even more pronounced. As the state is making plans and investments for the future, these risks need to be taken into account.

The 2009 CAS recommended that all new development "consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding, wildfire and erosion due to climate change." [2] To see this implemented, the state needs to take two critical steps:

1. Require that climate risk considerations be incorporated into state infrastructure planning; and
2. Provide guidelines for state agencies to incorporate climate risk considerations into all policies, plans, and investments.

Incorporate Climate Risks into State Infrastructure Planning

State agencies should identify climate risks to existing and new infrastructure projects. For new projects, climate risks should be considered in the planning, siting, design, construction, and maintenance of infrastructure projects. Similar risk considerations should be included in the maintenance and rehabilitation of existing infrastructure. All new investments should be made to minimize climate risks to the project and long-term risks associated with development generated by the infrastructure investment. In cases where the benefits of the project are deemed to outweigh climate risks, adequate risks management provisions must be made.

Full-life cycle cost accounting should be used in all infrastructure planning projects. This will help ensure that the costs of protecting an infrastructure investment from climate risks over the lifetime of the investment will be fully accounted for upfront and accounted for in the comparison of project alternatives. However, it is important to note, that such full-life cycle accounting for infrastructure projects may not fully capture broader societal costs associated with climate risks to development that occurs in response to the infrastructure project.

Develop Guidelines for State Agencies to Incorporate Climate Risks Into Policies, Planning and Investments

A cross-agency working group including representation from the Governor's Office of Planning and Research, the California Natural Resources Agency, the California Transportation Agency, the California Environmental Protection Agency, the California Department of Public Health, the Office of Emergency Services, the Department of Finance, and the California Department of Food and Agriculture should develop guidelines for state agencies to follow as they incorporate climate considerations into all policies, planning, and investments. This group should work in coordination with the Climate Action Team. At a minimum, these guidelines should address the following critical issues to ensure successful efforts to reduce climate risks.

Encourage Iterative Approaches

Global greenhouse gas emissions will continue to determine the pace and scale of climate impacts. Direct observation of climate impacts will help to refine and improve our modeled projections of climate risks. State programs need to be able to adjust their strategies for reducing climate risks as new information emerges. Therefore, long-term planning processes need to adopt iterative approaches to incorporate the best available climate science. State programs should be required to establish processes for incorporating new climate information and updating management practices and goals.

Protect California's Most Vulnerable Populations

Climate change will have disproportionate impacts on the state's most vulnerable populations. Threats to food security, public health, and water supplies will disproportionately affect the poor, elderly and other communities without adequate resources to respond. Steps need to be taken to identify these vulnerable populations and to ensure that California's most vulnerable people have access to information, services and resources to prepare and respond to climate risks.

Achieve Multiple Benefits from Efforts to Reduce Climate Risks and Prioritize Green Infrastructure Solutions

Steps to increase resilience can provide other types of significant benefits. Efforts to reduce climate risk should also achieve other types of benefits to the extent possible. Other benefits to consider include public health benefits besides those directly associated with climate risk reduction, economic benefits, and other environmental benefits besides those directly associated with climate risk reduction. Furthermore, actions that reduce climate risks across multiple sectors and actions that address multiple climate risks should be prioritized. Significant cross-agency coordination and collaboration will be needed to identify and implement risk reduction opportunities with multiple benefits.

One opportunity to achieve broad environmental benefits is through the use of natural infrastructure solutions to mitigate climate risk. Restoration and conservation of natural systems such as forests, grasslands and shrublands, agricultural lands, and wetlands can provide more resilient natural systems that also offer protection from climate impacts. For example, wetlands can provide protection from flooding, while also providing valuable habitat and other hydrological benefits. Prioritizing these solutions can maximize the benefits of investments to reduce climate risks by providing a broad portfolio of benefits across several sectors.

Integrate Efforts to Reduce Climate Risk with Efforts to Reduce the Emissions that Cause Climate Change to the Fullest Extent Possible

The state's climate program needs to maximize opportunities to reduce GHG emissions while also building resilience. Examples include energy efficiency measures, which can reduce energy demand and greenhouse emissions while at the same time reducing load on the state's energy system. These types of integration efforts can provide opportunities to leverage funding, such as revenues from the AB32 cap-and-trade program, to advance efforts to reduce climate risk.

Develop Metrics and Indicators to Track Progress on Efforts to Reduce Climate Risk

As the state undertakes more comprehensive efforts to reduce climate risk, it is important that metrics and indicators are developed as proxies by which the effectiveness of risk reduction activities may be measured. Such metrics may include tracking of processes undertaken to advance risk reduction and measures of the impacts of these policies and programs on changing vulnerability. Data collection on risk reduction actions and outcomes will be needed to support such evaluation, and careful consideration must be given to relevant timeframes over which progress is monitored. Disconnects may exist between the timeframes for achieving risk reduction and timeframes relevant for evaluation of policies. The capacity of natural and human systems to respond to climate risks and efforts to reduce climate risk may vary, and it is important to identify trends and gaps in adaptive response in order to refine strategies for addressing climate risk.

The Office of Environmental Health Hazard Assessment's (OEHHA) *Climate Change Indicators for California* provides valuable information about the changes in the state's physical and natural systems that are already underway. The Governor's Office of Planning and Research is also leading an effort develop an integrated set of indicators to help track progress on the state's efforts to reduce GHG emissions and build climate resilience.

PROVIDE DATA, TOOLS AND GUIDANCE TO SUPPORT EFFORTS TO REDUCE CLIMATE RISK

Climate science lies at the heart of much of the state's climate policy. The state's investment in research has played a large role in its leadership on climate change policy. As the state looks to move ahead on efforts to reduce climate risk, there are three critical areas that it must invest in:

1. Additional research to fill informational gaps about California's climate vulnerabilities and additional research on the scope, timing, cost and feasibility of management options to address climate change;
2. Tools and guidance to support efforts to plan for climate risks at the state, local, and regional level; and
3. Supporting monitoring to gather direct observations of the changing climate.

Climate Vulnerability Assessments and Research on Management Options

California's comprehensive climate policy is grounded in the most up-to-date climate science. California has completed three California Climate Change Assessments.[3] These assessments have provided initial information on climate risks, economic impacts, and barriers to efforts to prepare for climate risks across different sectors and different regions in California. The information developed through these assessments has served as a strong foundation for the state's policies to reduce the emissions that cause climate change, as well as efforts to reduce climate risk.

The state has leveraged its research investments through coordination with other partners. The state has drawn upon the strong intellectual capacity of California's universities and laboratories. The state has also worked closely with federal agencies and laboratories, local and regional governments and other partners and stakeholders.

Additional research is needed to fill continuing knowledge gaps regarding California's climate vulnerabilities and the scope, timing, cost and feasibility of regionally relevant management options to address climate change. Additional vulnerability assessments for the state's population, natural systems, and infrastructure will be important for allocating limited resources to build resilience. More detailed research needs are discussed in the sector-specific discussions contained in this *Safeguarding California Plan*. As noted above, scoping for a Fourth California Climate Assessment has been initiated in 2014, and will focus on helping to produce this needed research.

Tools and Guidance

Investment in tools to make climate data easily accessible and usable by decisionmakers is a critical role for the state. Cal-Adapt [see Inset 1] is an online, interactive, visualization tool that enables researchers, decisionmakers, and the general public to explore how climate change will impact specific regions in California. Cal-Adapt is specifically directed toward supporting local decision-makers and planners in identifying, understanding, and adapting to climate risks.

As further described in the Public Health section of this document, the California Department of Public Health (CDPH) has developed a Climate Change Population Vulnerability Screening Tool which supplemented an existing environmental justice screening method with metrics associated with climate change impacts and adaptive capacity, such as population sensitivities, air conditioning ownership, green space, and ecological risks. An interagency working group lead by CDPH is currently exploring further social vulnerability mapping for climate change and best practices for social vulnerability assessments.

In addition to providing tools like those described above, the state plays an important role in providing guidance on how to use climate data and providing guidance regarding processes for planning and implementing actions to reduce climate risk. The state has already issued a number of important guidance documents which are further discussed in this document, including the 2011 Climate Change Handbook for Regional Water Planning, the 2012 Adaptation Planning Guide, the 2013 Ocean Protection Council's State of California Sea-Level Rise Guidance, and the 2013 Preparing for Extreme Heat in California: Guidance and Recommendations. The state should continue to provide guidance on best practices for utilizing climate data and preparing for climate risks.

Supporting Monitoring to Gather Direct Observations of the Changing Climate

The state has already invested in some monitoring networks that help provide information about the environment in order to support our understanding of changing climate conditions and how to respond to climate risks. These monitoring networks include equipment that provides some measurements for air quality, sea level rise, atmospheric rivers, and other environmental conditions. Current monitoring equipment must be maintained and upgraded over time, and the *Safeguarding California Plan* also identifies a number of different areas in which additional monitoring efforts are needed. Monitoring information can help refine climate change projections, inform early warning systems, and aid California's efforts to respond and prepare for climate impacts.

BUILD CAPACITY TO PLAN FOR AND IMPLEMENT ACTIONS TO REDUCE CLIMATE RISK THROUGH COLLABORATION, EDUCATION, OUTREACH, AND FUNDING

In addition to incorporating climate risk considerations into state policy, planning, and investment decisions and further developing climate data, tools and guidance, it is necessary that the state build capacity to advance efforts to plan for and implement actions to reduce climate risk. Capacity building may be achieved in the ways described below.

Foster Collaboration and Innovation Across State Agencies and Across Levels of Government

Climate impacts will span sectoral and jurisdictional boundaries and efforts to respond to climate risks will necessarily require coordination between state agencies and across political boundaries (international, national, regional, state and local). For example, the Biodiversity chapter of this document identifies more than 14 state entities, as well as federal and local agencies, that work on biodiversity issues. Collaboration across entities is necessary for information sharing, can help generate innovative new approaches to addressing climate risk, and can help optimize the utilization of the scarce resources available to address climate threats. Collaboration is an integral part of preparing for a changing climate.

Collaborative work on climate challenges is already occurring in California. This *Safeguarding California Plan* was developed by a large working group of state entities, with important input gleaned from tribal leaders, stakeholders, and other partners. More information about the entities and individuals who contributed to the development of the Safeguarding California Plan may be found in the acknowledgements in Appendix B of this document.

California is also an active member of the President's State, Local and Tribal Leaders Task Force on Climate Preparedness and Resilience (Task Force).[4] The Task Force was established in November 2013 to advise the Administration on how the Federal Government can respond to the needs of communities nationwide that are dealing with the impacts of climate change.

California has more than 100 federally recognized tribes and the largest Native American population of any U.S. State. The Brown administration renewed its commitment to coordination with Native American tribes when Governor Brown signed Executive Order B-10-11, with the intent of strengthening communications and collaboration between California state government and Native American tribes. The state will continue implementation of this direction as it works to foster strong working partnerships with tribal nations and lead efforts to better coordinate with tribes on preparing for climate risks. Tribes are already experiencing climate impacts and working to address climate change.[5]

Local and regional entities in California are also working on collaborative efforts to address climate. For more information on such efforts, please see [Inset 3] below.

Develop a Comprehensive Climate Education and Outreach Strategy

It is necessary to invest in human capital to build the required expertise to address the new challenges presented by climate change. Providing state employees with access to climate training activities can also help build needed human capital. Some state entities have already started to develop these types of programs.[6] State agencies and departments should be provided with the resources to enable and encourage climate training for staff. Climate literacy programs should provide both general climate information and content specifically related to the activities and mission of the hosting agency or department. Training should disseminate climate science and climate risk information and empower staff to integrate climate change into their professional responsibilities. The state should develop a standardized curriculum for the general climate information portion of its internal climate literacy program. This standardized curriculum should also be made available as a public resource. The state should also work with education providers to integrate climate literacy into school curricula.

A high degree of engagement by governments at all levels, the private sector, communities, and individuals is needed in order to effectively prepare for climate risks. This level of engagement is predicated on effective communication of climate risks. The state should develop and maintain a standard set of communication materials regarding climate risks in California, and should provide translated materials for non-English speaking communities. Those materials should be made available online and through outreach efforts. Outreach efforts should be focused on increasing public awareness and increasing community engagement in preparing for climate risks. Funding will be needed to support adequate outreach efforts.

Provide Significant and Sustainable Funding for Investments that Reduce Climate Risks, Human Loss and Disaster Spending

Making adequate investments to prepare for near- and longer-term climate risks now can help protect California's people, economy and natural resources. Although needed investments are very substantial, these investments will save lives and provide very significant long-term savings. Significant, sustainable funding sources are needed. In order to achieve the needed level of investment, the state will need to work closely with governments at multiple scales (federal, tribal, regional and local) as well as a variety of non-governmental partners including members of the business community. Indeed, some important efforts are underway in the private sector to better quantify the economic risks of unmitigated climate change in order to better understand the nation's exposure to climate risk and inform decisions about the future.[7] Innovative risk sharing mechanisms will need to be considered and utilized.[8] Investments must account for time frames needed to realize benefits, changing climate risks over time, and the life expectancy of any capital investments.

4. Next Steps

The *Safeguarding California Plan* presents a call to action to address climate risks that threaten the state's people, economy, infrastructure and natural resources. Climate impacts are already manifesting in California, and strong state leadership is critical in order to safeguard our communities. While some of the recommendations in this *Safeguarding California Plan* may be carried out through existing programs and staff, the document more broadly describes needed actions to reduce climate risks in California even where current policies, staffing and funding capacity do not yet exist.

Inset 1

Cal-Adapt—California's Easy Access Tool for Visualizing Local Climate Impacts.

With a proliferation of climate research tools and resources over the past five years, it has become increasingly difficult to identify definitive sources of aggregated climate data for planning purposes. The state of California plays an important role in helping to develop regionally relevant climate research to support policy and planning efforts. Implementation of many actions to enhance community resilience will happen at the local and regional levels, and the state is committed to working cooperatively with local and regional governments to support their efforts to prepare for climate risks. Recognizing that climate data must be translated into a usable format and that having numerous sources of climate data can be difficult to navigate, the state created a tool called Cal-Adapt (http://cal-adapt.org); a web-based climate planning tool where you can quickly find information to help visualize impacts associated with climate change at the local level.

Cal-Adapt addresses one of the major challenges facing planners who are working to enhance community resilience in the face of climate risks: a scarcity of tools and definitive sources located in one easy access location that can provide regionally relevant information. Designed in response to a recommendation in the 2009 California Climate Adaptation Strategy, Cal-Adapt was specifically designed to support planning activities and provide public information on climate impacts and risks in the state. Cal-Adapt provides visualization tools and easy access to important data sets specific to California. The user-friendly platform provides a convenient and effective way to explore climate impacts and vulnerabilities. Since its release, the website is being used by local and regional entities to find out how the climate may change in their jurisdictions, and these partners have been providing the state with useful feedback about the functionality of the tool.

Cal-Adapt was originally developed with funding from the California Energy Commission's Public Interest Energy Research program. Limited funding has been identified to support a tool update in 2014. The goal of the 2014 update will be to refresh the data sets incorporated in the

Cal-Adapt tool and make the tool more responsive to the needs of local decision makers. However, as climate change projections and observations continue to evolve, planning efforts become increasingly sophisticated, and implementation of local climate plans moves forward, it will become increasingly important to continually maintain and enhance this tool to ensure it reflects best available knowledge.

Inset 2

Climate Risk and California Business

Climate change poses significant risks to businesses including supply chain disruptions, destruction of business assets, and interruption of distribution networks. By taking action to reduce climate risks, California can support a resilient and prosperous business community.

Businesses are important partners for the state with respect to preparing for climate impacts. For instance, as discussed in the Emergency Management section of this document, the insurance industry provides important risk sharing mechanisms that can work in tandem with government policies to reduce climate risk. Institutional investors can adopt investment practices that encourage positive climate action.[9] Companies help create markets for ecosystem services.[10] Businesses and industry groups can encourage the development of climate policies and raise awareness about climate change issues.[11] And, as discussed elsewhere in this document, innovative technologies, materials, and design can improve energy efficiency, reduce heat island effects, and reduce risks from the changing climate.

Inset 3

The Alliance of Regional Collaboratives for Climate Adaptation

The Alliance of Regional Collaboratives for Climate Adaptation (ARCCA) was formed in early 2012 to address the emerging impacts of climate change, including extreme storm events, heat waves, droughts, and sea level rise. ARCCA brings together Regional Collaboratives -- from San Diego, Los Angeles, the San Francisco Bay Area, and Sacramento -- that are coordinating and supporting local climate partners in projects to enhance public health, protect natural systems, build economies, and improve the quality of life in all communities. The mission of ARCCA is two-fold: to enhance cooperation and best practices sharing between regions and work more effectively with the State in its development of climate adaptation plans, policies and programs.

AGRICULTURE

INTRODUCTION

California is the leading agricultural state in the nation in terms of economic value and crop diversity. Farming and ranching are a critical part of our economy and daily lives, providing healthy fruits and vegetables, nuts, grains, lean meats and dairy protein that we eat and drink, cotton and wool for the clothes we wear, and bio-based energy to power our homes and businesses. In 2012, California agriculture generated $44.7 billion in revenue - representing 11.3 percent of total U.S. agricultural revenue.[12] California produces more than 400 different commodities on approximately 80,500 farms employing 800,000 people involved in all stages of farming and ranching.[13] California has a diversity of farm sizes including many small-scale and medium-scale farms. Agriculture depends on weather and a wide range of ecosystem processes that support productivity, so any significant changes in climate present potential vulnerabilities for the sector and may have serious implications for the well-being of California's economy and its people. In fact, California's agricultural bounty is a function of the fact that we are one of only five Mediterranean growing regions in the world; because of our climate California's farmers and ranchers are able to produce a wider diversity of commodities, many of them year round.

While California farmers and ranchers have always been affected by the natural variability of weather from year to year, the rate and scale of climate change is increasing and is outside the realm of experience for the agricultural community.[14] Projected climate changes in California include: changes to water quality and availability; changing precipitations patterns; extreme weather events including drought, severe storms, and floods; heat stress; decreased chill hours; shifts in pollinator lifecycles; increased risks from weeds, pest and disease; and disruptions to the transportation and energy infrastructure supporting agricultural production. The combined effect on agriculture from multiple changing climate variables is complex, difficult to predict, and can be a mix of positive and negative impacts (e.g. longer growing periods, but more pests); but by midcentury and beyond, climate change is projected to have overall detrimental impacts on most current crop and livestock production.[15] However, the vulnerability of agriculture to climatic changes is strongly dependent on the response taken by humans to moderate the effects of climate change, and there are many opportunities to minimize climate risks and safeguard our agricultural resources and food supply.[16]

Climate risks to California's agriculture cannot be fully understood without consideration of its national and global context. California's agriculture is interconnected to the nation and the world in important ways. The state produces nearly half of U.S.-grown fruits, nuts, and vegetables; and across the nation, U.S. consumers regularly purchase several crops produced solely in California.[17] Additionally, California's agricultural exports have grown at an exceptional pace over the past decade, increasing from $6.51 billion in 2001 to $18.18 billion in 2012.[18] California also imports agricultural products, including commodities not grown in the United States such as bananas and coffee, and feed grain to support California livestock.[19] Given these important interconnections, any climate-related vulnerabilities to agriculture within the state or within trading partner states can have implications for Californians and non-Californians alike.

The risk of significant climate changes is present against a backdrop of other stressors to California's food and agriculture. Farm and grazing lands in California decreased by more than 1.3 million acres between 1984 and 2008. This loss averages about one square mile every four days. Urbanization accounts for the vast majority of this loss, more than 1.04 million acres over the 1984-2008 timeframe.[20] According to the California Department of Finance, California's population will continue to grow and will cross the 50 million mark in 2049[21], so there will be continued pressures for farmland conversion at the same time that food demands are increasing and climate impacts are unfolding. Furthermore, a recent study by the University of California Los Angeles (UCLA) also notes that food insecurity has increased significantly over the last decade among low-income Californians; with 3.8 million adults struggling to afford food in 2009, including households with children.[22]

California's farmers and ranchers have a demonstrated history of innovation in enhancing agricultural resource use efficiency and environmental stewardship while at the same time growing more food with limited water and land. However, climate risks will bring unprecedented, new challenges and opportunities. There is an urgent need to invest in science and research efforts to ensure California farmers and ranchers can adapt to climate change while increasing their productivity to help feed a global population that is projected to climb to more than nine billion people within the next few decades.[23] Developing and supporting California-specific agricultural research, management options, and appropriate technical and financial assistance will help to ensure the resilience of California's agricultural sector and the health of California's economy and its people.

Several state entities play an important role with respect to food and agriculture in California. The state also has important federal, local and private sector partners with respect to food and agriculture. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 6 *California Food and Agriculture below.*

<u>Climate Risks to California's Agricultural Resources</u>

California's unique Mediterranean climate, and its many microclimates, supports a diversity of crops. California is the nation's leading agriculture state in gross cash receipts; $44.7 billion in 2012. A large portion of the crops grown in the state are "specialty crops", which are defined as fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops including floriculture. California is the United States' sole producer of several crops such as Clingstone peaches, olives, pistachios, walnuts, almonds and artichokes.[24] Agriculture relies directly on climate and natural resources, and is inherently vulnerable to changes in temperature, water resources, storm events, shifts in pollinator lifecycles, and other risks associated with climate change.[25] Risks to agriculture threaten the economic livelihood of California and the food security and the well-being of all those who depend on California agriculture. (For more information on food security, please see Box 4 Food Security and Climate Impacts to California Agriculture.)

Due to the many human and environmental factors influencing agriculture, the complex interaction of multiple projected climate changes (e.g. changing water availability coupled with changing temperatures and changing insect populations), and increased variability in weather over time and across space, climate change impacts are difficult to predict for a specific agricultural operation. Nevertheless, rigorous analysis of California weather data shows that climate change is already occurring in the state. For example, California has already observed a reduction in winter chill hours, due to an increase in average winter temperatures. Winter chill hours are the number of hours below 45°F, and are necessary for the flowers of fruits and nuts to bloom, and for certain crops to achieve homogeneous and viable yields. Several studies indicate that climate change will negatively impact many specialty crop yields and profits by the year 2050 and certainly by the year 2100.[26] (For a first person perspective on California's changing climate and its impact on agriculture, please see Box 1 below.)

Box 1

FIRST PERSON NARRATIVE: John Diener, Red Rock Ranch Inc., Five Points, California (Narrative used with permission)

I've been farming in Five Points for more than 30 years, and our family farming history dates back to the Great Depression. At Red Rock Ranch Inc., we have about 5,000 acres and grow many fruit and vegetable crops including almonds, grapes, wheat, alfalfa, sugar beets, tomatoes, and spinach.

Our farm is located in Fresno County, in the West Side region where water availability has been a challenge for many years. Over the past 10 years, I have noticed three trends that are making this challenge even greater. First, we are getting less rain, and this causes us to have to use more imported water and groundwater to supplement our crops. This puts a stress on the whole system. The inconsistent rains make it hard to plan when to prepare the fields, plant and manage crops.

Second, the snowpack is not lasting as long into the summer as it used to. Our efficient use of the developed water within California's water reservoir system is dependent upon a gradual melting of the snowpack in the Sierra and Cascade mountain ranges. As weather patterns have changed, the snowpack has melted earlier and faster in the spring, and farmers are not able to be as efficient with their water use. This is happening during the same time that the state's population is growing, creating more demand for urban and industrial uses which has grown four-fold since the 1970's, and as more pressure has been building for keeping water in ecosystems for environmental purposes.

Third, as the weather gets warmer with climate change, agricultural demand for water is intensifying. For example, in 2012 we had the hottest September on record. We used approximately 30 percent more water than we normally would during that month because the water was evaporating faster and the plants needed more water moving through their circulatory systems to stay cool.

Over the past decade, we have had an approximately 50 percent decrease in surface water supply availability, and I can directly attribute declines in our crop yields over that time to water shortages. This was most obvious in 2009 when we got only 10 percent of our historical water allotment, rather than the 25 percent we had expected — and we saw a 50 percent decrease in crop yields that year.

All of this not only makes it challenging for farmers to stay in business, but it has impacts on employment (the Central Valley has some of the state's highest unemployment rates) and the economy. Agriculture is a $44.7 billion industry, counting only the actual farm product sales; there are also many other related businesses and jobs that depend on it, not to mention the tax base it contributes to the state economy. Obviously, there is a food security issue at stake too — California produces more than half of the country's fruits, nuts and vegetables and more dairy products than any other state. More than half of that food is grown in the Central Valley.

Though agriculture gets blamed for using more than its share of water, the fact is that we have made huge strides in recent years on irrigation efficiency. But clearly, in the face of intensifying climate change impacts on water scarcity, we are going to have to find a way to do even more if we want to stay in business and keep feeding so many people.

The solutions to greenhouse gas reductions will have other benefits for the Valley too. Our air quality issues are caused in part by fossil fuel combustion that produces carbon dioxide and also particulate matter. While improvements have been made in farming practices, all Valley residents and businesses have to do even more to address the serious health impacts on our communities and families. We should also remember that plants like clean air too. It is in the interests of agriculture, other businesses, and the whole Valley community to keep looking for win-win solutions that address both climate change and air quality.

We all want to have a better life, to be healthy, and to make the world a better place where our kids can thrive. We have to figure out solutions that are real, that work, that can be widely adopted, and that keep farmers in business.

John Diener's Red Rock Ranch consists of approximately 5,000 acres in Fresno County. He farms an array of high value row crops, using innovative approaches to land, water, and wildlife management. Mr. Diener was a member of the California Ag Leadership Class XX and received the prestigious Profile in Leadership Award in the Environmental and Natural Resources Stewardship category. He is the 2009 recipient of Leopold Conservation Award.

California agriculture faces a myriad of climate risks. Different crops can vary widely in their sensitivity to climate.[27] Risks exist for both crops and livestock. Box 2 provides a summary of some of the major climate risks to agriculture. Some of these risks are discussed in more detail below. Box 2 also provides a summary of ways to prepare for and to manage those risks. Risk management strategies are discussed further below.

Box 2

Climate Risks to Agriculture Include:	Risk Management Strategies Include:
(multiple risks may occur together) • Changing air temperatures including loss of chill hours (record warm temperatures are becoming more common) impacting both crops and livestock - with increases beyond optimal temperatures causing declining yield and losses • More extreme weather events (more frequent and severe drought, more intense storms, floods, etc.) • Changing water availability and quality from: loss of snowpack and natural water storage, sea level rise and saltwater intrusion, flood events and drought • Altered precipitation patterns and increased soil erosion • Changing pressures from weeds, diseases and insect pests • Changes in timing and coincidence of pollinator lifecycles • Changing ground level ozone and cloud cover • Heat impacts on agricultural workers • Damage or disruption to energy and transportation infrastructure supporting agricultural production • Increases in prices of agricultural inputs (e.g. increased feed prices) • Changes to quality of agricultural inputs (e.g. decline in forage quality)	***(multiple strategies may be used together)*** • Soil conservation practices and building soil health • Adjusting crop/livestock mix • Diversifying crop/livestock mix • Housing/shading for livestock to reduce heat stress • Use of innovative sustainable farm operation systems that integrate energy, water, and natural resource conservation • Avoiding crop and livestock production in high risk locations • Government provision of insurance, loss compensation, incentives and technical assistance to promote more resilient and sustainable farming and ranching systems • Adjusting farm operations and management practices to respond to changes in seasonal temperature and precipitation patterns • Technological and scientific innovation (e.g. new irrigation technologies, decision support tools, enhanced weather forecasting, etc.) • Enhancing water use efficiency • Water recycling • Watershed protection • Developing flood protection (e.g. through restoration or creation of wetlands, etc.) • Developing conjunctive underground water storage • Reduce non-climate stressors such as farmland conversion • Enhance education of employers, workers and labor contractors on the health risks of heat and preventative measures • Implementing management practices to store carbon in soils (e.g., carbon sequestration)

Temperature

Climate change is projected to change both average and extreme temperatures, and to change the timing of temperature fluctuation (e.g. night and day; seasonal changes). Overall, warming is expected on an annual, seasonal, and even daily basis, with impacts differing by region. The significant, overall outcome of warming is the likely reduction in yield of some of California's most valuable specialty crops.[28] For instance, many of California's fruit and nut crops evolved in climates with distinct seasons, and inadequate winter cold can cause late or irregular blooming which affects yields.[29]

Increasing air temperatures can also affect livestock production when temperature exceeds optimal levels. Heat stress in livestock can result in reduced pregnancy rates, longer time needed to reach market weight, and reduced milk production.[30]

Heat stress in workers may reduce productivity, and may lead to illness, disability, or death in extreme exposures.

Water

Crops are sensitive to the availability of water, the quality of water, and the timing of water application. California's different agricultural regions utilize different sources of water; for instance there is the snowpack/runoff dependent Central Valley, the groundwater and reservoir dependent Coastal areas, and the Colorado River dependent Imperial Valley. In general, and regardless of the source, water resources for agricultural irrigation could decrease and become more variable with risks of flooding expected to increase. Impacts will differ greatly by region. Risks include reduced precipitation (drought) or increased precipitation (causing flooding and soil erosion), decreased winter snowpack, altered timing and quantity of snowmelt and runoff, altered reservoir storage regimes, impaired water quality, salt water intrusion, and more variability and uncertainty.[31] For more information about climate impacts to water resources, please see the Water section of this document.

Box 3

California Department of Water Resources
January 1, 2006; Twitchell Island; flood impacts to corn crops

Invasive Plant Species, Insect Pests, and Pathogens

A changing climate creates new conditions that may change weed-infestation intensity, insect population types and levels, the incidence of pathogens, and the distribution of many of these pests. Such effects can impair agricultural production yields and quality, and may necessitate changes to existing management practices.[32] Any increased use of pesticides due to increased pest and disease pressure may have potential impacts on worker health and safety, community exposure, and impacts to ecosystem health.

Infectious Diseases and Food and Animal Safety

Some infectious diseases are transmitted to humans or other animals by insects or other animals (transmitting insects or animals are called "vectors"); and these types of diseases are called "vector-borne" diseases.[33] As noted in the Public Health section of this document, vector-borne diseases are among the most complex of all infectious diseases to prevent and control.[34] This complexity is attributable to the many factors that can contribute to the transmission, rate of transmission and evolution of such vector-borne diseases, including, but not limited to, the vector populations, the disease pathogens carried by the vectors, ecological and climate patterns, and human interaction with the vector population.[35]

Changes in temperature and precipitation associated with climate change may lead to changes in the spread of vector-borne diseases. Climate change may alter the number of disease-carrying vectors. For instance, in places where there is increased rainfall, there may be more standing water where mosquitoes can lay eggs.[36] A number of vector-borne diseases affect animals in California. For instance, Bluetongue is a vector-borne disease that threatens both domestic and wild ruminants in California (e.g. sheep and cattle); and climate change may have contributed to a dramatic recent expansion in global distribution of the bluetongue virus, most notably in Europe.[37] Horses are also susceptible to West Nile virus which is carried by mosquitoes.[38]

Everyone, from the farmer to the consumer, has a role in keeping food safe. Because of the numerous factors governing food safety, a causal link between climate change and increased risk of food-borne diseases has not yet been well-established. However, as noted in the Public Health section of this document, Salmonella and Camplyobacter display a distinct seasonal pattern that has been associated with climate variability (increased temperatures, heat waves, and flooding) and may thus be exacerbated by climate change.[39]

CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. CDFA's Animal Health and Food Safety Services and Emergency Animal Diseases Management Program[40] may play increasingly important roles in the era of climate change. For more information on climate and emergency management, please see the Emergency Management section of this document.

Compound Impacts and Other Risk Considerations

It is likely that multiple changing climate variables (temperature, precipitation, wind, cloud cover, humidity, etc.) and multiple risks (flooding, extreme heat, pests, weeds, etc.) will occur together or in sequence due to unmitigated greenhouse gas emissions. These compound impacts will be added to existing stressors on agriculture such as farmland conversion. Predicting and assessing the full impact of climate change on agriculture will require integrated studies of multiple factors. More accurate projections and better understanding of how various changes interact will help inform risk management strategies and increase efficient use of available resources.[41]

It should also be noted that catastrophic crop or livestock losses are likely to affect financial viability in a fundamentally different way than moderate losses over longer periods of time.[42]

In addition to extreme heat and storm events, climate change is also expected to increase the frequency and severity of wildfires and such fires may increase soil erosion and otherwise impact water supplies. For more information about wildfire, please see the Forestry section of this document.

Transportation and energy infrastructure supporting agricultural production and food distribution systems are also vulnerable to climate disruptions. For more information about such disruptions, please see the Transportation and Energy sections of this document.

Ground-level ozone is formed primarily from photochemical reactions between two major classes of air pollutants, volatile organic compounds and nitrogen oxides (so called 'ozone precursors'); and climate change is expected to result in more days of weather conducive to ozone formation in California. (For more information on expected impacts of climate change on ozone formation, please see the Public Health section of this document.) Ozone can have negative impacts on both crops and livestock. For instance, studies indicate that elevated ozone exposure reduces the yield of some crops and reduces the nutritional content of common grassland species used as forage for livestock.[43]

California, U.S. and global agricultural markets are highly interconnected. Therefore, climate changes impacting agricultural yield and production worldwide will have an impact in California. Changes in relative productivity between regions will matter to both California's agricultural producers and consumers. For example, if global yield effects are generally negative, this can drive global food prices up and may benefit California's agricultural producers, but may also negatively impact California consumer welfare.[44]

Risk Management Strategies

The vulnerability of agriculture to climate risks is strongly dependent on human responses to moderate those risks. Adaptive behavior can significantly reduce the potential negative impacts of climate change on food production, farm income, and food security.[45] As shown in Box 2, there are a variety of strategies for managing climate change risks to agriculture.

Adjustments existing management practices such as building soil quality to manage water and nutrient cycles, diversifying crop rotations to manage pest populations, integrating livestock with crop production systems to manage resource cycles, and other practices typically associated with agriculture help increase the resilience of agricultural systems in the face of impacts. While these management practices with multiple benefits help avoid or reduce productivity losses, there may be barriers or challenges with respect to their adoption. For instance, there may be costs associated with transitioning to lower risk areas or installing water use efficiency technologies and the extent of financing and credit availability may limit the adoption of such adaptive management actions. Adaptive responses may also be constrained by "path dependency" such as technological lock-in (arising from prior capital investments) which limits the pace of adoption of innovative technologies. Current policies are not well-designed to integrate climate risks into comprehensive planning efforts or to incentivize adaptive measures.[46]

Adequate preparation for climate risks will require continued development of information about risks to agriculture, the further development of management tools and strategies, and the dissemination of information and technical assistance to both policymakers and farmers and ranchers.[47]

Box 4

Food Security and Climate Impacts to California Agriculture

As California faces the twin challenges of climate change and population growth, our ability to feed our population will be challenged. At the current pace of population increase, every day our planet has approximately 220,000 new mouths to feed.[48] To keep up with the growth in human population, food production must double by 2050. More food will have to be produced over the next 50 years than has been during the past 10,000 years combined[49]. California, with its unique climate and production of nearly half of U.S.-grown fruits, nuts, and vegetables, is key to helping feed the state, the nation and the world,

California's goal is food security – access by all people at all times to enough safe and nutritious food for an active, healthy life. Conversely, food insecurity describes both reduced food intake as well as reduced quality, variety, or nutritional value of diet.[50] Thus, food insecurity can, paradoxically, be associated with poverty and obesity.[51] Healthy foods like fruits and vegetables are more expensive as compared to many other foods that may be high in calories but low in nutritional value. In addition, access to fresh produce may be unavailable in low-income neighborhoods.[52] An economically stressed family may face limited choices as to their ability to purchase sufficient nutritious food.

In 2009, 3.8 million adults in California, especially those with children and low-incomes, could not put enough food on the table. The highest rates of food insecurity across California were observed in the San Joaquin Valley, some Bay Area communities, as well as in Shasta, Butte, Sutter, Yuba, Ventura, San Bernardino, Orange and Riverside counties.[53]

Negative climate impacts on California agriculture may cause price increases in foods that are important to food security.[54] Price increases for healthy foods may further exacerbate our food insecurity issues.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

The California Department of Food and Agriculture (CDFA), in partnership with the other state agencies, producers, research institutions, local government, non-profit organizations and other entities, are developing strategies and programs to prepare for climate risks to California's agricultural resources.[55] Some of the initial activities are described below.

California Agricultural Vision

In 2008, the State Board of Food and Agriculture inaugurated California Agricultural Vision (CAV) as a process to develop a strategic plan for the future of the state's agriculture and food system. Its motivation was the rapidly growing list of challenges facing agriculture, from regulations and water supplies to urbanization and climate change. After holding public listening sessions, the State Board adopted a Vision to serve as the framework for the plan. The Vision focuses on three basic goals:

- Better Health and Well-being - Meeting the Nutrition Needs of California's Diverse Population;
- A Healthier Planet - Agricultural Stewardship of the Natural Resource Base upon which California and Food Production Depend; and
- Thriving Communities - Food Production as a Driver of Sustainable California Economic Growth.

California Agriculture Vision: Strategies for Sustainability ("Ag Vision") was released in December 2010.[56] Ag Vision identified 12 major challenges for California agriculture along with strategies to address them. One of the challenges is climate change. However many of the other challenges that are identified directly overlap or relate to climate change - including adequate water supply, curtailing invasive species, farmland and water conservation, environmental stewardship, and the promotion of regional markets.

Since the release of Ag Vision, Ag Vision Advisory Committee has continued progress on the strategies and action items within the report to ensure a vibrant future for the state. In April 2012, CDFA released a report detailing progress to date.[57]

Climate Change Consortium for Specialty Crops

As an extension of Ag Vision, in August 2012, CDFA announced the formation of a Climate Change Consortium.[58] The Climate Change Consortium met four times during 2012 and 2013 to hear from researchers on the impacts of climate change such as increasing temperatures, changing precipitation patterns and water availability, increased pest pressures, and pollination concerns. The Consortium made recommendations for climate change adaptation drawing from their varied backgrounds as growers, researchers, and representatives from agricultural associations. The Consortium's recommendations fall into five categories: 1) On-farm strategies to improve resilience, 2) Planning and Resource Optimization, 3) Research Needs, 4) Outreach and Education, and 5) Technology and Innovation. The on-farm strategies are directed toward growers and include practical ideas such as diversifying farming operations, utilizing irrigation and water conservation plans, and considering best management practices that can help attract beneficial predators and pollinators.

The October 2013 final report, *Climate Change Consortium for Specialty Crops - Impacts and Strategies for Resilience*, is directed toward a large audience, including growers, researchers, and agency partners with the purpose of guiding CDFA and its partners in future activities and reducing agriculture's vulnerability to climate change.[59] Implementation of all the recommendations crafted by the Climate Change Consortium will be important; the recommendations below in the "Actions Needed to Safeguard Agriculture" section of this chapter were adopted from the recommendations made by the Climate Change Consortium.

CDFA Environmental Science Farming Panel and Ecosystem Services Database

In August 2011, CDFA convened the Environmental Farming Act Science Advisory Panel. The Panel is charged with reviewing and documenting agriculture's positive impacts to the environment. The Panel recognizes the importance of environmental stewardship practices in agriculture. Its current work focuses on incentives and evaluation of ecosystem services (defined as the multiple benefits gained from farming and ranching including crop and livestock production).[60] As part of the Environmental Farming Act, with consultation from the Science Advisory Panel, an Ecosystem Services Database has been developed.[61] The information contained in this database is collected from farm and ranch websites and on-line case studies. The database can be queried by key word and categories as well as through an interactive map.

The database is designed to communicate, to a wide audience, the many social and environmental benefits offered by farms and ranches in California, including food production.

California-Federal Task Force on Dairy Digesters

Agriculture has the ability to reduce the sector's contribution to greenhouse gas emissions (e.g., approximately 6 to 7 percent of California's total emissions are attributed to the agricultural sector) that cause climate change in a variety of ways. For instance, California is the largest dairy state in the USA, with approximately 1.7 million cows producing more than 3.6 million dry tons of manure per year that must be managed to reduce or mitigate environmental impacts. One way of reducing greenhouse gases is to process manure in anaerobic digesters to produce biogas, a flexible renewable source of energy and fuel.[62]

In 2011, representatives from USDA NRCS, USEPA and CDFA convened the California-Federal Task Force on Dairy Digesters to examine the lack of dairy digesters on California dairies. The three working groups of the task force finalized recommendations to reduce economic, technical and regulatory hurdles currently in place in order to make digester systems more feasible in California. The implementation of those recommendations has included, among other things, increasing the feed in tariff for biogas and consolidating permitting processes and clarifying permitting requirements.[63]

California Bioenergy Action Plan

As noted above, California has enormous potential to create energy from organic by-product materials. The *2012 Bioenergy Action Plan* outlines strategies, goals, objectives, and actions that California state agencies will take to increase bioenergy development in California. Pursuant to the 2012 Bioenergy Action Plan, CDFA is, among other things, leading efforts to develop and implement actions that will enhance the economic, regulatory and technical viability of dairy digesters and co-digestion of other agricultural byproducts.[64]

Agricultural Offsets and Agriculture in Climate Policy

In October 2011, the California Air Resources Board (ARB) adopted the nation's first economy-wide cap-and-trade regulations. As part of the cap-and-trade program, ARB has adopted a Livestock Projects Compliance Offset, recognizing the greenhouse gas benefits of manure management systems.[65]

CDFA, ARB and other governmental partners are continuing ongoing discussions with stakeholders about opportunities for agriculture in climate change policy. The discussion focuses on identifying the role of greenhouse gas emissions from agricultural practices; developing strategies on best practices to mitigate climate change; agricultural offsets; and pursuing incentives and recognition for best practices to support climate change policy. Incentives may include voluntary carbon market compliance, U.S. Farm Bill conservation programs, supply chain initiatives, ecosystem services, and emission reductions to support CEQA mitigation. For more information on federal climate accomplishments related to agriculture, please see Box 5: USDA Action to Prepare for Climate Risks to Agriculture.

Box 5

USDA Action to Prepare for Climate Risks to Agriculture

USDA Climate Adaptation Plan

The U.S. Department of Agriculture (USDA) Climate Change Adaptation Plan presents strategies and actions to address the effects of climate change on USDA's key mission areas including agricultural production, food security, rural development, and forestry and natural resources conservation. The USDA Climate Change Adaptation Plan includes input from eleven USDA agencies and offices. It provides a detailed vulnerability assessment, reviews the elements of USDA's mission that are at risk from climate change, and provides specific actions and steps being taken to build resilience to climate change. The plan advances efforts to integrate climate change adaptation planning into the actions of the federal government. [66]

Report on Climate Effects and Adaptation Strategies

In February 2013, USDA released a report synthesizing the scientific literature on climate change effects and adaptation strategies for U.S. agriculture. The report is entitled Climate Change and Agriculture: Effects and Adaptation.[67]

Research to Prepare for Changing Climate Conditions

USDA is supporting a variety of climate-related research. For instance, researchers at the USDA Agricultural Research Service (ARS) are developing heat-tolerant varieties of spinach and lettuce to ensure California will continue to provide important specialty crops to consumers.[68]

USDA is also working to support efforts to reduce the greenhouse gas emissions that cause climate change. In August 2013, USDA released for public comment a new report that outlines a set of scientific methods for quantifying greenhouse gas emissions and carbon storage at the local farm, ranch or forest scale.[69]

Efforts to Preserve the Genetic Diversity of Crop Species

As further described in the Biodiversity and Habitat section of this document, a number of efforts have begun to systematically collect and preserve genetic material in recognition of the risk of biodiversity loss from threats such as climate change. The mission of the USDA ARS National Center for Genetic Resources Preservation (NCGRP) is to acquire, evaluate, preserve and provide a national collection of genetic resources to secure the biological diversity that underpins a sustainable U.S. agricultural economy through diligent stewardship, research and communication.[70] For instance, noting that 20% of the world's livestock breeds are at risk of extinction, and that such a contraction limits the flexibility of livestock producers to respond to future biological or economic challenges, the USDA Plant and Animal Genetic Resources and Preservation Research Unit is continuing the development of germplasm and tissues collections for all major livestock species in the U.S., so that industry and the research community can access these resources at any time. Genetic preservation efforts will be important for food security and the economic vitality of the agriculture sector.[71]

Climate Hubs

In February 2014, USDA announced the creation of seven regional climate hubs and two sub-hubs, including a Southwest sub-hub in Davis, California. The Climate Hubs will build on the capacity within USDA to deliver science-based knowledge and practical information to farmers, ranchers and forest landowners to help them adapt to climate change and weather variability. The Hubs will build capacity within USDA to provide information and guidance on technologies and risk management practices at regional and local scales.[72]

Invasive Species Preparation and Response

As noted in the Biodiversity and Habitat section of this document, climate change may result in species migration, range shift, and novel combinations of species, and as discussed above agriculture may face changing pressures from invasive pests, weeds and diseases. These changes will occur against a backdrop where global trade is increasing over time, and more opportunities will arise for the introduction and establishment of invasive species through California, the nation's trading hub. In 2011, the Invasive Species Council of California (ISCC), comprised of six state agencies, approved *Stopping the Spread: A Strategic Framework for Protecting California from Invasive Species*. The Framework recommends a number of actions, including creating and funding a Rapid Response Work Group to guide response to new invasive species. The ISCC created the California Invasive Species Advisory Committee (CISAC), a stakeholder body, to advise the council and develop recommendations, which included developing the Strategic Framework and the 2013 Update and presenting them to the ISCC. The ISCC is planning to update the Framework by the end of 2014.[73]

CDFA is also preparing a Statewide Plant Pest Prevention and Management Program Environmental Impact Report (PEIR). The goal of this statewide program is to create a vehicle that provides a time-sensitive and efficient framework for evaluating potential environmental impacts of invasive pests and the pest management activities implemented by CDFA and its partners.[74]

Agricultural Research

CDFA, through its Specialty Crop Block Grant Program (a USDA program), is funding research to identify risks, develop adaptation measures and provide information to producers in adapting to climate change. California's leading research institutes, enabled in part by CDFA funding, are studying crop chilling, heat requirements, crop phenology, and furthering our understanding of the effect of agricultural management practices on greenhouse gas emissions.[75] CDFA's Fertilizer Research and Education Program is also funding and facilitating research into how to reduce nitrous oxide greenhouse gas emissions from nitrogen application fertilizers.[76] CalRecycle and CARB are collaborating on research that includes investigating GHG emissions or emissions reductions from the application of finished compost to agricultural soils.

The state's Climate Change Assessment program has also enabled research specifically focused on climate impacts to California agriculture. The Second Climate Change Assessment included six agriculturally-focused studies, and the Third Climate Change Assessment included three studies, including initial efforts to examine climate impacts and strategies for specific regions in California such as Yolo and Fresno County.[77]

Protecting Agricultural Land

As noted above, the risk of significant climate changes is present against a backdrop of other stressors to California's food and agriculture, including significant loss and conversion of agricultural land. Farm and grazing lands in California decreased by more than 1.3 million acres between 1984 and 2008. This loss averages about one square mile every four days.[78] Farmland protection is an important strategy for reducing stressors on agricultural production as climate risks escalate. Furthermore, protecting farmland from conversion can otherwise reduce California climate risks by helping to ensure food security, providing habitat and corridors for wildlife, and helping with flood mitigation and groundwater recharge. Protecting farmland can also have significant greenhouse gas benefits; one study has indicated that urban land produces seventy times more greenhouse gas emissions per acre than cropland.[79]

Land use planning in California occurs mostly at the local or regional level, and local and regional governments are key partners for the state with respect to farmland protection. The California Land Conservation Act of 1965--commonly referred to as the Williamson Act--enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. The Open Space Subvention Act of 1971 provided local governments an annual subvention of forgone property tax revenues from the state through the year 2009; however, these payments have been suspended in more recent years due to revenue shortfalls.[80]

The California Farmland Conservancy Program (CFCP), a grant-funding program run by the California Department of Conservation, has successfully conserved over 56,000 acres of California farmland since 1996.[81] The CFCP provides grants to local governments and qualified non-profit organizations. These grants support local efforts and planning projects that protect agricultural land resources. The State of California Wildlife Conservation Board also administers the Rangeland, Grazing Land and Grassland Protection Program which has supported conservation easements intended to prevent rangeland conversion, protect livestock grazing, and sustain the related water quality and open-space benefits of grazing practices.[82] Funding for both the CFCP and Rangeland, Grazing Land and Grassland Protection Program has diminished significantly in recent years.

In April 2012, Fresno City Council voted to support a 2035 General Plan Update that supports farmland protection and smart growth principles that contain sprawl. At the City Council meetings on the 2035 General Plan Update, there was a wide and diverse support base for the smart growth approach.[83] This is a significant step for a large city surrounded by some of the state's best agricultural land. Smart growth can also reduce the greenhouse gas emissions that cause climate change, both by reducing vehicle miles traveled and by preventing conversion of agricultural lands to urban lands which have a significantly higher greenhouse gas footprint.[84]

Other innovative planning projects that will help protect agricultural land and resources are also underway. For example, the Sacramento Area Council of Governments (SACOG) is undertaking the Rural Urban Connection Strategy (RUCS), which is creating an agricultural mapping tool that will be integrated into its model used for urban land use analyses. The project is evaluating the greater Sacramento area's growth and sustainability from a rural perspective – and will ultimately be the region's economic and sustainability strategy.[85] The San Joaquin Valley Greenprint will compile information describing the lands, waters and living resources of the San Joaquin Valley region and the trends affecting them, in order to reinforce local efforts and serve as a guide to local, state, federal and private sector decision-makers as they make choices about the future of the Valley's agricultural resources.[86]

Heat and Agricultural Worker Safety

As noted throughout this document, climate change is expected to bring more frequent and more severe weather events, including more extreme heat events. Since 2005, California employers have been required to provide services that protect outdoor workers— adequate water, shade, rest breaks, training and emergency procedures. In 2010, the standard was strengthened to include a high heat provision that must be implemented by five industries (agriculture, construction, landscaping, oil and gas extraction and transportation or delivery of agricultural products, construction material or other heavy materials) when temperatures reach 95° F and above. These enhancements included mandates to remind employees to drink water more frequently, to observe employees for signs and symptoms of heat illness, to ensure effective communications to summon help if needed, and to provide close supervision of new employees.[87] For more information on heat and health, please see the Public Health section of this document.

Improving Water Management in California

As further discussed in the Water chapter of this document, pursuant to SB 7x7, or the Water Conservation Act of 2009[88], DWR, in consultation with the California Agricultural Water Management Council, academic experts, and other stakeholders, developed a proposed methodology for agricultural irrigators, farmers and ranchers to use in quantifying the efficiency of agricultural water use and a plan of implementation that includes estimated implementation costs, roles and responsibilities, and types of data that would be needed to support the methodology. "A Proposed Method for Quantifying the Efficiency of Agricultural Water Use: A Report to the Legislature" was released in May 2012.[89]

In 2009, the Governor and Legislature also enacted SB 7x6, which requires the reporting of groundwater levels to DWR.[90] Specific recommendations for improving water use efficiency, preparing for hotter and drier conditions, supporting regional groundwater management for drought resilience, and other water-related recommendations to respond to climate risks are discussed in the Water chapter of this document.

<u>Resource Conservation Districts – Mobile Irrigation Labs and Mobile Water Labs</u>

Resource Conservation Districts (RCDs) are "special districts" set up under California state law for the control of runoff, the prevention or control of soil erosion, the development and distribution of water, and the improvement of land capabilities.91 The lands included in a district shall be those generally of value for agricultural purposes, including farm and range land useful for the production of agricultural crops or for the pasturing of livestock, but other lands may be included in a district if necessary for the control of runoff, the prevention or control of soil erosion, the development and distribution of water, or land improvement, and for fully accomplishing the purposes for which the district is formed. Many RCDs offer Mobile Irrigation Labs or Mobile Water Labs that perform on-farm water use evaluations to improve irrigation efficiency and awareness of water conservation tools.92

ACTIONS NEEDED TO SAFEGUARD AGRICULTURE

As described above, important first steps have been taken to help protect California agriculture from climate risks. Ensuring the sustainability of food production in the face of climate risks will require a concerted collaborative effort by farmers and ranchers, government agencies, agricultural service organizations, research institutions, and other partners. Such efforts will be important to safeguard California's agricultural production and economy, and will be important to food security in California, the nation, and the world. Recommended actions are described in more detail below.

Developing and promoting adoption of management strategies and systems that reduce climate risks to agriculture

Actions to develop and promote adoption of management strategies with multiple benefits that reduce climate risks to agriculture will be important, these may include:

- Developing new and adapting existing best management practices that reduce climate risks, including, for example, soil conservation practices and practices that support pollinator health;
- Developing incentive programs for sustainable, science-based practices that create resilience to climate impacts, including pilot-projects to demonstrate proof-of-concept;
- As further discussed in the Water section of this document, management strategies that reduce climate risks to water are needed including, but not limited to, enhanced flood management, water use efficiency, and regional groundwater management for drought resiliency;
- Reducing the rate of farmland conversion to buffer against climate risks to food production by supporting smart growth and reducing urban sprawl, and supporting farmland conservation;
- While continuing breeding research as discussed above, also supporting efforts to systematically collect and preserve agricultural genetic material in recognition of the risk of agricultural biodiversity loss from climate change;

- Investing in and improving agricultural equipment to be adaptable between crops to facilitate shifting crop patterns and to optimize capital investments in the face of changing climate conditions; and
- Working with industry to develop new technologies for field-level monitoring of climate impacts, including, for example pests.
- Provide technical assistance and financial incentives to farmers and ranchers implementing climate resilience strategies and systems.

Understanding and responding to evolving trends that relate to agriculture

Changing climate risks and emergency management
CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As noted in the Emergency Management section of this document, climate change is likely to require improvements emergency preparedness and response capacity. As discussed above, climate change has implications for infectious diseases and food and animal safety. It will be important to ensure that CDFA has adequate support and capacity to respond quickly to emergencies related to food and feed safety and agricultural diseases and pests.

Supporting new revenue streams for agriculture that support positive climate action
Climate change threatens the California agricultural sector with economic losses, and the ability to develop new revenue streams may help provide added fiscal resilience for California farmers and ranchers. Activities that generate new revenue streams may themselves help foster positive action on reducing the emissions that cause climate change, and help to build resilience against climate risks. For instance, as discussed above, the development of anaerobic digesters and co-digestion of agricultural by-products can provide flexible, renewable energy and help with waste diversion goals. Developing incentives for agricultural ecosystem services, such as beneficial soil practices (for example, cover crops, tillage practices, and the use of compost), can provide greenhouse gas and water quality benefits, and such practices can also foster greater resilience in the face of climate impacts (for instance by improving soil moisture during hotter, drier conditions).

Cross-sectoral climate impacts
Climate risks to other sectors are important to agriculture. Climate risks to water and management strategies to address those risks are obviously important to agriculture. Impacts in other sectors are also important, for instance, impacts to the energy system can disrupt agricultural production, impacts in the transportation sector can have critical implications for agricultural goods movement, and climate impacts to biodiversity and habitat may have impacts on species that are beneficial to agricultural production.

Furthermore, impacts to the agricultural sector can have important implications for other sectors. For instance, increasing temperatures, may require increased energy or water consumption for agriculture (for instance, to enhance or provide livestock cooling systems). As discussed in this chapter, declining agriculture productivity or price increases related to climate impacts may also have impacts on public health. Cross-sectoral collaboration and engagement will be increasingly important in the era of climate change.

Support risk sharing mechanisms that protect food security and California's agricultural sector

As discussed in the Emergency Management section of this document, insurance and disaster relief are important risk sharing mechanisms that can help foster resilience, especially when combined with other efforts to reduce climate risks. However, federal program spending on the types of crops grown in California remains a small fraction of that spent on crops, like corn, wheat, soy, and cotton, which are predominantly grown in other parts of the nation. Climate risks to California's crops and livestock not only threaten California's agricultural sector and economy, climate impacts may cause price increases in healthy foods, like fruits, nuts, and vegetables, that are important for food security in California, the nation, and the world.

California should continue to support national policy reforms that would provide crop insurance and disaster assistance safety net programs to all commodities, and ensure that California farmers and ranchers have access to these types of important risk sharing mechanisms.

Improving Understanding of Climate Impacts on Agriculture

<u>Research, Modeling and Monitoring</u>
Some important work has been completed with respect to research and modeling projected climate impacts to agriculture, but more remains to be done. Needed actions include, but are not limited to:

- Studies of infrastructure and capital associated with relocating crops or shifting between crops; and economic studies of crop relocation or crop shifting, including comparative cost studies of moving or losing certain crops;
- Studies that evaluate the climate benefits of organic materials as soil amendments, such as compost, biochar, and digestate;
- Research supporting the beneficial use of agricultural by-products for renewable energy and organic fertilizers;
- Studies to quantify carbon sequestration and water saving potential of compost use in agricultural setting such as irrigated croplands and rangelands;
- Cumulative impact studies: As discussed in this chapter, agriculture faces multiple changing climate variables and multiple climate risks, and these threats occur against the backdrop of other stressors such as farmland conversion. More research is needed to understand the compound and cumulative impacts of these risks, to develop more accurate projections to inform risk management strategies. Research is needed on the cumulative impact of farmland conversion on adaptive capacity and food security;
- More crop-specific and location-specific studies of climate risks, and modeling projections of productivity effects and impacts to help facilitate the development of

specific, actionable management activities to reduce climate risks (e.g. strategies for salt water intrusion for agriculture located in areas susceptible to such risks);

- Plant and animal breeding research, including research on pest and disease resistance, drought resistance, heat and chill resilience, and stress tolerance;
- Research on changing water needs for agriculture in times of more sustained higher temperatures and extreme heat events;
- Research on climate impacts on vector-borne diseases in animals, along with action to preserve and enhance monitoring, testing and reporting capacity for such diseases, especially in light of reductions in federal funding from the Centers for Disease Control and Prevention for such activities;
- Research on climate change risks to food safety;
- Research on temperature changes and other climate stresses on livestock;
- Further research on temperature changes and other climate stresses on crops;
- Further studies on barriers to efforts to prepare for climate risks and ensure the long-term sustainability of California agriculture, including possible strategies for overcoming such barriers;
- Creating an online "research needs" forum where agricultural stakeholders, including farmers, ranchers and industry groups, can share their needs, observations, and ideas directly with scientific researchers; and promoting cooperative research that involves farmers and ranchers in the research process, including "on-farm" research projects;
- Studies of the economic and social risks of negative climate impacts on California agriculture;
- Further research on climate impacts on weeds and invasive plant species, insect pests, and pathogens affecting crops;
- Further research on climate impacts on pollinators, including native pollinator species;
- Studies of the ability of California's beneficial species to control new or worsening invasive species problems; and
- Studies of the effectiveness of different cropping practices, e.g. organic, crop rotation, fertilization, for addressing climate risks to agriculture.

Visualization Tools

Climate research and data will need to be translated into tools that can be used by agricultural producers involved with on-the-ground management of agricultural resources. Tools may include:

- An early effort at mapping California agricultural vulnerability was developed as part of the Third Climate Change Assessment[93], but the mapping effort needs to be refined to consider additional variables and more fully assess the vulnerabilities to California's water resources and livestock systems in a spatially explicit manner, and to modify the mapping to accommodate future projections of climate, land use, and socio-economic variables;

- Vulnerability maps showing projected climate risks to California agriculture, should be integrated in state visualization tools such as Cal-Adapt and the California Geoportal;
- Climate risk visualization tools tailored more specifically to agricultural producers should be developed, supported, maintained, and publicized.

Outreach and Education

It will be important to disseminate information regarding the results of continuing research on climate risks to agriculture, the development of best management practices for dealing with such risks, and any expanded business, funding, or risk sharing opportunities that can enhance resilience. This information must be shared with farmers and ranchers, decision makers, and other partners in a format that is easily accessible and readily usable in order to promote timely action to protect agricultural resources from climate risks.

Efforts to foster this type of outreach and educational might include:

- Working collaboratively with partners (such as USDA Climate Hubs, USDA Natural Resources Conservation Service, University of California Cooperative Extension, Resource Conservation Districts, and the California Agricultural Commissioners and Sealers Association) to provide information on climate risks as well as financial and technical assistance to farmers and ranchers interested in adopting practices that create resilience against climate risk;
- Establishing an international exchange program to facilitate the learning and adoption of new tools and techniques to create resilience in farming and ranching in the face of climate risks;
- Developing a comprehensive list of adaptation strategies that have worked throughout the world to reduce climate risks to agriculture, and promote such strategies in California if relevant and useful;
- Hosting a recurring conference focused on preparing for climate risks to agriculture for farmers, ranchers, researchers, government agencies, and other partners;
- Continuing integration of agricultural climate risk considerations into broader state efforts to prepare for climate risks;
- Recognizing and publicizing the efforts of innovative farmers and ranchers who are proactive in preparing for climate risks and adopting practices that foster resilience; and
- Providing online materials, in addition to the visualization tools discussed above, regarding climate risks to agriculture (such as changing water availability, extreme weather events, loss of winter chill and other temperature changes, possible shifts in pests and disease, possible shifts in pollinator lifecycles, etc.).

Box 6

California Food and Agriculture

Several state entities play an important role with respect to food and agricultural in California. The state also has important federal, local and private sector partners. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks.

California Department of Food and Agriculture (CDFA) serves the people of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Conservation (DOC) among other things, DOC works to safeguard farmland and open space resources.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. The health of forested watersheds is important to California's water supply and water quality.

California Department of Public Health (CDPH) works with partners to implement outreach for CalFresh: California's Supplemental Nutrition Assistance Program which is funded by the U.S. Department of Agriculture. CDPH also has a number of other nutrition and food safety programs.

California Department of Water Resources (DWR) is responsible for managing and protecting California's water resources and supplies.

California Department of Resources Recycling and Recovery (CalRecycle) - part of CalRecycle's mission is to increase the diversion of organic materials from landfill disposal for beneficial uses such as compost and energy production.

Invasive Species Council of California (ISCC) is an inter-agency council that helps to coordinate and ensure complementary, cost-efficient, environmentally sound and effective state activities regarding invasive species. The ISCC is chaired by the Secretary of the California Department of Food and Agriculture and Vice-Chaired by the Secretary of the Natural Resources Agency; its members include the Secretaries from the California Environmental Protection Agency, California Business, Transportation and Housing Agency, California Health and Human Services Agency, and California Office of Emergency Services.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards.

Wildlife Conservation Board (WCB) administers the Rangeland, Grazing Land and Grassland Protection Program.

California has important federal partners with respect to food and agriculture including: the **U.S. Department of Agriculture (USDA)** which provides leadership on food, agriculture, natural resources, rural development, nutrition, forest management, and related issues based on sound public policy, the best available science, and efficient management, and the **Bureau of Land Management (BLM)** which manages livestock grazing on 155 million acres of public lands as guided by Federal law. California also has many important local government partners, including the **County Agricultural Commissioners and Sealers (CACASA)**, as well as private partners on food and agriculture.

BIODIVERSITY AND HABITAT

INTRODUCTION

Climate-related changes are adding pressure to ecosystems already stressed by habitat loss and fragmentation, pollution, disease, population growth, and other human-related impacts. This added pressure is significantly increasing the risk of biodiversity loss and species extinction. Healthy ecosystems and ecological processes provide a variety of benefits including, but not limited to, clean air, clean water, carbon storage, crop pollination, and recreational opportunities such as hunting, fishing, and wildlife viewing. Biodiversity resources are also an important part of the cultural heritage of communities. These are but a few of the many benefits, sometimes referred to as 'ecosystem goods and services' that are enjoyed by California residents and at risk of being negatively impacted by climate change.

The specific implications of climate change for biodiversity and ecosystem goods and services may vary by region, and research is improving our understanding of the potential impacts and projected risks in California. Some of the major challenges facing the biodiversity sector that are being exacerbated by climate change include the accelerated spread of invasive species that negatively impact native species and ecosystem processes, barriers to species migration or movement in response to changing climatic conditions, direct impacts to species health, and mismatches in timing between seasonal life-cycle events such as species migration and food availability. These potential impacts could have serious implications for the ecosystem services described above. Timely action is needed to address these risks.

California state agencies and partners have made important progress with respect to preparing for risks to biodiversity, including groundbreaking collaborative efforts. California agencies and partners have worked together to build a collective vision for how to address climate-related risks to biodiversity through national and regional planning efforts. Since 2009, an abundance of climate research projects and tools have been developed by numerous organizations to help visualize and improve our understanding of climate impacts and the vulnerabilities of fish, wildlife, and habitats. Perhaps most importantly, climate change is becoming an integral part of on-the-ground restoration and conservation activities. Since California habitats are owned and managed by a variety of different entities including federal, state, and private landowners, continued collaboration is particularly important to effective efforts to protect California habitat and biodiversity in the face of escalating climate-related risks. More remains to be done.

Some on-going resource management efforts, such as conservation and restoration efforts, help reduce stressors on ecosystems. However, as temperatures and water availability are changing in California, new efforts are needed to adequately safeguard California's natural resources. For instance, one of the primary means by which species are expected to respond to climate change is to adjust their geographic ranges to track shifting areas of climatic suitability. Therefore, there will be an increasing need to ensure that there are linkages, or 'connectivity', between habitat areas to facilitate the movement of species. Additional research is needed to support these efforts and to continually improve our understanding of climate impacts and risks to biodiversity. Monitoring of baseline species and habitat conditions and changes on the landscape will be necessary to support adaptive management, and education and outreach efforts will be key to communicating risks and gaining public support for action. To face these risks in a cohesive and effective way, environmental stewardship must be practiced across state agencies.

Several state entities play an important role with respect to biodiversity and habitat in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. For more information, see Box 15: *Entities Responsible for California's Biodiversity and Habitat at the end of the chapter.*

Box 7

Declining snowpack and the loss of a fly fishing dream
By William Geer [Used with permission]

The course of my career was pretty well set in July 1958 when I caught my first limit of rainbow trout from Pinecrest Lake up on Sonora Pass in the Sierras. My love for fishing culminated in a career as a professional fisheries biologist in which I have been able to devote field work and research into what makes or breaks good trout waters. I was raised in Salinas far from the Sierra trout waters, but dreamed of one day living along a good trout stream in the mountains.

Now about to retire, I am living my boyhood dream next to a wonderful little trout stream in western Montana – Lolo Creek – where I have enjoyed catching rainbow, brown, brook and cutthroat trout on flies all summer and fall. I figured I finally arrived at where I wanted to be, at least until a few years ago when I walked down to the stream one day in August and found no water – and no trout – in the channel.

The stream had not been drained dry by manmade diversion; it simply ran out of snowmelt. The late summer flows in Lolo Creek that had always been sustained by prolonged snowmelt from the Bitterroot Mountains were gone, victim to snowpack that has declined 17% over the past 50 years due to a changing climate. Even with an increase in spring rains, which do not sustain late summer streamflows, I see the damage that a 17% decline in snowpack has done for fish and fishing in Lolo Creek. I wonder about the consequences of a predicted 25% reduction in snowpack in California. Less snow and more rain have become a west-wide pattern in recent years.

Over the last several years as a fish and wildlife professional, I have focused almost entirely on the impacts of climate change on fish and wildlife, its implications for sustainable hunting and fishing, and on-the-ground adaptation projects that will help fish and wildlife survive in viable populations in the changing environment. I have examined the state-specific impacts of climate change in Montana, Washington, Oregon, Colorado and New Mexico.

In my little neighborhood stream, the reduced snowpack has become evident in both declining June runoff and loss of August streamflows. August is often the worst month in western trout streams due to low flows that confine trout populations in reduced habitat areas and higher water temperatures that exceed the upper limits of tolerance for cold-adapted native species like cutthroat and rainbow trout. A new research study in Wyoming, Montana and Idaho shows that the problem of declining August streamflows in trout-supporting streams is widespread.

I also fish for native Yellowstone cutthroat trout in the fabled Yellowstone River. The larger Yellowstone River also suffers from climate-driven lower runoff and August streamflows. The warmer water in August has allowed an upstream invasion of nearly 40 miles by warmwater smallmouth bass that have displaced native cutthroats that cannot tolerate the warmer water. The displacement of coldwater trout by invasive warmwater species like bass has become common in rivers and streams throughout the West the last 20 years.

Observations on climate impacts on western streams and trout populations have been made in all western states, and the outlook is not good. New research by fishery scientists in Trout Unlimited and state fish and wildlife agencies forecasts the effects of climate-altered streamflows and higher water temperatures on four species of trout on nearly 250 million acres across the Intermountain West based on fish surveys at 9,890 sites. Projections show a 47% decline in total suitable habitat for all trout by the 2080s. Habitat for brook trout and brown trout is predicted to decline by 77% and 48%, respectively. Cutthroat trout are predicted to lose a further 58% of habitat due to higher temperatures and negative biotic interactions with other fish species more tolerant of warming water.

It is expected that climate impacts on inland California trout streams such as those in the Sierra Nevada Range – the waters most immediately affected by less snow, more rain and warmer water – will mirror the impacts already observed in Montana, Colorado, New Mexico and eastern Washington and Oregon.

I won't be the only fly fisher losing a dream because of climate change in California and throughout the West.

Bill Geer worked for the Theodore Roosevelt Conservation Partnership from 2005 until his retirement in 2013. Bill served as the Director of Western Lands and Climate Change Initiative Manager for the Theodore Roosevelt Conservation Partnership. After earning a B.S. from the University of Montana School of Forestry and a M.S. degree in limnology from Montana State University, Bill spent 40 years as a professional fish and wildlife conservationist. He served as Chief of Fisheries and Director of the Utah Division of Wildlife Resources, Coordinator for the North American Waterfowl Management Plan for the National Fish and Wildlife Foundation, Vice President for both Field Operations and Conservation Programs for the Rocky Mountain Elk Foundation, Inland Northwest Conservation Manager for the Nature Conservancy in Idaho, Executive Director of the Outdoor Writers Association of America, and Special wildlife adviser to both Senator Jon Tester and to the Wildlife Conservation Society. Bill is from Salinas, California and is a well-respected leader in the hunting and fishing community.

Risks, Challenges and Opportunities with Respect to Safeguarding Biodiversity and Habitat

Impacts and Risks

Climatic changes are resulting in changes in biological systems. Changes to air and water temperatures, changes to water quality and availability, sea level rise, ocean acidification, aquatic hypoxia, and altered wildfire regimes are some of the changes that are affecting biological systems.[94] (For more information on ocean acidification and sea level rise, see the Ocean and Coastal Ecosystems and Resources section of this document. For more information on the impact of temperature, precipitation and other climate changes on tree species, please see the Forestry section of this document.) Recent research since 2009 has revealed that climate change related increases in extreme events such as fire, drought, flood, extreme temperatures, and storm events could have significant impacts on habitat, species, and human communities. [95]

Box 8

Ocean Acidification: Implications for Biodiversity

Ocean acidification is impacting the biological diversity of our oceans. As the oceans become more acidic, organisms that use calcium carbonate to construct skeletons and protective structures are especially at risk since acidic conditions can inhibit shell formation.[96] (*See also Ocean and Coastal Ecosystems and Resources Chapter narrative "Seeing is believing: shellfish growers confront ocean acidification").* Ocean acidification can also negatively affect fish larvae.[97] Ocean acidification threatens to disrupt marine food webs, and may lead to changes in fish stocks that threaten food security.[98]

Photo credit: David Liittschwager/National Geographic Stock. Used with permission.

The photos above show what happens to a pteropod's shell when placed in sea water with pH *and carbonate levels projected for the year 2100. The shell slowly dissolves after 45 days. It should be noted that this photograph is provided for illustrative purposes; ocean acidification is occurring over time and the capacity of species to adapt to the pace and scale of acidification is the subject of ongoing research.*

Climate changes impact ecosystems and species in a number of ways, and add to pressures on ecosystems already stressed by habitat loss, pollution, and other human-related impacts. The 2009 California Climate Adaptation Strategy[99] provides detailed information on projected impacts and risks to biodiversity. Notable impacts and risks include[100]:

1) Species migration in response to climatic changes, range shift, and novel combinations of species; the population distributions of some North American species are expected to move northward in latitude and upward in elevation. While this means a range expansion for some species, for others it means a range reduction, movement into less hospitable habitat, or increased competition. For instance, a USGS study indicates that temperature increases resulting from climate change in the Southwest will likely eliminate Joshua trees from 90 percent of their current range in 60 to 90 years.[101] Some species have nowhere to go because they are already at the northern or upper limit of their habitat or because there are impediments to migration. The collection of species making up any community of organisms in a given habitat (the "species assemblage") may change and this may result in changing species interactions and ecological processes.[102]
2) Pathogens, Parasites, and Disease: Climate change and shifts in ecological conditions could support the spread of pathogens, parasites, and diseases, with potentially serious effects on human health, agriculture, and commercial fishing, for example.
3) Invasive Species: Climate change may aid or accelerate the spread of invasive species that pose additional threats and stress to native fish, wildlife, and plants.
4) Extinction Risks: Climate changes may favor some species, while disadvantaging others. Climate change, along with habitat destruction and pollution and other human-related impacts, can act as a stressor that contributes to species loss and extinction. The Intergovernmental Panel on Climate Change (IPCC) estimates that 20-30% of the plant and animal species evaluated so far in climate change studies are at risk of extinction if temperatures reach levels projected to occur by the end of this century. While natural systems have some adaptive capacity to respond to change, many ecosystems may lack the ability to survive the rate and scale of environmental change associated with a changing climate. Efforts to reduce the effects of climate and other stressors on habitat and species can help alleviate the risk of species loss and extinction and build resiliency.
5) Changes in the Timing of Seasonal Life-Cycle Events; changes can lead to mismatches in the timing of migration, breeding, pollination, and food availability.
6) Food Web Disruptions: The impact of climate change on a particular species can ripple through a food web and affect a wide range of other organisms.
7) Threshold Effects: In some cases, ecosystem change occurs rapidly and irreversibly because a threshold, or "tipping point," is passed. Early efforts to prepare for climate

risks to biodiversity may help prevent losses from occurring.

The August 2013 Indicators of Climate Change in California report confirms observation of these types of changes, including for instance: the range of some conifer-dominated forests in the Sierra Nevada are shifting to higher elevations; in Yosemite National Park, distribution shifts of some mammal species populations have also been observed and these populations are being found at different elevations compared to the early 1900s; butterflies in the Central Valley have been appearing earlier than usual compared to the past four decades; and warming temperatures and reduced upwelling in the oceans negatively affecting the marine food web have had impacts on Sacramento fall run Chinook salmon abundance, auklet breeding, and sea lion pup mortality. [103]

Management Challenges and Opportunities

Managing natural resources in the face of the highly dynamic and evolving conditions presented by climate change requires more integrated, ecosystem-based approaches. The way conservation actions have been carried out in the past, which often focused on the designation of important or representative sites supporting key habitats or species, may no longer be adequate. To address climate change, managers will need to act over different spatial and temporal scales. The focus of restoration will need to shift from historic species assemblages to more dynamic management approaches that are capable of managing risk in the face of uncertainties and being modified over time to accommodate evolving climate science.[104] State information needs related to improving understanding of climate risks to biodiversity and improving knowledge with respect to management responses for such risks are further described below.

While it will be important to re-examine existing conservation practices to plan for climate risks to biodiversity, this must be balanced with the continued need to meet regulatory responsibilities and work within the confines of existing laws and regulations related to individual species management. Innovative new management approaches and collaborative efforts across disciplines and jurisdictional boundaries will be needed to adequately safeguard California's biodiversity. Important lessons may be gleaned from the study of a variety of resource management techniques. Land acquisition and conservation, restoration, and invasive species removal will continue to be high priority actions that can be taken quickly to increase ecosystem resiliency, however some innovative new approaches to conservation will likely be important and are already being developed in California. Governance structures that can support collaborative decision making are needed, and in some cases must be created. As science and information about the effectiveness of management responses continues to evolve, efforts to plan for climate risks will need to be refined.[105]

Box 9

Traditional Ecological Knowledge

For over 10,000 years, Native Americans from diverse tribes have been practicing natural resource management. Traditional Ecological Knowledge (TEK) is "the knowledge base acquired by indigenous and local peoples over hundreds of years through direct experience and contact with the environment."[106] This knowledge is place-specific and includes the relationships between plants, animals, natural phenomena, landscapes, and phenology that are used for regular practices like hunting, fishing, trapping, and forestry.[107] Indigenous groups are projected to be among the communities most heavily affected by climate change. Many American Indian and Alaska Native tribes are identifying and implementing culturally appropriate strategies to assess climate impacts and adapt to projected changes. TEK, as an indigenous knowledge system, has the potential to play a central role in both indigenous and nonindigenous climate change initiatives. The detection of environmental changes, the development of strategies to adapt to these changes, and the implementation of sustainable land-management principles are all important climate action items that can be informed by TEK.[108]

As environmental and biological changes related to climate change emerge, there will be a need to manage for a future that may contain species and habitat configurations unlike any we have seen in the past. As noted above, many North American species may migrate to inhabit new locations. Providing corridors and maintaining "connectivity" to facilitate the movement of species between suitable areas and to newly suitable areas over time as climate changes (e.g. northward or up in elevation) is the most frequently recommended strategy for conserving species. Given projected future climate change, it is likely species will need to move significant distances, and they may encounter substantial barriers to such movement.[109] Addressing these barriers can be an important part of preparing for climate risks to biodiversity.

Certain areas of refuge (refugia) will be particularly important as climate change impacts unfold. Refugia can be defined as areas that conserve natural elements that may be eliminated or significantly degraded elsewhere.[110] Refugia can help support the persistence of species and habitats, even in new assemblages. For instance, the Southern Sierras may provide areas of refugia for climate-stressed species because of its unique elevational and latitudinal gradients; a number of efforts are underway to study and protect the Southern Sierra.[111] The Southern Sierras are further described in the Forestry section of this document.

Technology is enabling new forms of scientific collaboration which may support efforts to protect biodiversity resources. For instance, citizen science can help provide information regarding historical conditions and can help monitor changes that may be attributed to climate change. For more information on citizen science, see Box 10.

Box 10

Citizen Science – Crowdsourcing Climate Monitoring

Citizen science is a form of scientific research collaboration involving members of the public[112], which has been greatly enabled through technological advances such as the internet, global positioning system technology, digital photography, and mobile phone technologies[113]. Citizen science projects that rely on information technologies are often considered a form of "crowdsourcing", where an open call for contributions is made to a large, undefined network of people.[114] The ways in which citizen scientists can contribute to the scientific endeavors varies, and there are a variety of ways in which scientific efforts may be designed to include input from citizen scientists. For instance, citizen scientists with mobile, networked devices can help collect data and help with monitoring efforts; and standardized field protocols for collecting and visualizing data can improve data quality. Innovations in the design of citizen science projects and continued technological advancements will help contribute to the evolution of citizen science and its ability to generate useful scientific data on a large scale.[115]

Citizen science can help contribute to efforts to identify threats to ecosystems and to observe changes in the range of land and marine based species as the climate changes. Citizen science efforts can also provide unique opportunities for public education and engagement. For instance, the National Park Service and the UCLA Center for Embedded Network Sensing (CENS) partnered to design a smartphone application to identify the locations of invasive weeds in the Santa Monica Mountains National Recreation Area. The technology behind the *What's Invasive!* project was developed by CENS, a National Science Foundation supported research center that develops ways to link human interaction with the natural world and technology. This application allows users to take a photo with a mobile device and map the location of invasive weeds. Invasive weeds are a significant threat to native plant and animal species in the Santa Monica Mountains, and combating invasive weeds requires a significant investment of resources. The Santa Monica Mountains National Recreation Area spent $200,000 over a three year period to map invasive weeds in the mountains. Assistance from citizen scientists helps keep the map up to date and better equip park staff and volunteers to remove invasive weeds.[116] The California Academy of Sciences (the Academy) also has a Citizen Science program which focuses on how California biodiversity has changed based on historic knowledge and the Academy's specimen collections.[117] For an additional example of citizen science, see "*Imagining California's Future Coastline – California King Tides Initiative"* in the Ocean and Coastal section of this document.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Planning Efforts

Natural Community Conservation Planning (NCCP): The NCCP program is an unprecedented effort by the State of California, and numerous private and public partners that takes a broad-based ecosystem approach to planning for the protection and perpetuation of biological diversity. The primary objective of the NCCP program is to conserve natural communities at the ecosystem level while accommodating compatible land use. The program seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process.[118] For more information on California's innovative land use planning efforts, please see Box 11: Innovative land use planning to balance multiple objectives.

Regional Advance Mitigation Planning (“RAMP”): In 2008, a coalition of infrastructure and natural resource agencies, nongovernmental organizations, and academic researchers launched an effort to develop a more comprehensive approach to mitigating unavoidable biological resource impacts potentially caused by state infrastructure projects, such as roads and levees. This approach, called Regional Advance Mitigation Planning (“RAMP)”, allows for natural resources to be protected or restored as compensatory mitigation before infrastructure projects are constructed, often years in advance.[119] RAMP considers a landscape scale or ecosystem approach to mitigation and conservation planning, helps to address climate risks, and can be integrated with federal Habitat Conservation Plan requirements and state NCCP requirements. A draft RAMP Statewide Framework has been developed and additional efforts to develop planning methodology and advancement of mitigation are in progress.

California’s Wildlife Action Plan: In 2000, Congress enacted the State Wildlife Grants Program to support state programs that broadly benefit wildlife and habitats but particularly “species of greatest conservation need.” As a requirement for receiving funding under this program, state wildlife agencies were required to submit a Wildlife Action Plan (a comprehensive wildlife conservation strategy) to the U.S. Fish and Wildlife Service (Service) no later than October 2005. Wildlife Action Plans must be updated every ten years, and the 2015 update is currently being developed. One of the key objectives of the update is to incorporate climate change impacts and adaptation strategies; climate change is already identified as one of four primary stressors affecting wildlife.[120]

Box 11

Innovative land use planning to balance multiple objectives

Cooperation between state, federal, and local governments is necessary to optimize land use planning to balance multiple state environmental objectives especially in light of projected population growth and climate stresses.

California has already undertaken complex planning processes that may serve as models for innovative land use planning efforts that balance multiple objectives.

- The Bay Delta Conservation Plan
  The Bay Delta Conservation Plan (BDCP) is being developed to support the co-equal goals of enhancing state water reliability and the ecological health of the Sacramento-San Joaquin Delta.[121] The Sacramento-San Joaquin Delta is a critical element of the state’s water system. The Bay Delta Conservation Plan seeks to improve the health of the ecological system as a whole. The plan also aims to provide for a more reliable water supply for California by modifying conveyance facilities to create a more natural flow pattern. The BDCP attempts to balance these goals in a way that is feasible given the variety of important uses in the Delta including flood protection, agriculture and

recreation.

- The Desert Renewable Energy Conservation Plan

The Desert Renewable Energy Conservation Plan (DRECP) is being developed to support programmatic development of large-scale renewable energy and the co-equal objective of conservation of the California desert.[122] The primary driver for renewable energy development in the DRECP area is the state's long-term greenhouse gas reduction goals. The DRECP will streamline permitting under the California Natural Community Conservation Planning Act, the federal Endangered Species Act, and the Federal Land Policy Management Act for utility-scale renewable energy development for solar, wind, and geothermal generation within development focus areas, while providing for the conservation of species and natural communities in a landscape-scale conservation plan.

National Fish, Wildlife, and Plants Climate Adaptation Strategy: CDFW collaborated with federal, tribal, and state partners and played a lead role in creating the first National Climate Adaptation Strategy for fish, wildlife, and plants. This strategy promotes a nation-wide unified approach to climate driven adaptation strategies, reflecting shared principles and science-based practices to safeguard the nation's biodiversity, ecosystem function and sustainable human uses of fish, wildlife and plants. The Strategy was released in March 2013. [123]

CDFW Vision for Confronting Climate Change in California: The September 2011 report "Unity, Integration, and Action: CDFW's Vision for Confronting Climate Change in California" outlines CDFW objectives for responding to climate change.[124]

Climate Change Adaptation Case Studies: Several organizations have created adaptation case studies to provide examples of successful climate preparedness projects. For example, the State Coastal Conservancy has developed case studies from various wetland restoration projects, sea level rise planning efforts, and vulnerability assessments.[125] The Bay Area Ecosystems Climate Change Consortium (BAECCC) has compiled case studies that demonstrate climate-smart conservation and restoration taking place in the Bay Area.[126] CDFW also created a number of case studies to highlight existing programs and projects that are helping CDFW to plan for or minimize the negative impacts associated with climate change. This series of case studies demonstrates that planning for climate change will not always require entirely new or novel management approaches; there are many existing management tools in the toolbox that can be utilized to address climate risks.[127]

Building Resilience: Resource Management and Conservation in the Era of Climate Change

First-of-its-kind Statewide Network of Marine Protected Areas**:** As further described in the Oceans and Coastal Ecosystems and Resources section of this document, on December 17, 2012, 19 Marine Protected Areas (MPAs) became effective in the Northern California coastal region, completing the nation's first statewide coastal system of marine protected areas.

Regional and Local Wetlands Restoration: Ecoregional planning and on the ground restoration projects are taking place along the California coast. In the San Francisco Bay, restoration projects are being supported by the Baylands Ecosystem Habitat Goals project, which is currently being updated to include climate change considerations. The Baylands Ecosystem Habitat Goals report recommends the types, amounts, and distribution of upland habitats, linkages, compatible uses and the ecological processes needed to sustain diverse and healthy communities of plant, fish and wildlife resources in the Bay Area[128]. In southern California, restoration efforts in the Southern California Bight are supported by the Wetland Recovery Project and its Regional Strategy. The Wetland Recovery Project is an effort chaired by the Resources Agency and supported by the State Coastal Conservancy, which has public agencies, non-profits, scientists, and local communities working cooperatively to acquire and restore rivers, streams, and wetlands in coastal southern California[129].

At the Elkhorn Slough National Estuarine Research Reserve, a CDFW ecological reserve and National Estuarine Research Reserve located at the center of the Monterey Bay coastline, intensive monitoring of marsh and water level elevation changes combined with modeling have revealed that predicted rates of accelerated sea level rise will lead to extensive marsh loss in coming decades. The Reserve's Tidal Wetland Project is currently initiating a major salt marsh restoration project involving beneficial re-use of sediments. Using this sediment, the project will create higher salt marshes to make them resilient in the face of sea level rise. The Elkhorn Slough and San Francisco Bay National Estuarine Research Reserves are also spear-heading an ambitious project to enhance the success of native oyster restoration projects in the face of climate change. In addition to restoration activities, Elkhorn Slough staff is undertaking numerous other activities to monitor the effects of climate change. The Reserve collects long-term monitoring data on over two dozen indicators of estuarine health that will eventually be used to track changes and identify adaptation strategies in response to climate change impacts over the coming decades.

Preparing for Climate Risks in the Tijuana River Valley: The Tijuana River Valley contains one of the largest intact coastal wetland systems in southern California, despite intense pressure associated with being situated on an international border between two major metropolitan areas - San Diego and Tijuana. The Tijuana River National Estuarine Research Reserve (TRNERR) has several collaborative projects underway that will help increase southern California's regional resilience to climate change, including the Climate Understanding & Resilience in the River Valley (CURRV) Project. The overarching goal of CURRV is to build upon a regional commitment to understand and adapt to climate change. In order to achieve this goal, TRNERR is collaborating with a diverse stakeholder group, including various state agencies, to conduct a vulnerability assessment that will inform the development of adaptation strategies addressing the impacts of climate change, specifically sea level rise and riverine flooding, to both built infrastructure and the natural environment. Through the Temporal Investigations of Marsh Ecosystems (TIME) Project, results from CURRV are being coupled with perspectives from the past (historical ecology) and present (research and monitoring) to inform restoration in the River Valley, as a model to steer wetlands recovery in the broader southern California region.

Incorporating Environmental Stewardship into Integrated Water Management Practices:

- Fish Passage Improvement Program: DWR, in partnership with the local water district and land owners, removed two fish passage barriers on the Calaveras River/Mormon Slough flood control channel. Through the Fish Passage Program, they have also designed and constructed two fish ladders on lower Butte Creek (Weir 2 and Willow Slough Weir) and completed design work for fish passage improvement at the Fremont Weir/Yolo Bypass. The DWR Division of Safety of Dams is currently overseeing the removal of San Clemente Dam on the Carmel River. This is the largest dam removal to be done in California and will provide access to historic coastal steelhead habitat.
- Meadow Restoration: DWR and the US Forest Service have completed a three-year investigation of the hydrologic effects of meadow restoration and how restored meadows can contribute to improved water management operation as well as ecosystem functioning. Restored meadows can also provide flood flow attenuation benefits and improve baseflows in creeks and rivers. The final report is expected to be released by Summer 2014.
- Flood Corridor Program: DWR continues to pursue nonstructural flood risk reduction projects that are coupled with habitat conservation and agricultural protection through the Flood Corridor Program. The program includes three flood protection grant programs that have awarded over $91 million in grant funding covering over 19,000 acres statewide since 2000. These projects can help restore floodplain functions and riparian habitats and enhance wetland development and water table recharge while reducing flood risk for people and property.
- Twitchell Island Wetland Research and the Sherman Island Permanent Wetland projects: The Department of Water Resources (DWR) is working collaboratively to implement projects that demonstrate subsidence reversal and carbon sequestration through wetland restoration in the western Delta (Twitchell Island Wetland Research and the Sherman Island Permanent Wetland). Through these demonstration projects, DWR will study the costs and benefits of these land use management practices to help reduce stress on Delta levees and define the potential value in a carbon market.

Research and Tools

February 2010 Essential Habitat Connectivity Project Report and Tool: CDFW and the California Department of Transportation (CalTrans) commissioned a team of consultants to produce a statewide assessment of essential habitat connectivity using the best available science, data sets, spatial analyses and modeling techniques. The goal was to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife.

Over sixty federal, state, local, tribal and non-governmental organizations collaborated in the creation of: 1) a statewide wildlife habitat connectivity map using a Geographic Information System (GIS) based modeling approach; 2) an assessment of the biological value of identified connectivity areas; and 3) a strategic plan that helps varied end users interpret and use the statewide map and outlines a methodology necessary for completing connectivity analyses at finer spatial scales.[130]

Third California Climate Change Assessment studies on biodiversity and ecosystems: The California Energy Commission's PIER program helped fund the following critical studies as part of the Third California Climate Assessment released in 2012:

- Projecting Growth in California (2000–2050) Under Six Alternative Policy Scenarios and Assessing Impacts to Future Dispersal Corridors, Fire Threats and Climate-Sensitive Agriculture;[131]
- Climate Change Impacts on California Vegetation: Physiology, Life History, and Ecosystem Change;[132]
- Consequences of Climate Change for Native Plants and Conservation;[133]
- Identifying Vulnerable Species and Adaptation Strategies in the Southern Sierra of California Using Historical Resurveys;[134]
- Fire and Climate Change in California: Changes in the Distribution and Frequency of Fire in Climates of the Future and Recent Past (1911–2099);[135]
- Decision-Making Under Uncertainty: An Assessment of Adaptation Strategies and Scenario Development for Resource Managers;[136]
- Projected Effects of Future Climates on Freshwater Fishes of California;[137]
- Scenarios to Evaluate Long-Term Wildfire Risk in California: New Methods for Considering Links Between Changing Demography, Land Use and Climate;[138] and
- Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in The San Francisco Bay Area[139].

Landscape Conservation Cooperative (LCC) Funded Conservation Projects: LCC's are collaborative public-private partnerships that provide shared science to ensure the sustainability of land, water, wildlife and cultural resources. The CA LCC has funded more than 25 collaborative projects in the past three years and has provided close to $4 million in project funding with an additional $4 million from partner contributions. These projects have included studies to support and develop decision-support tools and data, monitoring and modeling methods, population and habitat assessments, vulnerability assessments, and conservation planning and design.[140] The North Pacific LCC has also funded over 25 projects, several of which were carried out in the California north coast region, a small portion of the LCC's distribution. These projects have ranged from modeling sea level rise to exploring the use of traditional ecological knowledge in natural and cultural resource management.[141] The Desert and Great Basin LCCs have also supported research projects that address issues in the Desert and Great Basin regions of the state.

November 2010 "Bridging the Gap: Downscaling Climate Models to Inform Management Actions" Workshop sponsored by the CDFW, the US Geological Survey, the US Fish and Wildlife Service, and the California LCC. The workshop brought together those working on downscaling climate models with ecologists and land managers to explore the use of climate models to inform ecological resource management. [142]

Box 12

Tools to Support Biodiversity Conservation in the Era of Climate Change

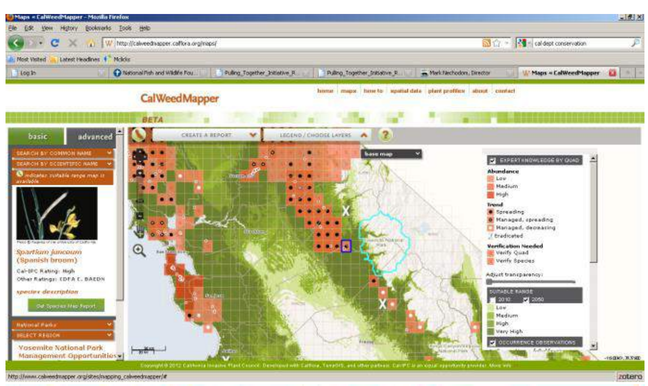
Since 2009, several tools that support climate adaptation planning have been developed. In addition to the Cal-Adapt and California Essential Habitat Connectivity tools discussed elsewhere in this document, the following resources are available:

CDFW's Areas of Conservation Emphasis Mapping and Modeling Tool was a CDFW project that was begun in 2009 to provide a spatial model that can be used to identify areas of biological or conservation interest throughout the state, in order to guide and inform conservation priorities.[143]

Point Blue Conservation Science Sea-Level Rise Tool: This sea level rise tool was developed to improve our understanding of how sea level rise may change the extent of tidal marsh habitat and bird species distribution in the San Francisco Bay Estuary.[144]

BIOS and Marine BIOS enable the management, visualization, and analysis of biogeographic data collected by the California Department of Fish and Wildlife and its partner organizations.[145]

California Climate Commons: The California Climate Commons is a project of the California LCC and offers an online environment where natural resource managers can quickly find climate change and related environmental information they need, communicate with each other and with the researchers producing the information, and then share lessons learned. The goal of the Climate Commons is to support conservation practitioners in their application of climate adaptation science and help guide new research directions by facilitating more effective information exchange between the climate change research and conservation communities. The Commons is a collaboration of the California Landscape Conservation Cooperative, Sonoma Ecology Center, Point Blue Conservation Science, and UC Davis Information Center for the Environment.[146]



CalWeedMapper CalWeedMapper provides a dynamic tool for mapping invasive plant distribution at the landscape level. The tool was developed by the California Invasive Plant Council (Cal-IPC) and helps support the development of regional invasive plant management strategies. [147]

Box 13

Climate Vulnerability Assessments

Three state-wide climate change vulnerability assessments, specifically for rare and priority species populations, were recently conducted in California. These assessments will be used to inform conservation planning in California, including management planning efforts within CDFW.

A Climate Change Vulnerability Assessment of California's At-Risk Birds This study, jointly funded by CDFW and PRBO Conservation Science, developed a framework for assessing climate change vulnerability of California's at-risk birds and integrating it into the existing California Bird Species of Special Concern list. Climate vulnerability was defined as the amount of evidence that climate change will negatively impact a population. The research showed that nearly 130 species of birds are vulnerable to the predicted effects of climate change and that 21 of the state's 29 threatened and endangered bird species (72 percent) will be further impacted by climate change, increasing their risk of extinction. Wetland bird species were particularly vulnerable to climate change due to their specialized habitat and the risks posed to wetlands by sea level rise and other climate-driven factors. The complete list of birds and their climate vulnerability scores are available online through the California Avian Data Center.[148]

Climate Change Vulnerability for Rare Plants CDFW, with support from the California LCC, conducted a vulnerability assessment of 156 rare plant species in California to determine which will be subject to negative impacts from climate change. This study employed the NatureServe Climate Change Vulnerability Index to assess vulnerability. Future habitat suitability was examined for these species to assess potential range shifts under various climate change scenarios. The resulting 156 assessments and a refinement of the methodology will be helpful to those needing to incorporate rare plants into their resource management plans.[149]

Amphibian and Reptile Vulnerability Assessment UC Davis, with support from CDFW, is currently undertaking an assessment of the climate impacts to amphibians and reptiles in California. This study includes 158 species.

The Climate Change Vulnerability Assessment Resource Center was created by CDFW to provide access to resources for those interested in learning more about climate change vulnerability assessment efforts related to wildlife and habitats. The Resource Center contains reports generated up to 2012.[150]

Box 14

New Frontiers in Biodiversity Research and Conservation

Estimating the vulnerability of biodiversity to climate impacts across broad areas
Rapid and cost-effective methods to estimate the vulnerability of biodiversity to climate change impacts across broad areas are being developed and implemented to help inform conservation strategies. These methods do not replace species-specific vulnerability assessments, however, they allow biodiversity managers to identify trends within large geographic areas to support timely conservation actions.[151] For instance, the Bureau of Land Management has initiated fourteen Rapid Ecoregional Assessments ("REA") throughout the western United States and Alaska, and has already completed the Mojave Basin and Range REA and the Central Basin and Range REA. REAs synthesize existing information rather than conduct research or collect new data, and are generally completed within 18 months. REAs look across all lands in an ecoregion to identify regionally important habitats and assess the potential of these habitats to be affected by climate change, wildfires, invasive species, and development. REAs identify and map key opportunities for resource conservation, while also establishing baseline ecological data to gauge the effect and effectiveness of future management actions.[152]

Adaptive management for climate risks and uncertainty
The concept of adaptive management of ecosystems for the conservation of biodiversity was developed in the 1970s. Adaptive management involves the following key elements: 1) defining management goals 2) development of plausible alternative management strategies to achieve the goals, 3) implementation of two or more strategies, 4) monitoring, and 5) iterative modification of strategies to improve outcomes. The capacity of adaptive management to accommodate uncertainties is especially useful in light of rapidly changing climate conditions, the complexity of ecological systems, and the uncertainties associated with how ecosystems react to human interventions. However, examples of actual implementation of adaptive management programs are still scarce; for instance, many conservation programs study only one management option at a time which provides 'trial and error management'. Implementation of alternative conservation strategies can provide comparative insights, reduce risk of failure, and aid understanding of system responses to management (e.g. separating policy effects from other causes of ecological change).[153] There is increasing emphasis on adaptive management as an approach for conserving biodiversity in the era of climate change.[154]

Managed Relocation
Managed relocation is the intentional act of moving species, populations, or genotypes to a location outside a target's known historical distribution for the purpose of maintaining biological diversity or ecosystem functioning as an adaptation strategy for climate change[155]. The conservation community is exploring how to support the natural migration and movement of species as climate changes, while avoiding maladaptive practices and over engineered approaches that can lead to negative ecological, social, regulatory, and economic ramifications. Connecting and conserving natural corridors will assist natural migration and species movement.

Genomics research
Genomics is the study of an organism's genetic makeup (or its 'genome'), and the how the genome interacts with environmental and other non-genetic factors.[156] Scientists are exploring how genomics tools and approaches may help inform conservation efforts, especially in an era where climatic conditions are rapidly changing.[157]

Establishing genetic banks
In recent years, a number of efforts have begun to systematically collect and preserve genetic material. For instance, the National Science Foundation is funding a multi-university "Project Baseline" to create a seed bank. The goal of Project Baseline is to create a resource for researchers interested in characterizing the genetic, taxonomic and functional dimensions of biodiversity over space and time in an era of rapid climate change. Studies of evolutionary responses to accelerated environmental change can shed light on the capacity of organisms to adapt to human disturbances.[158]

The Svalbard Global Seed Vault in Norway is an effort to ensure that the genetic diversity of the world's food crops is preserved for future generations, with the recognition that the loss of biological diversity is currently one of the greatest challenges facing the environment and sustainable development.[159] There are also a number of global efforts to create cryopreserved or live gene banks for fish and other species.[160]

For more information on California seed bank efforts, please the Forestry section of this document.

Education, Outreach, and Collaboration

<u>CDFW Climate College and climate education:</u> In early 2012, CDFW launched a ten-month climate literacy program to build staff capacity for incorporating climate considerations into existing professional responsibilities. Although the CDFW Climate College was designed to provide a basic foundation of climate literacy to CDFW staff, the course was open to the public. The inaugural year of the CDFW Climate College was completed in June 2013. More than 340 participants participated in the first year of the CDFW Climate College. A second iteration of the Climate College is currently under development and will be topically focused on climate change and marine issues in the state with the inclusion of a tribal component.[161] The CDFW Climate Science Program also features a variety of online educational materials related to biodiversity and climate change including resources for teachers, a collection of relevant vulnerability assessment tools and guidance, and information on CDFW projects helping to plan for or minimize impacts associated with climate change.

<u>2010 "Climate Change, Confronting the Challenge" Publication</u> The Fall 2010 issue of CDFW's Outdoor California magazine was dedicated to discussing climate change. The publication articulates how fish, wildlife, and habitat conservation and management play an important role in responding to the impacts of climate change and focuses on the importance of a multi-sector

approach to adaptation planning and action. The publication received a gold award in the State Information Officers Council's 2010 statewide competition for excellence in government communications.[162]

Governor's Conference on Climate Change and Extreme Events: California Governor Edmund G. Brown Jr. and environmental, business and public health and safety leaders came together in December 2011 at "The Governor's Conference on Extreme Climate Risks and California's Future."[163] The conference included a presentation and discussion on the "Impacts of Extreme Weather and Climate on Terrestrial and Aquatic Biota in California".

2013 National Adaptation Forum[164] CDFW worked with partners to create, develop, and implement the "Inaugural National Adaptation Forum: Action today for a better tomorrow". Over 500 adaptation practitioners from around the country came together to discuss moving adaptation planning to adaptation action. Planning is currently underway for the next National Adaptation Forum in 2015, and several regionally focused events are under consideration including one in California in 2014[165].

CDFW Climate Change Stakeholder Group Since 2008, CDFW has been convening a Climate Stakeholder Group to provide input on climate change-related conservation planning and implementation efforts. The group includes a diverse group of partners including federal, state, and local/regional governmental entities, NGOs, and members of the research and academic community.[166]

ACTIONS NEEDED TO SAFEGUARD BIODIVERSITY AND HABITATS

The following recommendations build on those made in the 2009 Adaptation Strategy based on emerging science and practice of climate adaptation. The recommendations below require adequate funding and staffing to be carried out.

Develop management practices to help safeguard species and ecosystems from climate risks

1) Improve habitat connectivity and protect climate refugia

Promoting habitat connectivity and protection of refugia will aid in species migration and movement and propagate ecological processes across the landscape. We must utilize existing programs such as NCCP and planning documents such as the State Wildlife Action Plan to continue improving connectivity between existing terrestrial, aquatic, and marine conservation areas in addition to creating new conservation areas where applicable. Priorities for creating, maintaining or restoring conservation areas should include landscape features that will ease the transition to future climatic conditions for species supported by the habitat (e.g., low fragmentation, climatic and elevational gradients, groundwater resources, etc.). Coordination should be promoted among state, federal, and private landholders to encourage consistency across management approaches to maximize biodiversity and promote large-scale connectivity.

2) Implement adaptive management studies to refine approaches for conserving biodiversity, especially for species and communities vulnerable to climate change

As mentioned in the 2009 CAS, the original CA State Wildlife Action Plan (2005) articulated an approach for designing monitoring programs to support adaptive management, which is still relevant today. Actual case studies that implement adaptive management are needed to further understanding of the relative merits of alternative management strategies for conserving biodiversity in the face of rapidly changing climate conditions. NCCP plans already incorporate adaptive management and may provide opportunities to study and refine approaches for managing biodiversity in the era of climate change. Vulnerability studies should help inform where adaptive management studies should be focused and which species and natural communities should be included in such studies.

Enhance biodiversity monitoring in California to detect climate impacts and inform responses

There continue to be gaps in the monitoring of resource conditions that can support effective management decisions in the era of climate change. A comprehensive, statewide approach to biodiversity monitoring is needed to help develop baseline ecological information and to detect changes in terrestrial and aquatic species and habitat patterns on the landscape. Monitoring and observing changing conditions is critical to refining climate impact and species/habitat response models and to informing the development of forward-looking conservation strategies and management actions that account for changing conditions.

The CDFW Species and Natural Communities Monitoring and Assessment Program, or simply Resource Assessment Program (RAP), was designed to help inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities in California. As such, RAP provides a basic infrastructure for addressing biodiversity inventory and monitoring needs in the state. With additional support, this program could be expanded to meet the need for comprehensive, state-wide biodiversity monitoring to support forward-looking management actions that are responsive to a changing climate. Climate considerations should be integrated into monitoring strategy design and the development of monitoring priorities; and strategic monitoring priorities may be informed by other state efforts including CDFW's State Wildlife Action Plan, DWR's California Water Plan, CalFire's Forest and Rangeland Assessment Program, State Water Resource Control Board's (SWRCB) Basin Plan, and the type of statewide climate vulnerability assessment discussed above.

Support Environmental Stewardship Across Sectors

1) Promote Nature-Based Solutions for Adapting to Climate Risks

Nature-based solutions can be a cost-effective means for addressing climate risks, and also provide additional benefits including benefits for habitat and biodiversity (see Box 47: "Wetlands - Nature's Flood Protection" in the Oceans and Coastal Ecosystems and Resources section of this document and Box 35: "Ecosystem Services – Smart Land Use to Save Money and Create More Sustainable Communities" in the Forestry section of this document). The State should encourage and support the consideration of nature-based approaches for preparing for climate risks where such approaches are available. In order to support informed decision making, funding is needed for studies that help quantify the benefits of ecosystem services that reduce climate risks.

2) Create, maintain and support tools that help resource managers determine when and where to focus conservation activities that will protect biodiversity in the face of climate risks

Improved modeling of the impacts of climate change on wildlife, fish, and plants will be necessary at a scope and scale appropriate for management application. Associated predictive and planning tools are also necessary to ensure that resource management actions are informed by best available science, and such tools require maintenance over time and support to encourage user adoption. As noted above, CDFW developed the Areas of Conservation Emphasis (ACE) Mapping and Modeling Tool to provide a spatial model that can be used to identify areas of biological or conservation interest to guide conservation priorities. Tools such as ACE should continue to be maintained and updated with new biological data developed over time, in order to support biodiversity conservation planning and management decisions within CDFW and other state agencies. Determining what biodiversity-related information and tools would be useful to other agencies in their climate change planning efforts will also be necessary to manage the needs of wildlife, habitats, and humans in tandem.

Improve Understanding of Climate Risks to Biodiversity and Habitats

As further described below, continued research is essential to improve understanding of climate risks to biodiversity and habitats in order to inform management responses that might reduce risks to biodiversity and promote resilience. One overarching need is to improve baseline information; there are still significant data gaps with respect to California's biological resources. Baseline information provides a reference point against which future changes in biodiversity can be assessed. Continued and enhanced predictive modeling combined with monitoring of certain species will be also be needed to guide resource management decisions. Further information is also needed regarding the interactions between plants, animals and their environment, especially as the timing of life cycle events shift in response to climate change. Finally, there is a need to continue vulnerability studies and the identification of critical connections and corridors.

In addition to informational needs around biological resources, it would be useful to consolidate and analyze non-habitat baseline information such as current land uses and land use policies throughout the state, as well as whether municipalities and permitting agencies have incorporated climate change impacts into their land use planning (i.e. General Plans, Local Coastal Programs). This information will be an important part of determining the best opportunities for habitat restoration and land acquisition as part of a larger effort to create a well-connected system of conservation areas, minimize the impacts of climate change to the greatest extent possible, and plan appropriate strategies for long term conservation and management actions.

It is important for the state to coordinate with other research efforts, including the efforts of federal, academic and regional collaboratives, in order to benefit from collaborative work and optimize resources. As noted in the introduction to this document, there is also a need to ensure consistency in data sets and tools developed and utilized by different state entities.

Research needs related to climate impacts and risks to biodiversity and habitat are described below. Additional information on these types of needs may be found in the August 2011 CDFW Climate Change Research Considerations document[167], the February 2012 CDFW Climate Change Research Needs document[168], the California Climate Research Plan, and the forthcoming 2015 update to the State Wildlife Action Plan.

1) Completing habitat and vegetation mapping
High-resolution, state-wide vegetation mapping following the National Vegetation Standard is needed to identify movement of vegetative communities, detect changes in their composition, and identify any new assemblages created throughout time. This information may provide insight into how species will move in accordance with changes in the location of their required habitat. Vegetation mapping can also be directly tied to the California Wildlife Habitat Relationships system, for example, to identify which species will likely be impacted most by these environmental changes. Additional funding and resources are needed to sustain existing efforts related to vegetation mapping, for example through the CDFW Vegetation Mapping and Classification Program.

2) Refining regional connectivity analyses
The California Essential Habitat Connectivity Project was a state-wide effort to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife. Finer-scale, regional corridor modeling and connectivity analyses are needed to help prioritize land acquisition and protection. Corridor prioritization exercises, for example those currently taking place in the Northern Sierra Nevada Foothills and Desert regions of California, should be replicated in other parts of the state. Work to identify critical habitat linkages has also been undertaken along the north-central coast of California led by the Science and Collaboration for Connected Wildlands in conjunction with many other agencies and organizations[169].

3) Additional climate vulnerability analyses
As described below, more research is needed to understand species and habitat vulnerability to climate change. Vulnerability studies will need to be refined and updated periodically to ensure that best available science informs management decisions. Training and tools may need to be developed to help translate vulnerability findings into management actions. Additional funding and resources may be needed to support vulnerability studies over time.

- A comprehensive, statewide climate change vulnerability analysis at the habitat scale is needed to better understand climate risks to California's biodiversity. Vulnerability information at this scale will support ecosystem-based conservation planning and management efforts, and can also be used to increase our broader, ecoregional understanding of the vulnerabilities of biodiversity to climate change. Existing and future species and taxa-specific vulnerability assessments can also be compared against habitat assessment results to gain further insight into climate risks and inform development of strategies that can help protect biodiversity resources.

- As mentioned earlier in this chapter, a subset of rare plants in the state have already been analyzed for climate vulnerability, however, follow-up coverage of additional rare plant species is needed. Species most likely to be at risk from climatic changes, such as those found in higher elevations, ephemeral systems, vernal pools, etc., should be high priorities for examination.
- A state-wide vulnerability assessment of mammal species of special concern is also necessary.
- A state-wide vulnerability assessment is needed for invertebrates. Examining certain invertebrates will contribute to our knowledge of how some pollinators will be impacted by climate change, with implications for agriculture and other ecosystem services. These species are already being impacted by changes in phenology that have been linked to climate change, and more information is needed on species future vulnerability.
- Marine and aquatic habitat climate vulnerability assessments are also needed. For more information on climate and marine habitat, please see the Oceans and Coastal Ecosystems and Resources section of this document.

4) <u>Understanding extreme events and disturbance regimes</u>

Research is needed regarding the risks posed by extreme events or disturbances (e.g. fire, flooding, drought, insect outbreaks, invasive species, etc.) to ecosystem function, resilience, and services. This will provide additional insight into how some existing stressors or processes may be exacerbated by climate change.

5) <u>Identifying opportunities to address the emissions that contribute to climate change</u>

As mentioned in the INTRODUCTION section of this chapter, carbon storage can be one of the benefits provided by healthy ecosystems. Additional research is needed to quantify baseline carbon information associated with natural systems, and to identify and prioritize conservation and restoration opportunities with carbon sequestration benefits. Pilot projects can help refine understanding of the greenhouse gas storage capacity associated with natural systems.

<u>Information Sharing and Education</u>

1) <u>Create and maintain partnerships that support biodiversity conservation in a changing climate</u>

Collaborating with other agencies and partners supports not only the transfer of data and information, but ensures that conservation priorities with respect to climate change are clearly communicated within the broader conservation community. Communication is imperative to identifying and promoting common goals, and to support adaptation planning and implementation to conserve biodiversity. Collaboration will also promote complementary actions across jurisdictions on adjacent landscapes, which is vital to achieving our objectives related to habitat connectivity. State agencies should continue to pursue national, regional, and local coordination and promote initiatives to conserve biodiversity beyond the borders of California such as through the Western Governors' Association, West Coast Governors Alliance on Ocean Health, Association of Fish and Wildlife Agencies, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management, and the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Continued engagement with partners in the CDFW Climate Change Stakeholder Group will also be important and should be supported.

2) Promote public education and outreach on climate change impacts to biodiversity

Increasing communication with the public and partners on climate change impacts to biodiversity will raise awareness of this important issue and help create support for state actions that promote biodiversity conservation. State agencies should develop a collaborative messaging campaign centered on California's climate activities to safeguard natural resources, while highlighting the importance of nature-based action.

Many state agencies have staff that interface regularly with the public through education or outreach programs, which provide opportunities to engage the public on this topic. Agencies should work with partners to develop information to be used for public interpretation and classroom education related to biodiversity conservation in the face of climate change. Opportunities may be available at visitor centers in hatcheries, State Parks, wildlife areas, or other facilities run by the state. Helping to educate the public on climate change issues may have the additional benefit of promoting public involvement in data collection activities across many locations with limited costs through citizen science (see Box 10: *Citizen Science – Crowdsourcing Climate Monitoring* in this chapter).

3) Provide support for the continuation of the CDFW Climate College and educational outreach efforts and link those efforts to broader state climate literacy programs

As noted in the Introduction to this document, it is necessary to build internal capacity for state entities to operationalize climate risk considerations into their activities. The CDFW Climate College provides a useful template for a departmental climate literacy program. The CDFW Climate College and related educational efforts should continue to be supported, and those efforts should be linked to any broader state climate literacy efforts.

Box 15

California Biodiversity and Habitat

Several state entities play an important role with respect to biodiversity and habitat in California. The state also has important federal, local and private sector partners. Understanding the jurisdictional scope of these entities is important for a robust discussion of *continued steps needed to adequately prepare for climate risks.*

California Department of Fish and Wildlife (CDFW) has public trustee authority to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend for their ecological values and for their use and enjoyment by the public. This includes habitat protection and maintenance through conservation, restoration, and law enforcement to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses. CDFW's regulatory responsibilities include environmental permitting and review.

Wildlife Conservation Board (WCB) selects, authorizes and allocates funds for the purchase of land and waters suitable for recreation purposes and the preservation, protection and restoration of wildlife habitat. WCB approves and funds projects that set aside lands within the State for such purposes, through acquisition or other means, to meet these objectives.

California Fish and Game Commission (FGC), established in 1870, is a Commission comprised of five members, appointed by the Governor and confirmed by the Senate. The Commission formulates general policies for the conduct of CDFW, but also has general regulatory powers, including deciding seasons, limits and methods of take for sport fish. The Commission also has responsibilities for invasive species; establishing/regulating use of Marine Protected Areas (MPAs); listing/delisting threatened and endangered species under the California Endangered Species Act; prescribing terms and conditions for issuance of licenses/permits by CDFW; and revoking or suspending privileges of those that violate California Fish and Game laws and regulations.

Many other state entities also play important roles with respect to biodiversity and habitat in California. These entities include:

California Department of Conservation (DOC) among other things, DOC works to safeguard farmland and open space resources that are important to habitat and connectivity.

California Department of Food and Agriculture (CDFA) is responsible for protecting and promoting California agriculture; CDFA's work on preparing for climate risks is further discussed in the Agriculture section of this document.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to fire protection and stewardship of over 31 million acres of California's privately-owned forestlands.

California Department of Parks and Recreation California State Parks (CSP) is a trustee agency responsible for managing 1.5 million acres of land in 280 park system units. CSP's mission is to provide for the health, inspiration, and education of the people of California by helping to preserve the state's extraordinary biological diversity and its most valued natural and cultural resources while also providing opportunities for high-quality outdoor recreation. Park units, which constitute about three quarters of the acreage of the system, are protected to "preserve outstanding natural, scenic, and cultural values, indigenous aquatic and terrestrial fauna and flora, and the most significant examples of ecological regions of California" (Public Resources

Code Sec. 5019.53). CSP lands thus protect important habitats and are integral to biodiversity protection efforts throughout the state.

California Department of Water Resources (DWR) is responsible for managing and protecting California's water resources and supplies. DWR is developing comprehensive conservation plans, new Delta habitat enhancement and carbon sequestration projects, Regional Advance Mitigation Planning (RAMP), fish passage implementation actions, floodplain ecosystem studies, and flood system improvement actions in planning for flood, water supply, and drought management. Programs such as the Central Valley Flood Protection Plan Conservation Strategy, System Reoperations Studies, Bay Delta Conservation Plan, and the Fish Restoration Program Agreement are helping to integrate environmental stewardship into DWR's water management practices.

California Ocean Protection Council (OPC) assists with the coordination of ocean-related activities carried out by state agencies. They also develop ocean and coastal policies for California.

California Ocean Science Trust (OST) is a nonprofit 501(c)(3) public benefit corporation established pursuant to the California Ocean Resources Stewardship Act of 2000 (California Public Resources Code Sections **36970-36973)**. OST's mission is to advance a constructive role for science in decision-making by promoting collaboration and mutual understanding among scientists, citizens, managers, and policymakers working toward sustained, healthy, and productive coastal and ocean ecosystems.

California State Lands Commission (SLC) provides stewardship of the lands, waterways, and resources entrusted to its care through economic development, protection, preservation, and restoration. SLC engages in public land management and resource protection to ensure the future quality of the environment and balanced use of the lands and resources entrusted to its care.

Invasive Species Council of California (ISCC) is an inter-agency council that helps to coordinate and ensure complementary, cost-efficient, environmentally sound and effective state activities regarding invasive species. The ISCC is chaired by the Secretary of the California Department of Food and Agriculture and Vice-Chaired by the Secretary of the Natural Resources Agency; its members include the Secretaries from the California Environmental Protection Agency, California Business, Transportation and Housing Agency, California Health and Human Services Agency, and California Office of Emergency Services.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards.

State Conservancies play a big role in habitat conservation and restoration in California including work to enhance habitat and protect important resource lands, including landscape corridors. For example, the Coastal Conservancy has conserved more than 300,000 acres and restored more than 33,500 acres in some of the most biologically rich ecosystems in the state and the Santa Monica Mountains Conservancy has been a leader in protecting habitat corridors, including implementing the South Coast Missing Linkages plan.

Other Partners In addition to state entities, many tribal nations, federal agencies, local governments, non-governmental organizations, non-profit land conservation organizations, and private sector partners play a critical role in helping to preserve and protect California's wildlife. For example, the **U.S. Fish and Wildlife Service** is responsible for reviewing and permitting projects that have the potential to affect fish and wildlife protected by federal laws. **The U.S. Geological Survey**, **U.S. Forest Service**, **National Park Service**, and **Bureau of Land Management** also play important roles in providing scientific expertise, research, and management of key lands throughout the state. The **National Oceanic and Atmospheric Administration-National Marine Fisheries Service** is responsible for the stewardship of the nation's living marine resources and works collaboratively with the state on management, conservation and protection of these resources while also providing research important for California's coastal and marine resource managers.

The pace and scale of climate changes and the attendant threat to biodiversity have required a greater degree of collaboration among partners in order to begin crafting relevant management responses. Several important collaborative efforts have emerged in California. **Landscape Conservation Cooperatives[170] (LCCs)** were established by the U.S. Department of the Interior and are a network of public-private partnerships that provide shared science to ensure the sustainability of America's land, water, wildlife and cultural resources. The LCCs support efforts to reduce the negative impacts of many landscape scale stressors, including but not limited to climate change. California has four LCCs within its borders, the California LCC, Desert LCC, North Pacific LCC, and Great Basin LCC. The LCCs recognize that challenges facing natural and cultural resources and landscape transcend political and jurisdictional boundaries and require a more networked approach to conservation. Ecosystem-based regional collaboratives such as the **Bay Area Ecosystems Climate Change Consortium[171] (BAECCC)** have also been established. BAECCC was formed to assess climate change impacts to the Bay Area and to identify management actions that will reduce negative impacts associated with climate change while preserving the many services and benefits that are derived from Bay Area ecosystems. Partners include state and federal agencies, NGOs, academic institutions, and more. Collaborative efforts are further discussed in the HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES section above.

EMERGENCY MANAGEMENT

INTRODUCTION

Emergency management includes actions to prepare for, mitigate against, respond to and recover from emergencies and disasters that impact our communities, critical infrastructure and resources by lessoning the likelihood, severity and duration of the consequences of the incident. Mitigation and preparedness focus on activities we can do every day, not just during a disaster. Hazard mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from natural or man-made hazards. Emergency preparedness refers to activities undertaken prior to an emergency to be ready to respond to and recover from any emergency. Emergency response efforts occur during an emergency and flow into actions to recover from emergencies.

Disaster risks typically associated with California include earthquake, flood and fire. However, California also faces emergency risks associated with landslides, avalanches, levee failures, train derailments, infrastructure failures, toxic releases and other public health threats such as heat waves and infectious disease outbreaks.

Climate impacts, such as more extreme weather events, sea level rise, changing temperature and precipitation patterns, and more severe and frequent wildfires, present new risks and uncertainties that will affect all phases of emergency management. Without actions to incorporate climate considerations into emergency management efforts, climate change will increase risk to public safety, property damage, and emergency response and recovery costs to government and taxpayers. For instance, sea level rise will elevate tsunami risks associated with earthquakes in California, and efforts to plan, prepare, respond and recover to such risks must be adjusted accordingly.[172]

In addition to the more traditional disasters that California has face in the past, there is an ever increasing acknowledgement that climate changes present a growing peril to the state. There is growing global recognition that experts from the fields of emergency management and experts in climate science and policy will benefit from collaborative efforts to share approaches, information, goals, viewpoints, and insights.[173] Risk reduction is a common goal of efforts to prepare for climate change and emergency management activities.

In California, this collaborative work has already begun, and the integration of climate impacts into emergency management efforts builds upon strengths and competencies that already exist in California's disaster management agencies. Further work must be done to incorporate the best available climate risk projections and science into emergency management activities. Managing emergency risks based on historical trends will no longer be sufficient.

Working together, we can promote and implement risk reduction activities and increase our awareness and resilience to threats, hazards, and vulnerabilities, and coordinate the development of strategies, actions, and plans to manage risk and create long-term sustainability. Resilience depends on a whole community approach and is a shared responsibility for all levels of government (federal, state, local and regional, and tribal), private and nonprofit sectors, and individuals. Short descriptions of state entities that play an important role with respect to emergency management in California are provided in Box 27: California Emergency Management at the end of this chapter.

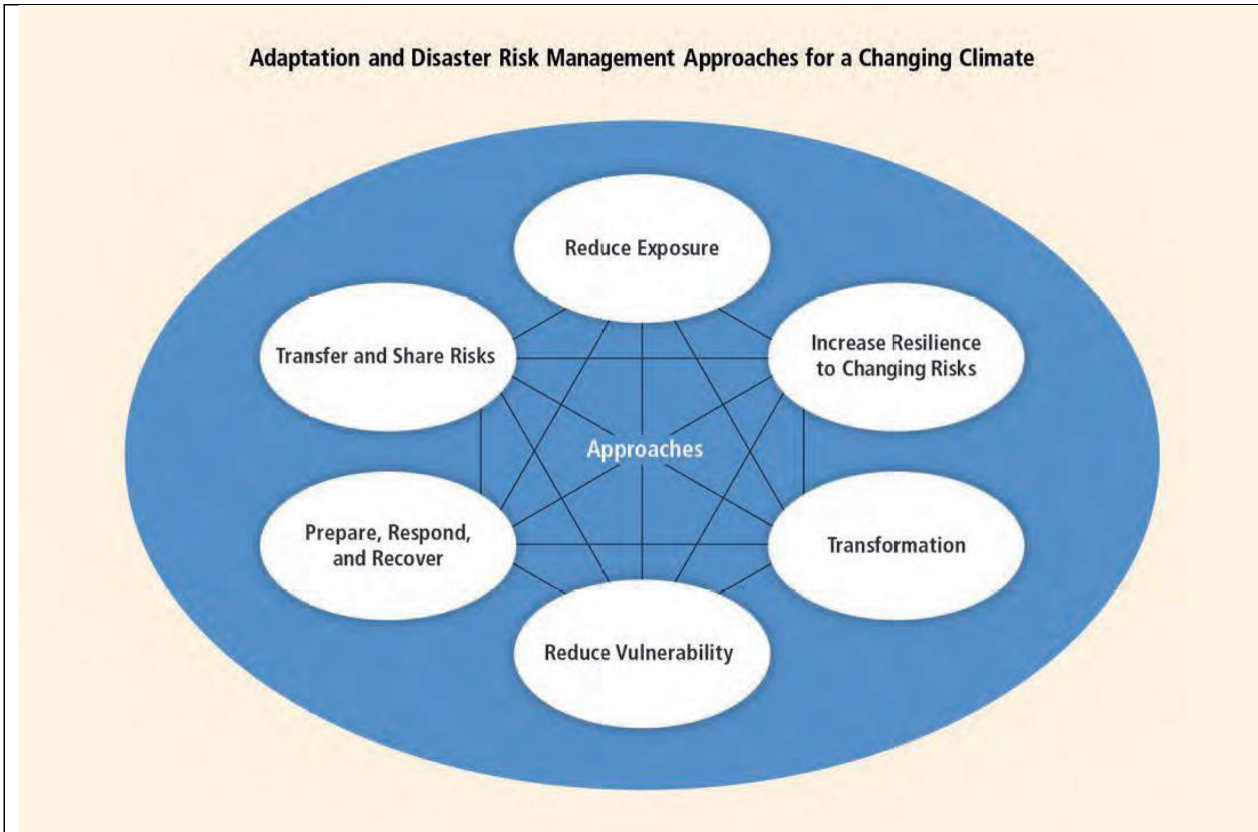
Integrating Risks of a Changing Climate into Emergency Management Activities

Emergency Management is a comprehensive system of policies, practices, and procedures designed to protect people and property from the effects of emergencies or disasters. It includes programs, resources, and capabilities to mitigate against, prepare for, respond to, and recover from effects of all hazards. While the scope, severity, and pace of future climate change impacts are difficult to predict, it is clear that potential changes could have impacts on emergency management capabilities and increased need for services. The severity of emergencies is determined not only by the occurrence of natural events (that may be increasing in magnitude and frequency due to climate change), but also on the level of exposure and socio-economic vulnerability to those events.[174] For instance, a severe fire in a largely uninhabited area may not cause significant property damage or loss of life. However, a less severe or less extensive fire in an area with many homes and businesses may cause significant property losses and impacts to public health and safety because of the greater degree of exposure. Also not all communities and not all members of a community are equally vulnerable to emergency situations; socio-economic conditions may vary and access to information, services and resources affects how impacts are experienced in emergency situations.[175] For instance, in the Los Angeles-Long Beach Metropolitan Area, a higher proportion of African-Americans do not have access to air conditioning compared to the general population (59 percent versus 40 percent, respectively). Similar trends hold for Latinos (55 percent) and communities living below the poverty line (52 percent).[176]

Incorporating projected climate impacts into emergency management can help reduce exposure and vulnerability and increase the resilience of California communities; working to reduce the causes of climate change by reducing greenhouse gases can also significantly reduce the risks associated with climate change.[177]

Box 16 below illustrates various climate risk adaptation and emergency management approaches for addressing climate risk. Risk sharing and cost transferring systems like insurance and disaster relief are tools for managing climate risk. Working to reduce exposures and vulnerabilities by lessening the likelihood, severity, and duration of adverse impacts from a changing climate is also important. Another approach for dealing with climate risks is to increase the resilience or ability of communities to anticipate, absorb, and recover from hazardous events in a timely and efficient manner that ensures the preservation, restoration or improvement of basic structures and functions. Finally, transformational changes in regulations and laws, technologies, financial institutions, land use management approaches, and other systems will be a necessary part of effective emergency management in the era of climate impacts.[178] These various approaches are overlapping and complementary. These approaches to managing climate risk also build upon traditional emergency management competencies and are further discussed below in the context of the four traditional phases of emergency management: hazard mitigation, emergency preparedness, response and recovery.

Box 16



From: IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea,K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19.

Hazard mitigation:

Hazard mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from natural or man-made hazards. This can include efforts to reduce exposure and vulnerabilities to climate impacts.

Climate change will result in new "normal" averages with respect to weather (e.g. new average temperatures at given times of year or new average amounts of precipitation in the form of rainfall). Climate change may also result in more 'extreme' events (e.g. Superstorm Sandy or extreme, prolonged heat events). Planning for projected new norms and more extremes must be part of hazard mitigation planning in the era of climate change.[179] Hazard mitigation planning based on historical trends will no longer be sufficient.

Hazard mitigation in the context of a changing climate can take many different forms including, but not limited to:

- Education for first responders and emergency managers on climate risks;[180]
- Minimizing new development in areas most vulnerable to hazards;[181]
- Investing in green infrastructure and other protective structures to address sea level rise;[182]
- Managed shoreline retreat;[183]
- Enhanced flood warning instrumentation;[184]
- Stabilize river banks and restore and create wetlands;
- Relocation or retrofits of structures in hazard areas;
- Climate risk communication and education;[185]
- Forest fire risk reduction through the removal of certain forest vegetation (or "fuels");[186]
- Defensible space clearance around homes and structures to reduce wildfire risk;[187]
- Implementing building codes that require use of fire resistant building materials in areas prone to wildfire risk;[188]
- Promoting sound land use practices;[189]
- Urban forestry and urban greening to address heat island effect;[190]
- Promoting use of cool pavements to deal with urban heat island effect;[191]
- Use of state-of-art materials in new infrastructure to optimize resilience in light of expected climate impacts;[192] and
- Mainstreaming climate risk considerations into government, business, and individual decisions.[193]

Attention to the timing and spatial dimensions of hazard mitigation efforts is critical in the era of climate change. Some efforts to reduce risk in the short term may actually increase exposure and vulnerability over the longer term. For instance, protective structures built to address sea level rise may encourage development patterns that may increase risk in the long term.[194] Therefore, such protective structures should be capable of being augmented over time, and adequate funding for long-term maintenance of such structures is needed.

Funding for hazard mitigation can be very cost effective. One study found that every dollar spent on a FEMA hazard mitigation grant produced, on average, four dollars of benefits.[195]

The California Governor's Office of Emergency Services (CAL OES) leads hazard mitigation activities in California. CAL OES maintains and coordinates the update of the State of California Multi-hazard Mitigation Plan (SHMP). As California's primary hazard mitigation guidance document, the SHMP provides a comprehensive description of the state's historical and current hazard analysis, mitigation strategies, goals and objectives. The integration of climate risks, such as heat emergencies, prolonged drought, wildfires, flooding, sea level rise and severe storms and erosion, into the SHMP is further described below in the subsection of this chapter titled “Highlights of Steps Taken to Date and Success Stories”.

The State of California is required to review and update its SHMP and resubmit for Federal Emergency Management Agency (FEMA) approval at least once every five years to ensure continued funding eligibility for certain Stafford Act grant programs. This includes FEMA’s hazard mitigation assistance programs: Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Assistance (PDM), Repetitive Flood Claim Program, as well as the Fire Management Assistance Grant Program and Public Assistance grants (Categories C-G). In addition, the state remains eligible for the reduced cost share for grants awarded under the Flood Mitigation Assistance grant programs. States which can demonstrate a more comprehensive “Enhanced Mitigation Plan” are eligible for an increased amount of mitigation funding following a disaster declaration.[196] The 2013 SHMP is an Enhanced Mitigation Plan.

In addition to maintaining and coordinating updates of the SHMP, CAL OES also engages in the following hazard mitigation activities:

- CAL OES supports and assists local governments in the development of Local Hazard Mitigation Plans (LHMPs) required under DMA 2000. CAL OES reviews and provides information on integrating hazard identification, risk assessments, risk management, and loss prevention into a comprehensive approach to hazard mitigation and helps local governments identify cost-effective mitigation measures and projects.

- The DMA 2000 introduced reforms to try and move hazard mitigation planning away from reactive, disaster-driven processes. DMA 2000 instituted a Pre-Disaster Mitigation Grant Program (PDM) which provides funds to states, territories, Indian Tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event; however, funding allocations for the PDM program have declined and there have been proposals to eliminate PDM funding altogether.[197] CAL OES administers the hazard mitigation program for plans and projects through the FEMA Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Grant Program (PDM), and Flood Mitigation Assistance Grant Program (FMA).[198] The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The FMA provides funds to assist States and communities in implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program.[199] CAL OES maintains a complete listing of mitigation grants.[200] Hazard mitigation that is based on proactively anticipating threats, rather than based on past disasters, will be necessary in the era of climate change since the magnitude, timing, and frequency of natural disaster risk is changing, and historical disaster reference points may no longer be accurate predictors of future threats.

- The CAL OES Dam Safety Program was established by Government Code §8589.5 in 1972 following a near failure of the Lower San Fernando Dam during the Sylmar Earthquake. The Dam Safety Program provides assistance and guidance to local jurisdictions on emergency planning for dam failure events, collects and reviews dam failure inundation maps, and evaluates waivers from the inundation mapping requirement. The Dam Safety program coordinates with the California Division of Safety of Dams and other state and federal agencies in activities to assure effective dam incident emergency response procedures and planning.

  The Cal OES Dam Program is also the designated repository of the official dam failure inundation maps used in California's Natural Hazard Disclosure statement as specified in Civil Code § 1103 for real estate transactions. For information on climate change and dam safety in California, please see Box 17: California Dam Safety & Climate Change.[201]

- CAL OES developed and maintains the MyHazards online tool that allows Californians to identify hazards in their area (earthquake, flood, fire, and tsunami) and learn steps to reduce personal risk.[202] In 2011, CAL OES also launched the MyPlan online tool for hazard mapping to support local planning efforts. CAL OES and the California Natural Resources Agency, partnered with FEMA to develop MyPlan as a risk assessment and communication tool. MyPlan facilitates city, county, special district, and Tribal access to federal- and state-produced hazard data for use in creating maps for preparing, upgrading and reviewing Local Hazard Mitigation Plans (LHMPs), General Plan Safety Elements, Local Coastal Plans (LCPs), and hazard mitigation projects.[203] Currently, the MyHazards and MyPlan tools do not incorporate climate projection data; however, Cal-Adapt, discussed in Inset 1 in the Introduction, does provide climate projections for local areas.

Box 17

Dam Safety in a Changing Climate

Climate change can present new conditions that could potentially even exceed historical dam design standards, and result in dam overtopping or failure.[204] For instance, increases in precipitation, changes in precipitation patterns, changes in run-off timing and quantity, and obstruction of spillways from increased debris and sediment caused by more frequent watershed wildfires can potentially increase the risk of dam overtopping or failure. However, because California dam design standards have been very conservative, climate change is not expected to have a significant effect on the near-term safety of California dams under State jurisdiction for dam safety.[205]

The Division of Safety of Dams (the Division), under the California Department of Water Resources, is charged with protecting people against loss of life and property from dam failure.[206] The Division regulates about 1,250 jurisdictional sized dams in California.[207] There are roughly 180 Federal dams that are exempt from State regulation as well as hundreds of non-Federal dams that are not subject to Division's regulation due to their smaller size and/or storage.

The Division requires all jurisdictional dams to have sufficient spillway capacity to safely pass the design storm. Dams with even minimal downstream hazard consequences (i.e., the downstream risk associated with a sudden catastrophic failure) are designed for 1,000-year return period storms. As the level of downstream risk increases, the required design storm also increases, up to the Probable Maximum Precipitation (PMP) for the larger dams/reservoirs with extreme downstream hazard consequences. The PMP is determined in accordance with federal hydro-meteorological reports.[208] A "Probable Maximum Precipitation" can be thought of as the ceiling of all possible storms and results from the most severe combination of meteorological and climatological conditions that are considered reasonably possible from the study area.[209]

The Division considers spillway performance to be the greatest threat to dam safety arising from climate changes and is therefore continuing to coordinate with the Department of Water Resources climate staff to incorporate updated climate considerations into its analyses and work.[210] Also, as part of the Division's maintenance and inspection program, dam spillways and their inlets are closely monitored to ensure that they are, or will be, clear of debris prior to the onset of the wet season. Wildfires have historically occurred during the warm season when watersheds and their reservoirs can be managed to ensure spillways remain clear.

Box 18

What is a 100-year storm (precipitation) or a 100-year flood?

A 100-year storm or precipitation refers to a specified depth of rainfall, in inches, for a given duration that has a 1 in 100 or 1% chance probability of occurring at least once at a particular location in any given year. Likewise, a 50-year rainfall event has a 1 in 50 or 2% chance of occurring in any given year. Statewide, 100-year precipitation estimates may vary, depending on the statistical method or distribution that is followed and the rainfall data set(s) used. [211]

Similarly, a 100-year flood refers to a specified rate or magnitude of water flow, usually expressed in cubic feet per second, that has a 1 in 100 or 1% chance probability of occurring in any given year. [212] Its flow value is typically estimated by statistically evaluating recorded stream flow data from a particular watershed.

Not every 100-year precipitation corresponds to a 100-year flood since the recorded data set for the precipitation and the recorded data set for the flood flow values are different from each other and at the time of the storm event, the watershed 's conditions and characteristics are variable. In practice, in the media, both terms are used interchangeably.

As noted elsewhere in this Safeguarding California Plan, climate change is expected to increase the frequency and the magnitude of more severe weather events which will lead to an increase in the magnitude of the 100-year event. For example, a previous 100-year estimated event is now a 70-year event. In addition, the Plan noted that climate change is expected to increase the frequency of 100-year storms/floods in any year, resulting in multiple 100-year storms or floods that occur in a single year.[213]

Emergency Preparedness:

Emergency preparedness is part of emergency management that encompasses preparations to be ready for disasters that may strike. For CAL OES, this includes activities such as supporting local efforts in emergency planning, integrating the needs of vulnerable populations in emergency planning, and maintaining the State Emergency Plan.[214] Cal OES is delegated by the Governor to support and enhance all phases of emergency management which include Preparedness, Response, Recovery and Mitigation. The Cal OES "Planning and Preparedness Division" web site identifies a number of plans, guidance materials, support information, points of reference, and other materials to assist in development of a successful all-encompassing preparedness program. As further discussed below, many other state entities – including, but not limited to, HHS, CDPH, CDFA, CalTrans, Cal/EPA, the Resources Agency, and the CEC, play key roles in California's emergency preparedness.[215] The need for emergency preparedness is greater than ever given new climate risks, including increasing frequency of disasters, coupled with other trends like a growing California population, which may leave more people vulnerable to the effects of disasters. Climate change will likely require improvements to "surge" or rapidly increase capacity to ensure the ability to meet increased needs during disasters and emergencies – including, for instance, assessing and addressing staffing and equipment needs to create a more flexible workforce by increasing employee readiness, cross-training staff, and increasing the pool of employees who are qualified and trained to respond to disasters and other events.[216]

The State of California Emergency Plan (SEP) addresses the state's responses to extraordinary emergency situations associated with natural disasters or human-caused emergencies. The SEP provides a consistent, statewide framework to enable state, local, tribal governments, federal government and the private sector to work together to mitigate against, prepare for, respond to and recover from the effects of emergencies regardless of cause, size, location, or complexity.

The 2009 SEP recognized growing trends such as greater vulnerability to floods and wildland fires, and the influence of extreme weather events on emergency management activities.
The 2009 SEP also established the California Emergency Functions (EF) which consists of 18 disciplines deemed essential to the emergency management community in California. The California Emergency Functions define state functional capabilities, emergency management activities and resources needed in the following areas:

EF 1 – Transportation
EF 2 - Communications
EF 3 - Construction and Engineering
EF 4 - Fire and Rescue
EF 5 – Management
EF 6 - Care and Shelter

EF 7 – Resources
EF 8 - Public Health and Medical
EF 9 – Search and Rescue (USAR merged with EF 4 Fire and Rescue and Wildland SAR merged with EF 13 August 2013)EF 10 – Hazardous Materials
EF 11 – Food and Agriculture
EF 12 – Utilities
EF 13 – Law Enforcement
EF 14 – Recovery
EF 15 – Public Information
EF 16 – Evacuation (merged with EF 13 Law Enforcement August 2013)
EF 17 – Volunteers and Donations Management
EF 18 – Cyber Security

In 2010, CAL OES released a Contingency Plan for Excessive Heat Emergencies, a contingency plan supporting the SEP. This plan outlines the actions the State of California will take in support of local government when an extreme temperature event is anticipated or has occurred. This plan also provides guidance for local government and non-governmental organizations in the preparation of their heat emergency response plans and other related activities, and is further discussed below under the heading of Highlights of Steps Taken to Date and Success Stories.[217] As noted in the Public Health section of this document, CDPH and Cal/EPA have also released "Preparing California for Extreme Heat: Guidance and Recommendations"[218]. CAL OES also has a Contingency Plan for Extreme Cold/Freeze Emergencies.[219]

The SEP designates lead agencies for each emergency function, and as noted above, many state entities play key roles in California's emergency preparedness. For instance:

- Pursuant to the State Emergency Plan, HHS is the lead agency for Public Health and Medical activities and services statewide in support of local jurisdiction resource needs for preparedness, response, and recovery from emergencies and disasters.[220] As noted in the Public Health section of this document, climate change poses risks to public health, including, but not limited to, severe heat events and smoke exposure from increased wildfires. HHS includes both the California Department of Public Health - Emergency Preparedness Office (CDPH EPO)- the state's lead on health emergencies and the Emergency Medical Services Authority (EMSA). CDPH EPO and EMSA both work closely with CAL OES. Among other things, EMSA coordinates statewide activities for emergency medical services, assists CAL OES with the emergency management component of the State Emergency Plan, and develops the California Disaster Medical Response Plan.[221] CDPH's EPO plans and executes activities to prepare Californians for public health emergencies.[222] CDPH EPO also maintains the "Be Prepared" website to provide information on preparing for public health emergencies including floods and wildfires.[223]

- CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As further discussed in the Agriculture section of this document, climate change poses a variety of risks to food and agriculture, including, but not limited to food and feed safety and agricultural diseases and pests; for instance, severe drought is a climate-risk, with significant impacts for agriculture (and other sectors). Drought and drought management is discussed further in the Water section of this document.

- The California Utilities Emergency Association (CUEA) serves as a point-of-contact for critical infrastructure utilities and CAL OES and other governmental agencies before, during and after an event to:

  - Facilitate communications and cooperation between member utilities and public agencies; and with non-member utilities (where resources and priorities allow);
  - Provide emergency response support wherever practical for electric, petroleum pipeline, telecommunications, gas, water and wastewater utilities and;
  - Support utility emergency planning, mitigation, training, exercises and education.

The Energy Commission works with and provides support to CAL OES in the form of information gathering, technical expertise, programs, and contingency planning with respect to energy. The principal contingency planning programs include the Energy Emergency Response Plan, Petroleum Fuels Set-Aside Program, Local Government Program, Economic Assistance Program, and Demand Reduction Program. Climate risks to Energy are further discussed in the Energy section of this document.[224]

Box 19

California Department of Water Resources; 1997

<u>Response</u>:
As noted in this section and in other sections of this document, climate change is likely to lead to more frequent and more severe weather events and climate-related disasters and emergencies, such as heat waves, floods, drought and wildfires. Emergency response capability will likely need to be enhanced in order to address these escalating threats.

Box 20

California Department of Water Resources; 1997

The Standardized Emergency Management System (SEMS) unifies all elements of CA's emergency management community into a single integrated system and standardized key elements. SEMS continues to be used in California for managing emergencies involving multiple jurisdictions and agencies.

SEMS-NIMS Integration- the CAL OES is responsible for coordinating and monitoring the overall statewide integration of the SEMS and the National Incident Management System (NIMS) to meet federal NIMS requirements and timeframes. NIMS was developed by the federal Department of Homeland Security (DHS) pursuant to Homeland Security Presidential Directive/HSPD-5 to ensure that all levels of government across the nation have the capability to work efficiently and effectively together, using a national approach to domestic incident management.

CAL OES Response includes Regional and State Operations California State Warning Center, Public Safety Communications Office, Fire and Rescue, Law Enforcement, Mutual Aid System, Membership in Emergency Management Assistance Compact (EMAC), Catastrophic Response Planning, the Joint State/Federal CONOS, and public/private coordination.

    - When emergencies exceed the capabilities of local resources, CAL OES activates the State Operations Center (SOC) in Sacramento and the Regional Emergency Operations Centers (REOCs) in impacted areas to receive and process local requests for assistance. During major emergencies, CAL OES will call upon its own response resources, state and local government agencies and public/private partners based on their specialized capabilities and expertise to help provide support to local government.

- The California State Warning Center (CSWC) provides emergency communications and is staffed 24 hours a day, seven days a week, 365 days a year. Although the system was established primarily to provide communications and warning in the event of nuclear incident, it serves as a system of communications and notification for all disasters. Upon direction of the CAL OES Executive Duty Officer, the CSWC will begin notification of the on call CAL OES Operational Readiness Team. This team's purpose is to staff the State Operations Center as quickly as possible. The CSWC also begins the notification process of the departmental 24 hour points of contact that are required to staff the State Operations Center.

    - Public Safety Communications Office (PSCO) serves the State of California by providing public safety communications to the State's first responders and oversight of the 9-1-1 system to the People of California. The PSCO is dedicated to the preservation and protection of human life and public safety by delivering reliable and dependable communication services keeping the public connected during times of crisis.

    - CAL OES Fire and Rescue coordinates the systematic mobilization, organization and operation of necessary fire and rescue resources throughout the state and its political subdivisions in an effort to mitigate the effects of disasters, whether natural, technological or human caused. For more information about the impacts of climate change from the perspective of an emergency services first responder, please see Box 22 First Person Narrative - Climate Change and Wildfire in California by Thom Porter - CAL FIRE Unit Chief San Diego.

    - CAL OES Law Enforcement works directly with California's sheriffs and police departments. Law Enforcement deploys assets to disaster scenes, provides law enforcement mutual aid guidance, Search and Rescue resource deployments, and Coroners and Mass Fatality coordination.

    - The Mutual Aid System is an extension of the concept of "neighbor helping neighbor." As a component of the Standardized Emergency

Management System [SEMS], the Mutual Aid System is based on four organizational levels: cities, counties, regions and the State.

- California is a member of the Emergency Management Assistance Compact (EMAC), a congressionally ratified organization among the 50 states and territories. Through EMAC, a disaster impacted state can request and receive assistance from other member states quickly and efficiently.

- Catastrophic planning. Through a collaborative effort by CAL OES and the Federal Emergency Management Agency (FEMA), the Catastrophic Incident Base Plan establishes the Concept of Operations (CONOP) for the joint Federal and State response to, and recovery from, a catastrophic incident in the State of California. The CONOP defines the joint State/Federal organization and operations that support the affected local governments and other entities in the incident area.

- There is a critical need for the organized synchronous exchange of information and resources between public and private sector organizations. To meet that need, CAL OES has agreements with private sector and non-profit organizations which will provide support to the state during times of crisis. Together, these organizations form the Business and Utility Operations Center (BUOC) - comprised of two components: the Business Operations Center (BOC) and Utility Operations Center (UOC) - and they serve as a critical component in emergency response and addressing the needs of impacted communities.

Box 21

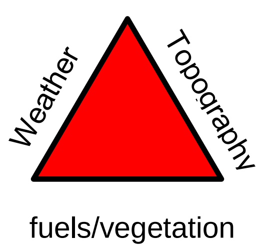
Harris Fire - San Diego County - October 2007
Photo: CAL FIRE - Wes Schultz

Box 22

<u>FIRST PERSON NARRATIVE: *Climate Change and Wildfire in California*</u>
By Thom Porter CAL FIRE Unit Chief San Diego [used with permission]

As a fourth generation Southern Californian, I have had a lot of opportunity to hear stories of how it used to be. I love the stories and conjecture about the old days. Recently, I have developed an interest in verifying some of the "stories" through research of my family history. I found that I come from a family of outdoorsman/foresters, some of whom helped shape the West. In fact, my great grandfather was one of the first foresters to come to San Diego County and the mountains of Southern California in the U.S. Government's effort to preserve forest lands for the public good. I am honored to follow the family calling and find new challenges with similar scope and importance to those of the past.

In California and much of the West, wildfire is an accepted environmental norm. However, humans cause the vast majority of fires while natural events (lightning, volcanic activity, etc.) cause relatively few. Essentially there are three elements that define wildfire behavior: weather, fuels, and topography. These are the basic components of the wildfire behavior triangle



The wildfire behavior triangle simply displays the elements that effect wildfire spread. It is important to note that humans can effect change on only one part of this triangle (Fuels/Vegetation). Topography remains more or less constant, changing on the geologic time scale. Weather is the most variable and excessively difficult to predict. Weather is the element that will most quickly alter as the climate changes. Firefighters are keenly aware of what weather pattern changes can do to fire behavior. It is more difficult to determine what the long term effect will be on the health of watersheds and all of the values they support.

For over 100 years, we have geared up to fight wildfires on a seasonal basis. “Fire season” has been a staple in our way of planning for and deploying firefighting resources during the late spring, summer, and early fall. The West has had a predictable cycle of wildfire occurrence (with a few local exceptions). The Southwest gets fires early and then the monsoons dampen the region and fires start to breakout in the Great Basin as summer takes hold. In mid- to late summer, the Pacific Northwest and Northern California dry out, and fires can easily consume the parched vegetation. Southern California closes the “fire season” with the potential for Santa Anna Wind-driven fires. These are some of the most dangerous due to the large population in the region including cities and towns intermixed with wildland vegetation.

The “fire season” cycle identified above seems to be breaking down. There is less predictability. More and more large and damaging wildfires are occurring outside of fire season, deep into the winter or earlier in the spring. Weather is the primary reason for this change. Less precipitation is coming in the form of snow which slowly charges water supply facilities and keeps fire threats in the high country to a minimum until deep into the summer months. We are getting long dry spells sometimes accompanied by winds that drive fires like the Viejas Fire in January 2001 (San Diego County), to over 10,000 acres in one active day of burning. Southern California has its share of large and damaging wildfires. It is part of the Mediterranean climate that indigenous plants, animals and humans have adapted to over millennia. However, the adaptations are based on a cycle that seems to be changing at a rate that can’t be matched. Scientists have found that many of the species of animals whose habitat was consumed by the massive wildfires in 2003 and 2007 are starting to return and some are thriving. Others are gone. Those requiring woody debris (stumps, logs, and sticks) and thick leaf litter have not returned and they may not for decades, or ever.

You may wonder why this matters to a forester turned fire chief. As a chief in one of the most progressive wildland fire agencies, I feel it is my duty to know how fire is likely to affect the people and natural resource values of California and beyond. Informed proactive decision making will help me and my colleagues best meet our mission to …serve and safeguard the people and protect the property and resources of California.

Climate change has the potential to shift local and regional weather patterns. Drought may persist in some areas while above average precipitation may occur elsewhere. It is certain however that wildfires will be a permanent issue for Californians. I often say, "Every acre of land can and will burn at some point in time." Where the next large damaging fire will occur is not certain. However, we must expect and prepare for it to come. Likewise, we must plan for a less predictable and longer firefighting season including fires that defy our conventional recollections.

I am proud of California's leadership and governmental effort to address climate change. As a senior manager, I look forward to continuing my personal and family's service to the people and natural resources of California. As the climate changes, there will be tough issues to deal with and I am confident California will lead the way with innovative solutions.

Recovery:
Post-disaster recovery and reconstruction periods provide an opportunity for reducing vulnerability to weather- and climate-related risk. However, an emphasis on rapid rebuilding of infrastructure, homes and businesses often leads to recovering in ways that recreate or even increase existing vulnerabilities, and preclude longer-term planning that could enhance a community's resilience to climate impacts.[225]

Risk and cost sharing mechanisms like disaster relief and insurance can help increase resilience by providing means to finance recovery of livelihoods and reconstruction, and by providing knowledge and incentives for reducing risk.[226] FEMA's National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.

> As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:
>
> - Reduce flood damage to insurable property;
> - Strengthen and support the insurance aspects of the NFIP, and
> - Encourage a comprehensive approach to floodplain management

Please see Box 23**: Climate Change and Insurance** below (please also see Box 48**: Flood Insurance** in the Oceans and Coastal Ecosystems and Resources section of this document). It should be noted, however, that in some circumstances, risk and cost sharing mechanisms can provide disincentives for reducing disaster risk; see, for example, the discussion of repetitive loss and the National Flood Insurance Program in the Oceans and Coastal Ecosystems and Resources section of this document.[227]

CAL OES administers a number of recovery programs including:

- Public Assistance to aid state agencies, local governments, special districts and eligible private non-profit organizations that have been impacted by a disaster. Through Public Assistance, CAL OES facilitates state and federal support to applicants to assist in community recovery from a major disaster or emergency;

- Individual Assistance involves coordination with federal, state, local, and voluntary/non-profit entities to provide recovery assistance following a disaster where individuals and households, businesses, and/or the agricultural community are impacted; and

- Additional Technical Resources provided through Recovery Programs include post-disaster Safety Assessments, Debris Management and Environmental/Historic assistance to address environmental compliance issues.

- Emergency Function (EF) 14 – Recovery supports and coordinates the state-level activities of its stakeholders in the mission to achieve recovery success within California. The EF 14 stakeholders work together within their statutory and regulatory authorities to effectively and efficiently coordinate recovery operations. EF 14 is currently under development.

- The California Disaster Recovery Framework (CDRF), which is under development, is organized by the six Recovery Support Functions (RSFs) and the recovery core capabilities of public information and organizational coordination (leadership). The RSFs outline roles and responsibilities of stakeholders and anticipate and identify the significant functions or categories of support. CDRF is currently under development.

- National Disaster Recovery Framework, updated in 2013, provides context for how the whole community works together and how response efforts relate to other parts of national preparedness. It is one of the five documents in a suite of National Planning Frameworks. Each Framework covers one preparedness mission area: Prevention, Protection, Mitigation, Response or Recovery.

Box 23

Climate Change and Insurance

The insurance industry is vulnerable to climate change, but can also help society manage climate risks. The insurance industry is the world's largest industry with 4.6 trillion USD of annual revenues.[228] Insurance provides a way of pooling risk and facilitating recovery from losses and disasters. Insurance cannot make whole all losses (such as loss of life and the loss of other irreplaceable items), however insurance can provide important financial relief.

Generally, insurance companies are required to maintain adequate reserves to cover claims.[229] However, when there is the potential for claims to exceed the amount of reserves an insurance company can maintain, insurers look for other instruments to pay claims, including re-insurance[230] and, more recently, catastrophe bonds. However, the cost of reinsurance can decrease the affordability of insurance.[231]

Reinsurance and global risk sharing are ways of making insurance actuarially viable. According to the Reinsurance Association of America:

> "Reinsurance is best thought of as 'insurance for insurance companies,' a way for a primary insurer to protect against unforeseen or extraordinary losses…to share liability when losses overwhelm the primary insurer's resources…reinsurance plays a critically necessary…role in the financial management of natural disaster losses.
>
> In a reinsurance contract one insurance company (the reinsurer…) charges a premium to indemnify another insurance company…against all or part of the loss it may sustain under its policies…Reinsurance is a global business. Its international nature reflects a further spreading of risk and access to broader capital markets to help cover losses. About 46% of all U.S. property/casualty reinsurance premiums, and two-thirds of all U.S. property catastrophe reinsurance premiums, are written by foreign reinsurance companies."[232]

The re-insurance company Swiss Re published a report in 2013, that notes that a loss like the one triggered by Superstorm Sandy should be expected about every five years when looking at the U.S. as a whole.[233] International insurance and reinsurance companies are expected to cover half of total insured losses (in excess of $8 billion USD) from Superstorm Sandy, according to the industry Association of Bermuda Insurers and Reinsurers (ABIR).[234]

The risks can eventually become so extreme, that insurers can decline to underwrite, leaving the public without a means to cover losses[235]. Then, public insurance mechanisms become vital. This has occurred with flood, crop, wind and earthquake insurance.

Public Insurance Mechanisms

The government does offer some insurance products through the National Flood Insurance Program and the Federal Crop Insurance Corporation. Those programs are further discussed in the Oceans and Coastal Ecosystems and Resources section of this document and the Agriculture section of this document. It is important to note, that much of California's agricultural production is not eligible for federal crop insurance. The National Flood Insurance Program's rates have significantly increased due to the Biggert-Waters Flood Insurance Reform Act. As a result, many who are at risk may not be able to afford flood insurance. [236]

States offer insurance through public instrumentalities, such as the California Earthquake Authority and Florida's Citizens Property Insurance Corporation. Because the risk of loss remains high, insurance rates from these providers can be expensive and the take up rate can be low, leaving many who are at risk without coverage.[237]

When losses are not covered by insurance, Federal disaster aid is the last resort for disaster victims. In the event of a major disaster, federal funding for response and recovery comes from the Disaster Relief Fund managed by FEMA and disaster aid programs of other participating federal agencies. These programs are provided with emergency supplemental appropriations to cover the costs of damages. The federal government does not budget for these costs; without a comprehensive view of overall funding claims and trade-offs, it is difficult for federal decision makers to manage such fiscal exposures. FEMA has obligated over $80 billion in federal assistance for disasters declared during fiscal years 2004 through 2011; with a growing number of disaster declarations—a record 98 in fiscal year 2011 compared with 65 in 2004.[238]

Challenges and Opportunities

When risks are too great or undefined, insurers may withdraw from at-risk market segments, increase prices, or limit coverage, and this creates undesirable societal vulnerabilities.[239] Nontraditional capital in the form of reinsurance backed by hedge funds or insurance-linked securities may help bolster insurance capacity in disaster prone areas[240], but the threat that climate risks pose to insurer solvency is still of concern for insurance regulators.[241]
In 2005, insurance regulators foresaw the impending threat of climate change on the insurance industry and began to address it. Although insurance is regulated on a state-by-state basis – in California, the Department of Insurance, headed by Insurance Commissioner Dave Jones, serves this function, insurance regulators actively participate in the National Association of Insurance Commissioners (NAIC, the U.S. standard-setting and regulatory support organization created and governed by the chief insurance regulators from the 50 states, the District of Columbia and five U.S. territories.)[242]

To address the implications of climate change on insurers and insurance consumers, the NAIC hosted a public hearing in 2005. Subsequently, the NAIC released *The Potential Impact of Climate Change on Insurance Regulation* white paper in 2008.[243] The white paper examined the effects of climate change on insurance industry investment decisions, disclosures and underwriting practices. The white paper also recommended regulators develop a framework for the collection of information related to the impact of climate change on insurers. [244]

In response to the white paper, the NAIC adopted the *Insurer Climate Risk Disclosure* Survey ("survey") in 2010. The eight question survey was designed to be an insurer reporting mechanism that would provide regulators with information on how insurers incorporate climate risks into their mitigation, risk management, and investment plans. Insurers are also asked to identify steps taken to engage key constituencies and policyholders on the topic of climate change. [245]

The survey was modeled after the CDP (formerly named the Carbon Disclosure Project) voluntary questionnaire and, as such, cross references its questions. The CDP questionnaire asks respondents to disclose their greenhouse gas emissions, water management and climate change strategies. Although the CDP holds the largest collection of self-reported climate change data, insurer participation is low. Insurance regulators developed the survey as a way to fill the void of pertinent climate risk information. According to the CDP, insurers typically disclose such things as their carbon footprint reduction efforts, modeling, physical risk assessments, liability concerns, investment strategies, and underwriting policies. Many also report on climate change related innovations and green practices, such as sustainable real estate, catastrophe bonds, renewable energy practices and green reconstruction. [246]

Unfortunately, California was one of only a handful of states to actually participate in the administration of the survey, and was the only state to do so in 2011, during the second year of the survey[247].

In 2012, the insurance departments of California, Washington, and New York administered the *NAIC Insurer Climate Risk Disclosure* Survey ("survey") for the 2011 reporting year as part of a multi-state initiative. The multi-state initiative was designed to bolster participation in the survey by capturing most of the insurance industry. The survey was required for insurers writing more than $300 million in direct premium in these states, covering 68 percent of the U.S. insurer market. Approximately 470 company responses were collected in 2012 and made publicly available on the California Department of Insurance's website.[248] It should be noted uniform responses were permitted for insurers that are part of a group. [249]

The multi-state initiative was expanded in 2013 to include the insurance departments of Connecticut and Minnesota. Additionally, the required reporting threshold was lowered from $300 million to $100 million in direct written premium and applied mandatorily to all individual companies that write business in one of these states, regardless of where they are domiciled. Assuming full reporting compliance, this change in threshold is expected to double the number of reporting companies and should give insurance regulators, investors and policyholders a better picture of how insurers are responding to climate change. [250]

The California Department of Insurance, which serves as the central filing point and data warehouse, now offers companies the ability to submit their data directly online. The move to online filing will allow submitted data to feed directly into a database sortable by regulators and interested parties, enabling more people to provide analysis. [251]

In recognition of the growing need to ensure that insurers are addressing climate related risks, the NAIC also adopted revisions to the 2013 *Financial Condition Examiners Handbook* at the end of 2012. These revisions incorporated risk-focused examination questions that provide examiners with needed guidance on what questions to ask insurers regarding any potential impact of climate change on solvency. They were specifically designed to help examiners identify unmitigated risks and to provide a framework for them when examining such risks and their impact on how an insurer invests its assets and prices its products. The updates made changes to the Handbooks' Exhibit B – Examination Planning Questionnaire, Glossary, Interview of Investment Management, Interview of Chief Risk Officer, Exhibit V – Prospective Risk Assessment, Investment Repository, and Underwriting Repository sections. [252]

Disclosure of climate risk is important because of the potential impact climate change can have on insurer solvency and the availability and affordability of insurance across all major categories. Munich Re estimates weather related losses increased nearly fourfold in the United States since 1980. According to a study by Munich Re, from the period 1980 to 2011, insurers faced losses of $510 billion from extreme weather events such as prolonged droughts, hurricanes, floods, and severe storms.[253] Experts predict climate change will continue to intensify the frequency and severity of these types of weather related events. Given these trends, it is important for insurers to identify climate-related factors and evaluate how they will impact their business and the exposures they indemnify. Recognizing the need to ensure insurers account for any potential effect these risks might have on the marketplace and the availability and affordability of insurance, state insurance regulators and other stakeholders have moved forward to administer a climate risk disclosure tool. Disclosures allow regulators a window into how insurers are incorporating these changing dynamics into their risk management schemes, corporate strategy, and investment plans. Disclosures also benefit insurers, providing them with a benchmark from which to assess their own climate change strategies and strengthening their ability to identify how climate change impacts their business. Furthermore, disclosure allows policymakers to gain an insight into needed public policy changes. [254]

Changing Regulation

Effective insurance regulation must strike a balance between allowing insurers to earn a return on their business activities while ensuring their solvency in the event of major losses, and maintaining the affordability and availability of insurance for the public.[255] Continued investments in climate science can help improve data and risk analysis supporting the insurance industry. Reducing the emissions that cause climate impacts can help prevent risks from becoming actuarially uninsurable, and the insurance industry can help disseminate information on emergency management and play an important role in increasing the resiliency of communities.[256]

The difference between the life span of insurance policies and climate risk planning time horizons may present challenges. For instance, when insurance policies are written for one to three years, insurers may have little incentive to reward short-term actions by policyholders that might reduce losses 50 to 100 years in the future.[257]

Government policies to reduce climate risks, such as land use regulation, zoning, and building standards, can work in a complementary fashion with private insurance, by helping to manage risks that are beyond the control of private insurers.[258]

California, as well as other states have enacted laws and regulations that address the impacts of climate change and encourage climate change mitigation.

Florida, for example requires residential property insurance companies to offer premium discounts to policyholders who carry out specified actions to reduce their vulnerability to hurricane- and tropical storm-force winds.[259] This encourages homeowners to mitigate their risks of loss.

In California, the Department of Insurance has facilitated mitigation of carbon emissions by enabling insurers to offer new products.

In 2009, the Department of Insurance enacted new regulations that enabled insurers to offer "pay-as-you drive" automobile insurance, which rewards consumers with reduced rates when they reduce miles driven. Since a reduction in a policyholder's miles driven corresponds to a reduction in an insurers' risk of loss, reduced rates are justifiable under the Insurance Code. Regulations for the product, permits insurers to offer premiums based on distances driven; and reducing vehicle miles traveled which helps reduce the greenhouse gas emissions that cause climate change.

The California Department of Insurance has also approved policy discounts and other financial incentives for green buildings recognizing the reduced risk of loss for buildings with features associated with green buildings. The first commercial green policy was offered by Fireman's Fund Insurance Company in 2006.[260] In 2008, the California Department of Insurance approved the first green homeowners insurance policy, allowing homeowners with conventional homes to rebuild to the latest environmental standards after a loss.[261] (For more on green buildings and energy efficiency, please see the Energy section of this document.)

The Insurance Commissioner also takes an active role in improving California's catastrophe mitigation efforts related to wildfires. Every year more than $100 million is spent on fire suppression and even more in disaster recovery, but California continues to burn and the losses continue to mount. Eleven (11) of the 20 largest fires in California have occurred in the last decade and eight (8) in just the last four and a half (4 ½) years. In an effort to push mitigation, CDI entered into a Memorandum of Understanding with CAL FIRE to mutually promote an increased awareness and collaboration among fire officials, the insurance industry and the public with the following goals:

- Reduce the risk that wildfires will cause in the loss of life or large-scale property damage/loss.
- Increase awareness of fire officials, the insurance industry and the public on methods and ways to prevent and mitigate fire losses.
- Increase incentives for homeowners, businesses, and insurance companies to actively prevent and mitigate fire risks.

New weather-based products (or weather derivatives) are also being developed. Although these would not be considered insurance because they do not provide coverage directly related to losses, they compensate purchasers (often businesses that are weather-dependent) for a shortfall in the realization of a particular weather variable (e.g. rain, snow or temperature) measured over a certain time period. If the weather variable is sufficiently correlated with the policyholder's profit, the payoff of the weather derivative can offset weather-related policyholder losses.[262]

Investing to address climate change

With $25 trillion in assets—equal to global mutual funds or pension funds—insurers are central players in world financial markets. Recognizing investment opportunities, insurers have invested at least $23 billion in emissions-reduction technologies, securities, and financing, plus $5 billion environmentally focused funds.[263] Using the California Department of Insurance Climate Risk Disclosure Survey results, an organization representing public pension funds has evaluated insurers' preparedness for climate change.[264]

The California Insurance Commissioner has encouraged the insurance industry to make green investments, meaning investments that emphasize renewable energy projects, economic development, and affordable housing focused on infill sites so as to reduce the degree of automobile dependency and promote the use and reuse of existing urbanized lands supplied with infrastructure for the purpose of accommodating new growth and jobs. In fact, insurance companies can receive tax credits offered under the California Organized Investment Network (COIN) program, administered by CDI for making such investments.

Climate Impacts and Different Market Segments of the Insurance Industry

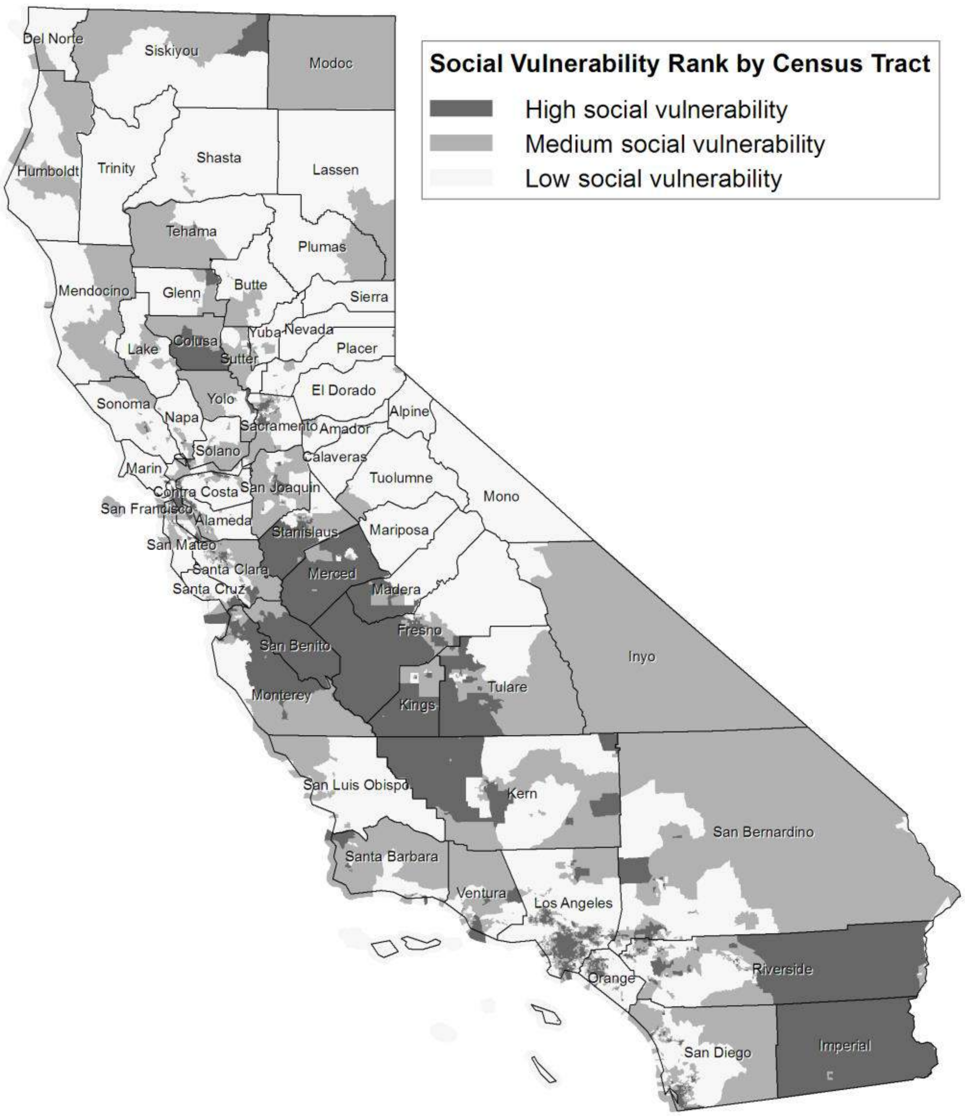
Worldwide, insured claims for weather catastrophes have more than doubled each decade since the 1980s, adjusted for inflation, and average $50 billion USD/year.[265] Insurance by weather event type may vary, as insurance coverage is often limited to specific causes and losses. For instance, property damage coverage may be available for some losses associated with storms, while the same policy may offer no coverage for losses sustained due to heat waves. Increased weather catastrophes are also not the only climate-related risk that may impact the insurance industry.[266] As noted in the Public Health section of this document, climate change may have a number of different health-related impacts. This may have significant implications for the life-health segment of the insurance industry.[267] The life-health segment of the insurance industry represents over half of U.S. insurance premiums. While companies such as Swiss Re have helped sponsor studies on climate change and health issues, more attention has been focused on climate risks and property/casualty insurance.[268]

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Research on Climate Exposure and Socio-Economic Vulnerability of California Communities

Before funding for the CEC Public Interest Energy Research program sunset, it funded a number of studies on the exposure and vulnerabilities of California communities to climate impacts. These studies included studies of particular communities, like Fresno and San Luis Obispo, and the development of a climate vulnerability index to identify the areas of the State most vulnerable to climate impacts.[269] The climate vulnerability index combined 19 indicators into one overall climate vulnerability score and includes factors specifically related to climate impacts, such as air conditioner ownership, percentage of tree cover, and workers in outdoor occupations. [See Box 24 and Box 25 for State Climate Vulnerability Maps; also see the Public Health Chapter of this document for additional efforts to assess climate vulnerability.]

Box 24



Cooley, H., E. Moore, M. Heberger, and L. Allen (Pacific Institute). 2012. ***Social Vulnerability to Climate Change in California.*** California Energy Commission. Publication Number: CEC-500-2012-013.

Box 25

Cooley, H., E. Moore, M. Heberger, and L. Allen (Pacific Institute). 2012. ***Social Vulnerability to Climate Change in California.*** California Energy Commission. Publication Number: CEC-500-2012-013.

Climate Change in the State of California Multi-hazard Mitigation Plan

In 2007, CAL OES began to integrate linkages between hazard mitigation, climate adaptation and emergency preparedness into the State of California Multi-Hazard Mitigation Plan (SHMP).

The SHMP must be updated and approved by FEMA every five years.

The 2013 SHMP was approved as an Enhanced State Mitigation Plan; as discussed above, this makes California eligible for an increased amount of mitigation funding following a disaster declaration.[270] The 2013 SHMP continued the work of integrating climate change into the state's hazard mitigation efforts, and expanded climate risks considered in SHMP. The 2013 SHMP includes additional consideration of climate risks to public health, agriculture, and energy.

Adaptation Planning Guide

CAL OES in partnership with the California Natural Resources Agency (CNRA), and with technical support from California Polytechnic State University – San Luis Obispo (Cal Poly) and funding from Federal Emergency Management Agency (FEMA) and California Energy Commission, developed an Adaptation Planning Guide (APG). The APG, released in 2012, provides a decision-making framework intended for use by local and regional stakeholders to assist with planning for climate risks.[271] The APG implements key actions called for in both the 2010 California State Hazard Mitigation Plan (SHMP) and the 2009 California Climate Adaptation Strategy (CAS).

The APG is comprised of a set of four complementary documents, and provides guidance to support communities in addressing the unavoidable consequences of climate change. The APG introduces the basis for climate change adaptation planning and details a step-by- step process for local and regional climate vulnerability assessment and adaptation strategy development. The APG was developed to allow flexibility in the commitment of time, money, and scope.

The APG consists of the Planning Guide overview document and three companion documents for use in various combinations on an as-needed basis:

APG: Planning for Adaptive Communities This document presents the basis for climate change adaptation planning and introduces a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. All communities seeking climate adaptation planning guidance should start with this document.

- APG: Defining Local and Regional Impacts - This document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are included to support communities conducting a climate vulnerability assessment.

- APG: Understanding Regional Characteristics - The impact of climate change varies across the state. This document identifies climate impact regions, including their environmental and socioeconomic characteristics.

- APG: Identifying Adaptation Strategies - This document explores potential adaptation strategies that communities can use to meet adaptation varying needs. Adaptation strategies are categorized into the same impact sectors used in the APG: Defining Local and Regional Impacts document. Communities seeking to understand their vulnerability to climate change and develop strategies to address the issue should refer to the APG.

Climate Change and Heat Emergencies

As noted above, in 2010, CAL OES released a *Contingency Plan for Excessive Heat Emergencies* that outlines the actions the State of California will take in support of local government when an extreme temperature event is anticipated or has occurred.[272] CAL OES is in process of updating the *Contingency Plan for Excessive Heat Emergencies* to reflect climate change impacts. The plan is a supporting document to the State Emergency Plan and although primarily designed to guide preparedness and response activities, also identifies mitigation actions to prevent life loss, including:

- Identifying the location of vulnerable populations;
- Establishing cooling centers;
- Issuing advisories and warnings; and
- Conducting pre-season public information campaigns.

As noted in the Public Health section of this document, CDPH and Cal/EPA have also released "Preparing California for Extreme Heat: Guidance and Recommendations".[273]

CaLEAP Planning Tool

As described in the Energy section of this document, the California Local Energy Assurance Planning (CaLEAP) web-based tool was launched in 2012.[274] CaLEAP is a CEC sponsored project to help local governments with preparations to make their communities more resilient in the face of disaster events that can interrupt energy supplies. The web-based tool was designed with local government end-users in mind. The tool is structured around CaLEAP methodologies, provides links and resources, can be used to identify needed materials, and can also act as a virtual office for planning teams in order to foster communication and coordination.

Amendment of California Insurance Code After 2003 Wildfires

In 2004, the California Insurance Code was amended to provide additional protections to victims of catastrophic losses such as those experienced in 2003 wildfires in southern California.[275] As noted above, despite additional laws that offer protections to insurance consumers in the face of natural disasters, the availability and affordability of private insurance may decline particularly where risks are too great or undefined, and there may be no viable public insurance alternative.[276]

Senate Bill 1241

Adopted in 2012, Senate Bill 1241 requires inclusion of additional wildfire safety considerations as part of local general plans in all State Responsibility Areas and Very High Fire Hazard Severity Zones, together with special findings of fact supporting local approval of new subdivisions in such areas.[277]

Box 26

Forecasting Extreme Events - Multi-Hazards Demonstration Project & Science Application For Risk Reduction project

An effort to integrate science and disaster management at the federal level, the Multi- Hazards Demonstration Project (MHDP) was initiated by the United States Geological Survey (USGS) with a five- year, pilot project in 2006. The project's goal is to improve California's resiliency to earthquakes floods, wildfires, tsunamis, and other hazards. The project engages emergency planners, businesses, universities, government agencies, and others in preparing for major natural disasters. The project also helps to set research goals and provides decision-making information for loss reduction and improved resiliency.

The first public product of the MHDP was the ShakeOut Earthquake Scenario published in May 2008, which detailed a hypothetical magnitude 7.8 earthquake on the San Andreas Fault in southern California. The next major project for MHDP was the ArkStorm scenario - a winter storm scenario for the U.S. West Coast for a storm estimated to produce precipitation that in many places exceeds levels only experienced on average once every 500 to 1,000 years.[278]

The Coastal Storm Modeling System (CoSMoS) was developed for the ARkStorm to incorporate atmospheric information (that is, wind and pressure fields) with a suite of state-of-the-art physical process models (that is, tide, surge, and wave) to enable detailed prediction of currents, wave height, wave runup, and total water levels for mapping the distribution of coastal flooding, inundation, erosion, and cliff failure.[279] The Coastal Storm Modeling System (CoSMoS) was developed by the USGS and a Netherlands-based research institute to predict coastal flooding caused by both sea-level rise and storms driven by climate change. CoSMoS modeling begins with feeding the results of the latest global climate models into a global wave model to predict wave conditions for the U.S. west coast through 2100.[280]

The Google Earth-based product output of CoSMoS is designed to provide emergency planners and coastal managers with critical information to increase public safety and mitigate damage associated with powerful coastal storms.[281] CoSMoS not only can serve as a long-term planning tool, but—when extreme storms are approaching—is capable of serving as a real-time warning system for emergency managers, lifeline operators, and resource managers.[282]

The ARkStorm study showed that an extreme winter storm in California could cost on the order of $725 billion - with total direct property losses of nearly $400 billion, of which $20 to $30 billion would be recoverable through public and commercial insurance, and business interruption costs of $325 billion.[283] For more information on monitoring and forecasting of "atmospheric rivers" (or the powerful winter systems, sometimes called "pineapple express" storms) in California, please the Oceans and Coastal Ecosystems and Resources section of this document. For additional information regarding floods, please see the Water section of this document.

In January 2012, the Multi- Hazards Demonstration Project evolved into a permanent project known as Science Application for Risk Reduction (SAFRR) that has a similar mission and national purview. Under SAFRR's auspices, the USGS, National Oceanic and Atmospheric Administration (NOAA), California Geological Survey (CGS), and other entities are collaborating to develop a Pacific Basin Tsunami Scenario. The scenario focuses on ports, harbors and marinas.

ACTIONS NEEDED FOR IMPROVED EMERGENCY MANAGEMENT IN THE FACE OF CLIMATE IMPACTS

Improve Integration of Climate Impacts and Projections into All Phases of Emergency Management

Promote the implementation of the Climate Adaptation Planning Guide (APG) and Inclusion of Climate Risk Reduction in Hazard Mitigation Planning Efforts
The State will continue to promote APG implementation and principles of sustainability, resilience and hazard mitigation through collaboration with key public and private sector organizations through mechanisms including:

- Local hazard mitigation plans encouraged under federal law;
- Emergency operations plans required under federal law;
- Local general plan safety elements required by California law;
- Encouraging LHMP adoption into Local Government General Plan Safety Element;
- Sustainable Communities Strategies of metropolitan planning organizations;
- Local Coastal Programs under the California Coastal Act;
- Strategic Fire Plan for California;
- The Central Valley Flood Protection Plan;
- California Water Plan and other flood planning documents; and
- The Energy Assurance Plan.

These mechanisms relating to transportation planning, fire, flood, energy and coastal planning are discussed in their respective sections in this document.

Hazard mitigation efforts should consider the vulnerability of these community resources to climate risks:

- Essential Facilities – hospitals, medical facilities, police and fire stations, waste management facilities, emergency operations centers, shelters, schools, etc.
- Transportation Systems – airways, bridges, tunnels, roads, railways, waterways, etc.
- Lifeline Utility Systems - potable water, wastewater, landfills, oil, natural gas, electric power, communication systems.
- High Potential Loss Facilities - nuclear power plants, dams, military installations, etc.

- Hazardous Material Facilities
- Facilities Supporting Vulnerable populations
- Economic elements - major employers, financial centers, etc.
- Areas of special consideration – high-density residential or commercial development resulting in high death tolls/injury if damaged.
- Historic, cultural, and natural resources areas

<u>Continue to support the integration of climate risks in state and local government emergency planning efforts and enhance capacity to respond and recover from climate risk</u>
Emergency management grants, planning assistance and guidance, mutual aid agreements and post-disaster recovery and hazard mitigation, all play key roles in effective emergency management efforts. As California agencies plan for climate change, there may be opportunities for joint projects, information sharing, and shared funding opportunities with local and regional partners as well as with other States. Preparing for climate risks may also offer additional benefits for overall resilience in emergency situations; for example, increasing energy and water security to prepare for climate risks will help California better prepare and respond to earthquakes and terrorist attacks and will help to ensure first responders, the military and other emergency services can continue to operate during emergencies and disasters.

Support Risk Sharing Mechanisms

As noted above, public and private insurance and disaster relief provide important risk sharing mechanisms. Efforts to reduce climate risks through hazard mitigation activities, including but not limited to fire hazard reduction, minimizing new development in areas most vulnerable to hazards, and improved flood management, will be important to managing risks and supporting sustainable insurance and disaster programs. Specific recommendations regarding National Crop Insurance and the National Flood Insurance Program may be found in the Agriculture and Oceans and Coastal Resources sections of this document respectively.

Better Understanding of Climate Impacts on All Phases of Emergency Management

<u>Assess adequacy of surge and response capacity in light of climate projections for more frequent and more severe weather events</u>
Climate change is projected to increase the frequency and severity of natural disasters related to flooding, fire, drought, extreme heat, extreme cold, and storms (especially coupled when coupled with sea-level rise). This may require preparing for additional emergency surge capacity across the various emergency functions identified in the State Emergency Plan and for additional emergency response capacity. The State should assess the adequacy of its current emergency surge and response capacities. Funding for this type of assessment may be needed.

<u>Research and monitoring</u>
As discussed in this document, the State has already invested significant resources to conduct and support initial climate vulnerability and cost assessments in a variety of sectors. As noted

in the various sections of this document, additional research is still needed to continue to expand and refine information about the climate vulnerabilities of California's populations, infrastructure, property, food and agriculture, and biodiversity. Monitoring and research related to extreme weather events including flood, drought, heat, fire, and related losses will be especially important for emergency management and public safety. Coordination between sectors will help to maximize research and monitoring funding, information sharing, and will help facilitate well-integrated actions to build safe and healthy communities.

Climate Risk Communication and Education

Integrate climate projections into the MyHazards and MyPlan tools, and continue to update and maintain the MyHazards and MyPlan tools

As noted above, the MyHazards and MyPlan tools provide important information for individuals and local and regional governments to plan for hazards. As the climate changes, it will be important to integrate future climate projections into the tools. The Cal-Adapt tool, discussed in the Introduction to this document, is a climate projection visualization tool, and might be used to help integrate climate projections into My Hazards and My Plan. The tools will need to continue to be updated and maintained as new information and risk management strategies are developed.

Increase outreach efforts to prepare for extreme events

Increasing outreach efforts can help households and business better understand and prepare for climate risks and extreme events such as fires, floods, storms, drought, extreme heat and extreme cold. Funding may be needed for such outreach efforts, but prospective emergency planning can help lower emergency response risks and costs. The state should continue to support outreach to encourage emergency preparedness actions including the development of evacuation plans and preparedness kits. These outreach efforts should tailored to be culturally and linguistically relevant for California's diverse populations.

Training for first responders and other emergency managers on climate risks

First responders and other emergency managers play a key role in emergency management; and first responders are directly at risks from increasingly frequent and severe risks such as fire and floods. As noted in the Introduction to this document, state agencies and departments should be provided with the resources to enable climate training for staff. Climate training for emergency managers is critically important for both public health and safety and for the safety of first responders. Funding may be needed to support such training.

Box 27

California Emergency Management

California Governor's Office of Emergency Services (CAL OES)[284] CAL OES is responsible for the coordination of overall state agency response to major disasters in support of local government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. CAL OES includes the Public Safety Communications Office.

CAL OES accomplishes its mission of creating a safe and resilient California through leadership and collaboration. That collaboration includes important partnerships with federal, state, tribal and local entities, as well as with the private sector and individual citizens. For instance, in addition to deploying its own response resources to assist local government during major emergencies, CAL OES calls upon state, federal, local and private sector entities to assist based on their specialized capabilities and expertise.

While CAL OES plays a central role in California's emergency management activities, many other state agencies and departments have key roles to play as well. Some examples include:

California Department of Forestry and Fire Protection (CAL FIRE) and **State of California's Office of the State Fire Marshall (SFM)**. CAL FIRE's work in forest fire prevention is further discussed in the Forestry section of this document. SFM's role is also discussed in the Transportation section of this document. The mission of the State Fire Marshal is to protect life and property through the development and application of fire prevention engineering, education and enforcement.[285]

California Department of Housing and Community Development (HCD) was established in 1965 and works to provide leadership, policies and programs to preserve and expand safe and affordable housing opportunities and promote strong communities for all Californians. HCD administers a Disaster Recovery Initiative (DRI) as part of its State Community Development Block Grant program. The DRI was established in early 2010 to distribute federal funds to assist physical and economic recovery from wildfire disasters in 2008 that affected 14 California counties and two Indian tribes. In late 2010, HUD offered additional funds from the DREF to extend and improve the recovery, by offering incentives to eligible jurisdictions to mitigate the danger of future disasters (e.g., earthquake, flood, fire) through forward-thinking planning measures, such as updated building codes and code enforcement, creation of Local Hazard Mitigation Plans (LHMPs) and/or the adoption of Safety Elements of local General Plans.[286]

California Department of Food and Agriculture (CDFA) among other things, CDFA administers the Emergency Animal Diseases Management Program for the prevention, detection, immediate containment, and eradication of emergency animal diseases.[287]

California Department of Insurance (CDI) - CDI, headed by the Insurance Commissioner, licenses and regulates insurance companies, agents, and brokers in California. CDI works to foster an insurance market that is fair, competitive and accessible to all Californians. The CDI does this in a variety of ways including regulating insurance rates, ensuring that insurers are solvent and able to pay policyholders' claims, bringing enforcement actions against insurance companies, agents and brokers, and unlicensed individuals for violating the law, combating insurance fraud, and assisting consumers, including victims of wildfires, with their insurance issues.[288]

California Department of Transportation (CalTrans) provides a variety of emergency management services including administering the Federal Highway Administration Emergency Relief Program in California, providing assessments of transportation infrastructure and traffic conditions, establishing route priorities during recovery efforts, developing routing and directions for the movement of incident victims out of an impacted area and the delivery of necessary personnel and medical supplies to local medical facilities and shelters, preparing road information and displays, and helping the California Highway Patrol (CHP) and local traffic agencies.[289]

California Department of Water Resources (DWR) - DWR's work on flood detection and prevention are further discussed in the Water and Ocean and Coastal Ecosystem and Resources sections of this document. **California Division of Dam Safety –** works to protect people against loss of life and property from dam failure. The California Water Code entrusts this regulatory power to DWR which delegates the program to the Division of Safety of Dams**.**[290]

California Geological Survey (CGS) established in 1860, provides scientific products and services about the state's geology, seismology and mineral resources that affect the health, safety, and business interests of the people of California. These products include landslide inventory maps and seismic hazard zone maps.[291]

California Health and Human Services Agency (HHS) is the lead agency for Public Health and Medical activities and services statewide in support of local jurisdiction resource needs for preparedness, response, and recovery from emergencies and disasters.[292] HHS includes both the California Department of Public Health - Emergency Preparedness Office (CDPH EPO)- the state's lead on health emergencies and the Emergency Medical Services Authority (EMSA).

California Seismic Safety Commission (CSSC) established in 1975 pursuant to the Seismic Safety Act, works to investigate earthquakes, research earthquake-related issues and reports, and recommend to the Governor and Legislature policies and programs needed to reduce earthquake risk.[293]

Governor's Office of Planning and Research (OPR) was created by statute in 1970 and constitutes the comprehensive state planning agency. OPR provides General Plan Guidelines (GPG). The 2013 update to the GPG (GPG 2013) will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.[294]

As noted above, CAL OES works closely with a number of federal partners. These partners include the **Federal Emergency Management Agency (FEMA)**, the **Center for Disease Control and Prevention (CDC)**, and the **U.S. Department of Defense (DOD).**

CAL OES also works closely with tribal and local entities, private sector partners, and individuals. For instance, to enhance emergency planning and response, CAL OES has a number of

Memoranda of Understanding (MOUs) in place with key private sector partners including an agreement with the **California Utilities Emergency Association**. During disasters, these partners also form the Business and Utility Operations Centers at CAL OES which are a critical component in emergency response and addressing the needs of impacted communities.[295]

ENERGY

INTRODUCTION

California's economy and its residents' quality of life depend on a sufficient supply of safe, affordable, and reliable energy services. The energy sector provides these services through a complex, integrated system involving production, transmission and distribution, and consumption in our homes, businesses, schools, hospitals, vehicles, and other facilities. Transformation of the energy sector is an essential component of successful mitigation strategies, since energy services account for roughly 85 percent[296] of California's greenhouse gas emissions. While the energy sector is a primary contributor to climate change, its supply and demand infrastructure is also vulnerable to climate change impacts such as those associated with extreme events, sea level rise, and heat waves. Ignoring the potential impacts to the energy sector, particularly during peak periods of higher-than-average energy usage, could lead to a shortfall in energy supply and potentially even power outages unless we adapt our planning processes.

Box 28

California Department of Forestry and Fire Protection, 2008 Humboldt Fire – Butte County

This chapter addresses the electricity and natural gas systems as well as other energy sources used in buildings. Transportation infrastructure (e.g., highways and bridges) is discussed in the Transportation chapter, while vehicles and transportation fuel with its infrastructure (e.g., refineries) are covered in more depth in this Energy chapter.

California's energy systems are vulnerable to a variety of climate impacts, as reported in the 2012 California Climate Change Vulnerability and Adaptation Study.[297] The primary climate impacts to the energy system in California are warmer temperatures, less snowpack, more frequent extreme weather events, and sea level rise. Electricity demand increases with rising temperatures, while the energy system becomes less efficient. Less snowpack means less hydropower during the peak demand period. Extreme events and sea level rise expose parts of the energy systems to greater risk of damage and outages.

Indirect vulnerabilities of energy infrastructure and operations may surface as adaptation strategies for other resources are implemented. For instance, meeting non-energy water demands in extreme drought years would impact hydroelectric generation and power plant cooling. Additionally, the growing interdependencies of infrastructure systems increase risk of cascade failure. As an example, sea level rise and flooding add stress on the levee system in the Delta (water system), where failure may render natural gas storage and pipelines more vulnerable. This in turn would threaten the natural gas supply for electricity generation as well as heating and cooking in homes and business and use in industrial processes.

Several state entities play an important role with respect to energy in California. The state also has important federal, local and private sector partners with respect to energy. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 34 *California Energy below.*

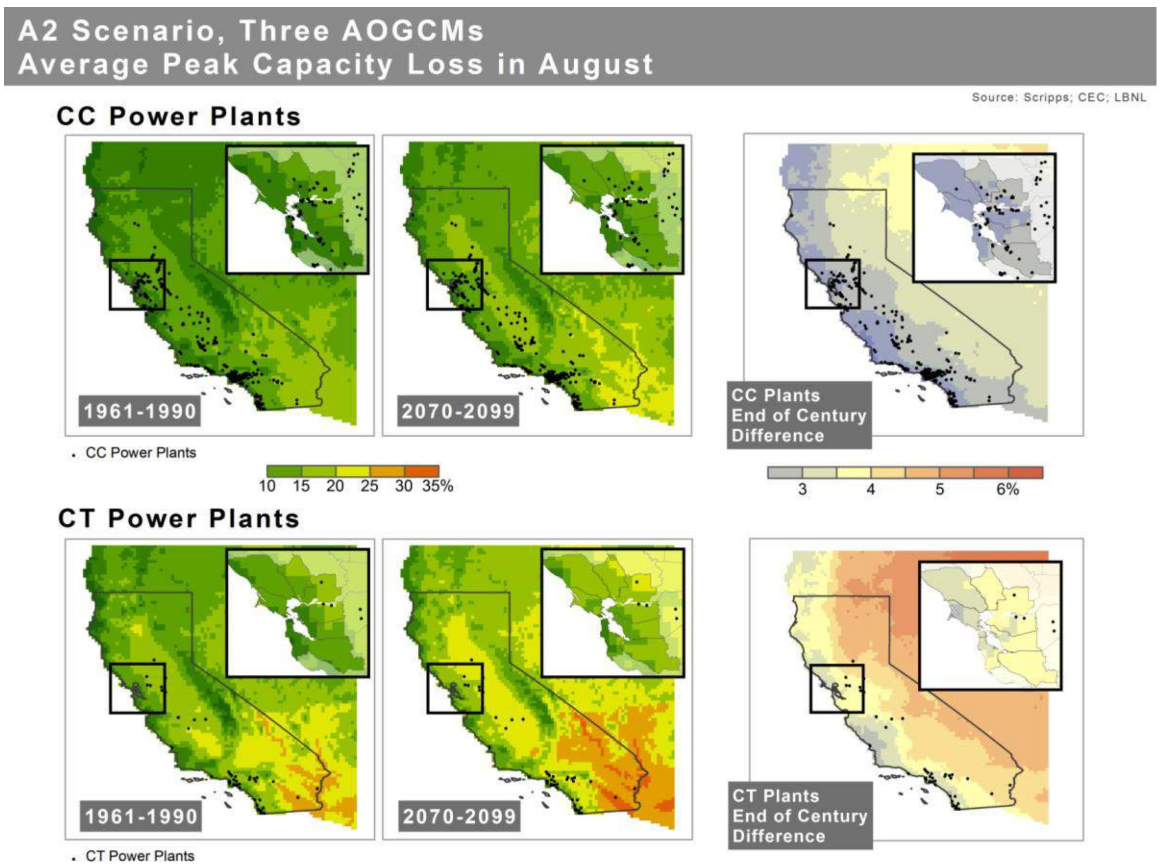
Climate Change Impacts on Energy Services: Electricity

Climate change presents a variety of threats to California's energy infrastructure, including the supply of both conventional and renewable energy resources, electricity generation, fuel refining, and transmission and distribution. This section begins with a discussion of vulnerabilities in the electricity sector. A brief indication of risks to infrastructure associated with transportation fuels and natural gas follows.

Climate change could negatively impact the supply of renewable energy resources, especially water for hydroelectric power. Hydropower contributes about 15 percent of California's in-state generation on average and provides low-cost, low-carbon power in the hottest months of the year when electricity demand is at its highest. Mountain snowpack is essential to provide a steady flow of snowmelt water to hydroelectric reservoirs. Higher temperatures will mean that more precipitation falls as rain instead of snow, with remaining snowpack melting and running off earlier in the year. That means in the summer – when air conditioning demand and peak electrical loads are the highest – there will be less water in storage to be used to generate hydroelectric electricity. Potential reductions in annual precipitation would also reduce the total amount of electricity generated from hydropower units, and alternative generation would need to be procured, likely at a higher cost.

Power plants that generate electricity are vulnerable to higher temperatures wrought by climate change. Higher temperatures decrease the capacity of thermal power plants (for example, natural gas, solar thermal, nuclear, and geothermal) to generate electricity, because power plant cooling is less efficient at higher ambient temperatures and this in turn reduces overall efficiency and the net amount of energy generated (Box 29 in this chapter).

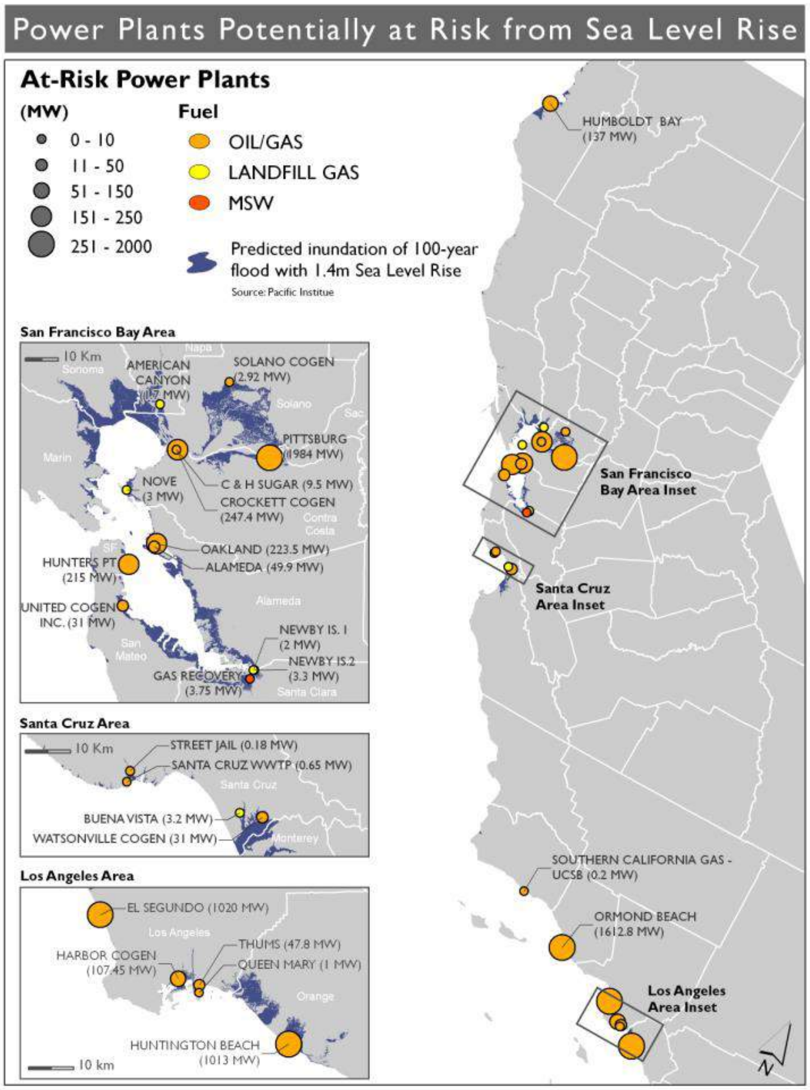
Box 29



Projected Change to Natural Gas-fired Simple-cycle Combustion Turbine (CT) and Combined-cycle (CC) Power Plant Peak Capacity: Average August loss for the recent past and end of century under the higher emissions (A2) scenario. Source: Sathaye et al. (2012).[298]

Sea level rise, as discussed more fully in the Ocean and Coastal Ecosystems and Resources section of this document, threatens about 20 existing coastal power plants (Box 30 in this chapter). These low-lying power plants face the risk of flooding or partial flooding due to sea level rise and increased storm surges. Flood damage could remove these facilities from service and require electricity from other, often more expensive, sources.

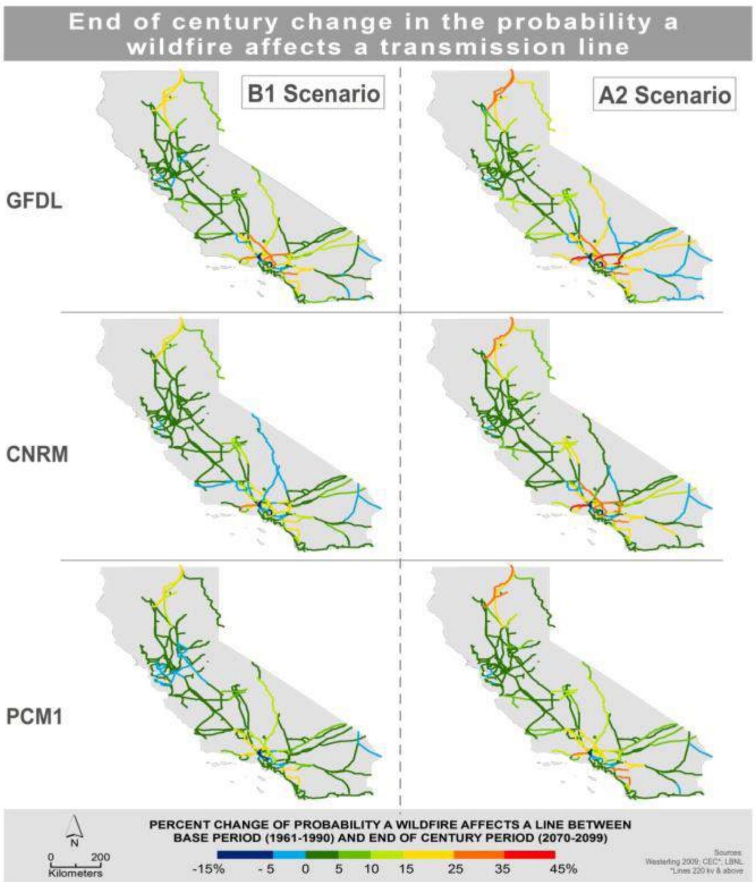
Box 30



Power Plants Potentially at Risk to a 100-year Flood with a 1.4 m Sea Level Rise. Source: Sathaye et al. (2012).[299]

Similarly, transmission and distribution infrastructure is vulnerable both to increased temperatures and to increasing risk of flooding and wildfire. Higher temperatures would result in a reduction in transformer and substation capability, an increase in transmission and distribution line losses, and a decrease in the capacity of a fully loaded transmission line. For example, higher nighttime temperatures impede cooling of transformers, which renders them less efficient the next day. In the worst cases they may even fail. Thus, with high temperatures, less electricity is available for customers than if climate change had not occurred. Researchers expect the likelihood of wildfires occurring near large transmission lines to increase dramatically in parts of California by the end of the century, including along the line that brings hydropower generation from the Pacific Northwest to California during peak demand periods (Box 31 in this chapter). A power line disabled by a fire can take days or weeks to repair and alternate power may need to be procured from other places.

Box 31

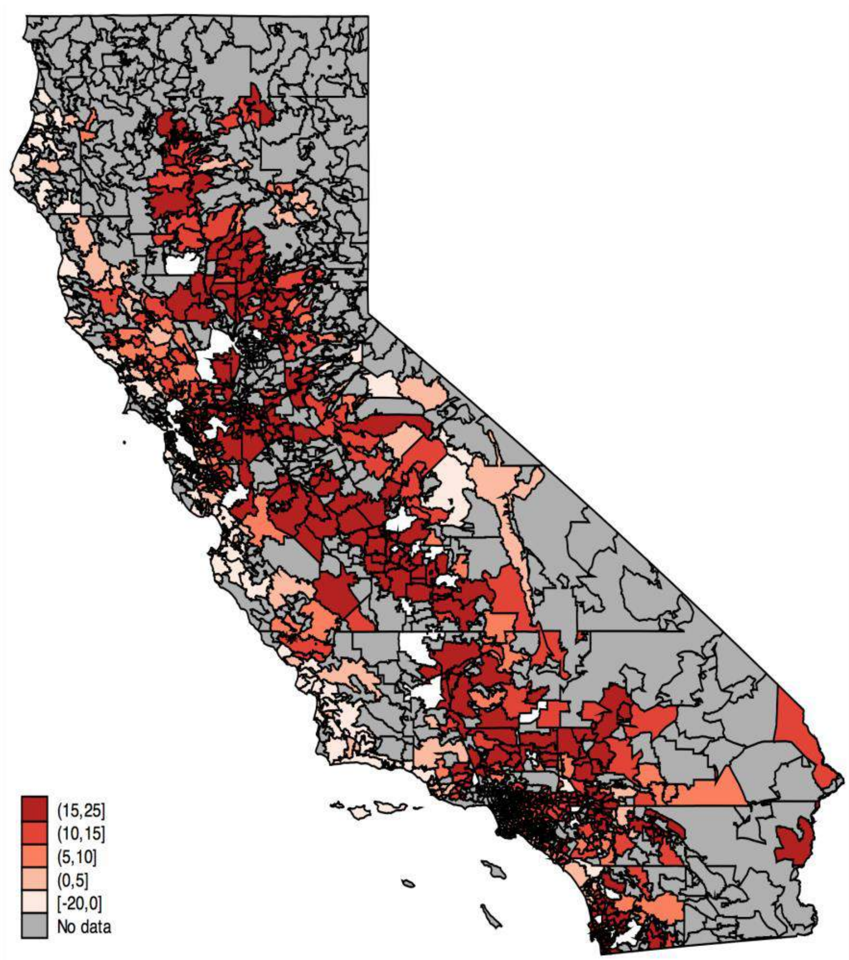


Projected Fire Risk to Transmission Lines for the lower (B1) and higher (A2) emissions scenarios with three climate models. Source: Sathaye et al. (2012).[300]

In addition, about eighty substations are at risk of flooding (or partial flooding) due to sea level rise. Natural gas pipelines and storage tanks are also at potential risk from flooding and sea level rise in the Sacramento-San Joaquin Delta where fragile, decaying levees are vulnerable to breaching.

Energy customers, the end users, would not only be subject to the costs and inconveniences of these potential impacts on the energy supply but also would be exposed to higher temperatures that tend to drive demand upward. Increasingly hot and longer summers are likely to increase demand for air conditioning, while warmer winters will decrease demand for heating (mostly for natural gas) in the cooler season. Overall demand for electricity will increase with more frequent operation of existing air conditioners and as more air conditioners are installed in areas of the state, such as the coastal regions, where there are currently few. For example, high temperatures could increase peak demand by up to 1.6 Gigawatts (equivalent to two large power plants) in the next ten years. This peak demand will occur at the hottest time of day when thermal power plants may not be able to deliver at full capacity.

Box 32



Projected Percent Increases in Household Electricity Consumption 2080–2099 over 1961–1990 Average Consumption due to a Change in Temperature Increases (GFDLv3 model with SRES A2 (high emissions) Scenario. Source: Auffhammer and Aroonruengsawat (2012).[301]

<u>Climate Change Impacts on Energy Services: Transportation Fuels and Fueling Infrastructure and Natural Gas</u>

Just as the electrical grid is vulnerable to climate change, the transportation fuel infrastructure and associated facilities (e.g., refineries) that support transportation are vulnerable to extreme events, sea level rise, and coastal inundation or levee failure. Although electricity may provide a substantial fraction, or even a majority, of transportation fuels by mid- to late century, it is imperative that the State evaluate and address vulnerabilities to refineries as well as transportation fuel pipelines in the meantime. The infrastructure that provides natural gas to our homes, industries, and power plants is also vulnerable to indirect impacts of climate change. Vulnerability assessments and adaptation studies for these parts of the energy system, however, remain to be examined in more detail. This will change as planned studies supported by the State of California are completed.

ELECTRICITY RELIABILITY

Maintaining a reliable energy system is vital to the health and well-being of California's residents and its economy. Reliable grid operation depends on meeting demand with adequate supply and ensuring uninterrupted delivery to customers.

The balance of this chapter focuses on the overarching goal of climate adaptation in the electricity sector, which is to ensure that the electrical system is resilient in the face of climate-induced impacts. To the extent that our system relies too heavily on any one resource or transmission pathway, we increase the likelihood of failure in the event of an extreme climate event. California must continue to increase the use of energy efficiency and demand response, renewable energy, microgrids, distributed generation, and other tools to improve the resiliency of the system. The following is a brief discussion of some of these elements.

Smart Grid

"Smart grid" generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from power plants and wind farms all the way to the consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers -- mostly seen in improvements in energy efficiency and reliability.

An additional benefit of a smart grid is that the communication and control strategies embedded in a smart grid are enablers of transportation electrification.

Development of a smart grid is a cornerstone of California's strategy to maintain reliability in the electricity sector in the face of extreme weather events, higher peak demand, and other challenges posed by a changing climate.

Updating the aging electrical infrastructure to cope with weather-related and other disturbances is a critical and growing need, given that major local power outages in the United States increased from two to five per year from 1950 through the 1980s to several dozen per year in the past five years. Just as the smart grid in California will help to maintain continuous, reliable operations during earthquakes or extreme weather events, it can maintain grid reliability when stressed by intermittencies associated with renewable energy. Accordingly, the smart grid not only fosters adaptation to extreme weather events, but also helps support deployment of renewable energy and mitigation goals.

Microgrid

A microgrid is just as the name implies: a small self-contained electricity system where demand is met by onsite generation and dispatch control is at the distribution circuit level. Microgrids can be an ideal way to add reliability and resiliency by isolating disturbances and distributing generation at the point of consumption.

In a smart grid that connects microgrids, the high-voltage grid serves as a flexible backbone, linking the electricity system in a manner that enables smart communications and control, which in turn enables isolation of disturbances or allows the functioning of a microgrid when the rest or parts of the electricity system fails. For example, the University of California, San Diego's microgrid, which supplies 92% of its energy, is able to "island" from the larger grid to maintain power supply in an emergency, as in the case of the power blackout that struck parts of Southern California, Arizona and Mexico in September 2011.

Energy-Efficiency and Energy Resilience

Energy efficiency is a very cost-effective tool to reduce peak demand and total energy use and to mitigate greenhouse gas emissions. Accordingly, California needs to continue to support deep energy efficiency retrofits as well as new energy efficiency codes for existing and new buildings as they will play a significant role in the state's adaptation efforts. These programs will promote the use of more efficient heating, ventilation and air conditioning (HVAC) systems, lighting equipment, consumer appliances/electronics, building envelopes, industrial processes, and other energy consuming systems.

For instance, recently approved regulations for new buildings require increased levels of insulation (ceiling, floor and walls), increased energy-conserving window glazing to reduce solar heat gain, increased roof reflectance requirements for new construction and alterations, enhanced lighting controls, and improvements to HVAC systems and controls.[302] These 2013 Standards will use 25% less energy for lighting, heating, cooling, ventilation, and water heating than the 2008 Standards and are estimated to annually save 200 million gallons of water and avoid 170,500 tons of greenhouse gas emissions.[303] Research is underway to continue advancements of emerging energy efficiency technologies and tools that can provide for future "zero net energy" homes, businesses, communities and highly efficient existing buildings. Coupled with other smart-grid enhanced energy strategies such as demand response and energy storage, aggressive energy efficiency will improve the ability of the electricity system to respond to peak demands by shaving some peak demands.

Next-Generation Demand Response as a Smart-Grid Enabled Energy Resilience Strategy

The Federal Energy Regulatory Commission defines demand response (DR) as follows: "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." To date, California has made limited use of this tool, but is currently looking at ways to expand its use.

DR provides the ability to aggregate customers capable of reducing their electric demand (load) to decease impacts to the grid during times of stress. The use of DR can offer flexibility to adjust load in response to market schedules and dispatches. Although DR was not originally designed for the purpose of preparing for climate risks, it presents a powerful strategy for reducing peak energy demand and thereby boost grid resilience when, for example, extreme heat waves raise peak demand. Moreover, the communications associated with a smart grid enable the development of automated demand response, which can bring a larger contingent of residential, commercial, and industrial participants to DR programs than have been able to participate in past DR programs that required manual actions by customers.

By changing when and how electricity is delivered and consumed, demand response enables location of storage at strategic points around the grid to increase reliability, improve efficiency and minimize costly improvements to transmission infrastructure. Demand response can effectively reduce both overall demand and area-specific demand as needed.

Energy Storage to Improve and Maintain Grid Reliability

The smart grid will also enable integration of extensive energy storage, which will be an essential feature of California's future energy infrastructure as the state advances toward achieving multiple energy goals related to renewables and climate change. Energy storage will boost the stability and flexibility of the electrical grid, so that it can manage peak demand surges as well as increased variability in supplies due to an increase in the share of renewable energy. The stability and flexibility conferred by energy storage will thus help utilities minimize renewable energy curtailments, avoid large investments in transmission and sub-station upgrades, reduce reliance on conventional generation, and increase the return on investment of renewable energy generation.

The introduction of environmental policies to concurrently lower greenhouse gas emissions and increase the security and reliability of energy supplies will heavily influence the market rules and drivers for energy storage. Energy storage is an indispensable part of California's energy future, especially for the state to meet the 2020 goal of 33 percent of electricity derived from renewable sources.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

In compliance with the 2009 California Climate Adaptation Strategy, and in response to the current and anticipated effects of a changing climate, the State has initiated various adaptation measures. Below is a list of actions the Energy Commission, CPUC, and others have already implemented to date.

Incorporating Adaptation Measures into Energy Management Activities

Energy management supports adaptation by ensuring a reliable supply of energy despite a changing climate and during extreme weather-related events, outages, and other catastrophes. These activities let energy managers know how much energy demand there will be under these new conditions and how to manage energy more efficiently. Key adaptation accomplishments include the following:

- Assisted local agencies in preparing for all aspects of emergency situations that impact energy via the CEC-sponsored California Local Energy Assurance Planning (CaLEAP) project.[304] CaLEAP assists local governments throughout the State in preparing plans to ensure resilience of key assets to disaster events that impact energy. The CaLEAP project covers all aspects of Emergency Management (prepare for, respond to, recover from, and mitigate against).
- Considered higher temperatures due to climate change in the official energy forecasts produced by the Energy Commission as part of the Integrated Energy Policy Report (IEPR).
- Organized public workshops on April 30, 2012 and on June 4, 2013 as part of the IEPR proceedings about the vulnerability of the energy system to extreme weather events and climate change and about broader climate-related energy sector impacts and adaptation responses underway, respectively. The 2013 IEPR includes discussions and energy policy recommendations on these topics.
- Identified communities that are potentially vulnerable to increased electricity demand.
- Investigated the vulnerability of the hydropower system to climate change and explored adaptation options. For example, in collaboration with the Department of Water Resources and federal agencies, Energy Commission-funded researchers developed a decision support system designed to substantially improve the management of five major water reservoirs in Northern California. The researchers also showed that the same management system would substantially reduce the impacts of climate change by increasing water supply and electricity generation when compared to the performance of the same reservoirs under current management practices.
- Completed field demonstrations of distributed generation resources that manage customer energy demand and reduce their reliance on the utility grid. Distributed generation allows the utility grid to reduce the need to call on high peak demand generation resources, which historically have the highest levels of GHG emissions.

<u>Support for Energy Efficiency and Demand Response as Climate Adaptation Strategies</u>
Energy efficiency and demand response have long been a hallmark of California's energy policy, and the state has worked with many partners to promote such policies. (For more information about local efforts on energy efficiency and climate change, please see Box 33: **First Person Narrative: Climate Action is about Quality of Life By Brendan Reed and Ed Batchelder, City of Chula Vista** below) Energy efficiency and demand response are California's first priority energy resource, pursued for the economic and environmental benefits they provide, including as a mitigation strategy for climate change. However, they also represent a powerful adaptation strategy because they facilitate the development of a more sustainable and resilient energy system. The energy system and end users are most vulnerable during times of peak electricity consumption or emergencies when part of the supply is interrupted. Energy efficient buildings and appliances, and demand response, will both reduce demand and therefore reduce the likelihood of power outages during hot summer days. Here are some examples of activities in this adaptation area:

- Enhanced the CEC's Title 24 Building Efficiency Standards[305] and Title 20 Appliance Efficiency Standards[306], which are two of California's most important efficiency programs impacting both new and existing residential and commercial buildings and a variety of appliances including the growing use of plug loads. The following are examples:
    - Adopted new building energy efficiency standards in 2012 that are 25 percent more energy efficient than previous standards for residential construction and 30 percent better for nonresidential construction. Over the next 30 years, the standards will save the energy output equivalent to six modern natural gas-fired power plants. The standards ensure that better windows, insulation, lighting, HVAC systems, and other features that reduce energy consumption are installed in homes and businesses.
    - Adopted new appliance energy efficiency standards in 2012 that will reduce wasted energy by battery chargers commonly used to power cell phones, laptop computers, power tools, and other devices, saving nearly 2,200 gigawatt-hours each year – enough energy to power nearly 350,000 homes or a city roughly the size of Bakersfield. Previous appliance standards for televisions, external single volt power supplies, and battery chargers are projected to save Californians about $1.2 billion per year by 2020.
- Developed and implemented the CPUC's groundbreaking Long-Term Energy Efficiency Strategic Plan which presents a single roadmap to achieve maximum energy savings across all major groups and sectors. This comprehensive plan for 2009 to 2020 and beyond was the state's first integrated framework of goals and strategies for saving electricity and natural gas in government, utility, and private sector actions. The unifying objective of the plan is to compel a sustained market transformation that moves California beyond its historic reliance on short-term programs with limited market impacts and towards long-term, deeper savings achievable only through high-impact programs. The CPUC has continued to refine and update this plan through the development of action plans for specific high energy using target areas to enhance the scope and effectiveness of these programs.
- Provided energy efficiency research in both electricity and natural gas sectors through the Energy Commission's research programs. Current efficiency research includes development of technologies, tools and strategies for advanced HVAC systems (including controls), lighting systems, consumer and office electronics (plug loads) and controls, building envelopes, water heating and distribution, food service operations, zero net energy buildings and sustainable communities, and existing building retrofits especially for multi-family and low income.
- Funded energy efficiency programs through the American Recovery and Reinvestment Act (ARRA) stimulus, allowing the state to leverage more dollars and distribute the funds throughout the state more effectively in alignment with the intent of the federal legislation. The Commission's Energy Conservation and Assistance Account provides up to $3 million dollars at 1 percent to cities, counties, public care institutions, public hospitals, public schools & colleges, and special districts to install energy efficiency projects.

- Supported the development and demonstration of demand response actions that reduce peak electricity load during grid emergencies or in response to high energy prices during peak demand periods. Automated demand response (ADR) is triggered by a signal from a utility or grid operator to automatically reduce a user's load to a pre-agreed level. The Energy Commission has supported the development of OpenADR, which is a communication standard protocol to increase demand response availability in California. ADR substantially increases participation compared to manual systems. Implementation at the national level is occurring via the National Institute of Standards and Technologies (NIST).

Box 33

First Person Narrative: Climate Action is about Quality of Life

By Brendan Reed and Ed Batchelder, City of Chula Vista

"The city of Chula Vista is located at the center of one of the richest cultural, economic, and environmentally diverse zones in the United States. It is the second largest city in the San Diego region, with a population of nearly 250,000 and an area of about 50 square miles that includes bay front, canyons, rolling hills, and numerous other natural resources that contribute to a high quality of life.

Chula Vista has a long-standing history of being proactive with climate action. Our efforts have initial roots in our growth management thresholds from the mid-1980s, one of which pertained to air quality. These threshold standards evolved into our Growth Management Element in our General Plan update in 1989. We fully incorporated these requirements by ordinance in 1991, and the air quality provisions obligated the development community to address what we now think of as climate mitigation issues. For example, major development plans were required to produce Air Quality Improvement Plans and emission reductions through smart growth planning (compact mixed-use development, pedestrian and transit orientation, open space preservation, etc.) and other actions. As greenhouse gas emissions became a larger focus of air quality regulations, it was a natural progression to integrate climate action measures into our planning process.

The city further institutionalized its climate-related activities in 2001 by adopting a formal "Climate Action Plan." The plan has continued to evolve; the plan's mitigation measures were updated in 2008 and climate adaptation strategies were added in 2011. Over the years, our climate action planning process has always relied on an extensive community stakeholder engagement process; we have not turned anyone away from the table. Critical voices came from within our community through residents, civic associations, the business and development community with additional input from San Diego Gas & Electric, and other regional partners. We have certainly had robust dialogue, but we have always managed to have support from the community. Historically, certain voices questioned the ability of projects to meaningfully address local air quality improvement in a regional basin or to be economically feasible. *Were we disadvantaging ourselves with additional requirements related to outcomes that were beyond our control? What about imported air pollution? Do projects become financially inviable due to the new requirements?* Our community leadership trusted the process and input, and saw value in Chula Vista effecting incremental change and looking at long-term cost benefit scenarios. Also, community members recognized the numerous co-benefits from climate-oriented planning such as cleaner air, less traffic, lower consumer utility bills, and improvements to human and environmental health.

Another key element of success was, and is, the support of the elected officials, as they see climate planning as an important quality of life issue for our community. As such, city leadership have made this a priority and ensured that city staff is accountable to these goals. Staff must report twice per year to the city council on our progress implementing the Climate Action Plan, which keeps our commitment at the forefront of everyone's mind. Because the Climate Action Plan incorporates very discreet tasks, it is also easier for staff to track and manage its implementation. In particular, there has been much interest in the implementation of our Mitigation Measure #4, which is our Green Building Standard, and our Adaptation Strategy #10 Sea Level Rise and Land Development Codes integration.

Mitigation Measure #4 directed staff to adopt regulations requiring new and renovated residential and non-residential projects to incorporate green building practices, and to create an energy "reach code" that requires projects to be more energy efficient than the 2008 Building Energy Efficiency Standards of Title 24. In addition, the measure directed city staff to implement a green building awareness program and establish regulatory provisions that incorporate sustainable practices at a community-scale.

Our green building efforts started with the early adoption of the state's Department of Housing and Community Development's California Green Building Standards Code, known as "CalGreen." Early adoption of the CalGreen standard was the result of community discussion that addressed a few approaches to accelerating green building in our community. We investigated the possibility of creating our own standard, or the possibility of using a third party standard such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) green building rating system. The decision was made to move early on CalGreen for commercial, residential and tenant improvements with specific requirements that made sense for our location and development patterns. We also felt it was important to link the design and construction process to ongoing building operations and maintenance.

Over the coming decades, local sea levels are expected to increase 12 to 18 inches higher than their current levels. Higher sea levels can result in increased erosion, more frequent flooding from storm surges and increased property damage. Additionally, loss of wetland habitats, ecosystem services and reduced waterfront public access options is also anticipated. Adaptation Strategy #10 Sea Level Rise and Land Development Codes direct staff to amend our land development codes and California Environmental Quality Act (CEQA) guidelines to incorporate climate change-related sea level rise into future development and municipal infrastructure projects. Specifically, the components of this adaptation strategy include revising the grading ordinance to consider a project's vulnerability to future sea level rise and flooding events, modifying the Subdivision Manual to ensure that storm water/drainage infrastructure can address future sea level rise and flooding impacts, and ensuring that environmental review and CEQA procedures are consistent with these changes.

Linking land development and climate change is especially important in the planning of the Chula Vista Bayfront project on the South San Diego Bay. This redevelopment project, in partnership with the Port of San Diego, represents a significant waterfront development opportunity in Southern California. As this project re-connects our community to our waterfront, we want to ensure that the project will serve our residents and businesses for many future generations. To that end, the Chula Vista Bayfront Master Plan EIR was one of the first in the state to incorporate an analysis of sea level rise, and the project approvals incorporate extremely progressive energy conservation and pollution reduction requirements. For example, new buildings along the bay front will be designed to be resilient to 50 years of projected sea levels and to have 50 percent higher energy performance than traditional structures by extensively incorporating efficiency and renewable energy technologies. The new Chula Vista Bayfront will be another on-the-ground example of Chula Vista's Climate Action Plan positively contributing to the community's long-term sustainability and high quality of life."

Brendan Reed is the environmental resource manager for the city of Chula Vista where he is responsible for the development of sustainability programs and policies dealing with energy management, water conservation, and global climate change. As part of these efforts, Reed coordinates a multi- department team tasked with implementing the city's Climate Action Plan to help lower greenhouse gas emissions and to reduce future risks from climate change impacts.

Ed Batchelder currently serves as the advance planning manager for the city of Chula Vista overseeing long-range planning operations. Batchelder is also responsible for administering environmental and resource planning efforts and the development of energy conserving and carbon reducing community and site design provisions as part of the city's Climate Action Plan.

<u>Support for a Diversified Energy Supply and Demand Response to Reduce Vulnerability to Extreme Weather Related Events and Climate Change</u>

A more diversified energy system will reduce the negative impacts of climate-related events. For example, hydropower generation is a key source of electricity during peak demand periods in the hot months of the year. However, because climate change is expected to reduce electricity generation from hydropower units during the summer, this shortfall could impact electricity supply reliability. A diversified portfolio of electricity generating units, including photovoltaic (PV), thermal solar power plants, wind energy, geothermal units, biomass, and conventional power plants will be able to cover for the expected shortfall. Here are some examples of actions taken so far:

- California is aggressively procuring renewable generation to ensure that 33% of total procurement comes from renewable energy resources by 2020, one of the most ambitious renewable standards in the country. California is currently on track to meet its interim requirements of 20% renewables by 2013 and of 25% renewables by 2016, and is well positioned to meet 33% by 2020.

Over 7,000 megawatts (MW, nameplate) of renewable generation capacity have been awarded a contract of 10 years or more with a California Investor Owned Utility and achieved commercial operation under the RPS program between 2003 and 2013.[307] More than 790 MW of renewable capacity came online in the first and second quarters of 2013, and another 2,385 MW of capacity is forecasted to reach commercial operation by the end of the year. The 3,175 MW of renewable generation capacity forecasted to come online in 2013 would represent the largest year-to-year increase in capacity since the beginning of the program.

- The California Solar Initiative (CSI) is overseen by the CPUC and provides incentives for solar system installations to customers of the state's three investor-owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E). The CSI Program provides upfront incentives for solar systems installed on existing residential homes, as well as existing and new commercial, industrial, government, non-profit, and agricultural properties within the service territories of the IOUs.[308] In July 2013, the CPUC issued its annual report on the progress of the CSI, showing that the program has installed 66 percent of its total goal, with another 19 percent reserved in pending projects. This equals an estimated 1,629 megawatts (MW) of installed solar capacity at 167,878 customer sites in the investor-owned utility territories through the end of the first quarter of 2013, enough to power approximately 150,000 homes and avoid building three power plants.

  CSI highlights include:
    - A record 391 MW were installed statewide in 2012, a growth of 26 percent from 2011.
    - Pacific Gas and Electric Company achieved the most installations in the non-residential sector of any investor-owned utility, having met 70 percent of their non-residential installation goal.
    - Applicants to the low income portion of CSI, known as the Single-Family Affordable Solar Homes program, have received $64 million in support for their residential solar systems while the Multifamily Affordable Solar Housing (MASH) program has completed 287 projects representing a total capacity of 18.4 MW. There are an additional 83 MASH projects in process, for a total capacity of 11.3 MW. Virtual Net Metering[309] has allowed thousands of tenants to receive the direct benefits of solar as reductions in their monthly electric bills.
    - In just over three years of operation, the CSI-Thermal program has received 1,215 applications for $56.3 million in incentives.
    - All but 92 MW, or 6 percent, of solar capacity in the state is signed up for Net Energy Metering (NEM) tariffs. Pursuant to Assembly Bill 2514 (Bradford, 2012) and CPUC Decision 12-05-036, the CPUC has initiated a study on the costs and benefits of NEM to ratepayers.

- The CPUC's Self-Generation Incentive Program (SGIP)[310] - with 544 completed projects for a total capacity of 252 megawatts - is one of the longest-running and most successful distributed generation incentive programs in the country. In 2011 alone, these facilities provided over 760,000 MWh of electricity to the California, enough electricity to meet the needs of over 116,000 homes. The program continues to make strides towards a cleaner, distributed-energy future.

  The SGIP was initially conceived of as a peak-load reduction program in response to the energy crisis of 2001. Assembly Bill 970 (Ducheny, 2000) designed the Program as a complement to the California Energy Commissions' Emerging Renewables Program, which focused on smaller systems than the SGIP. Since 2001, the SGIP has evolved significantly. It no longer supports solar photovoltaic technologies, which were moved under the purview of the California Solar Initiative after its launch in 2006. It has also been modified to include energy storage technologies, to support larger projects, and to provide an additional 20% bonus for California-supplied products.

- Created the first Desert Renewable Energy Conservation Plan (DRECP).[311] The DRECP working group – consisting of the Energy Commission, California Department of Fish and Wildlife, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service – is developing guidelines to identify areas suitable for renewable energy projects and transmission corridors, while developing long-term natural resource conservation areas that protect fragile desert ecosystems. (See also Box 11: Innovative Land Use Planning to Balance Multiple Objectives in the Biodiversity and Habitat section of this document.)

- Implemented several programs and planning activities that support policies and incentives and that will help spur distributed generation and on-site renewable energy generation systems.
  - The Renewables Program in the Energy Commission's research program successfully implemented the Renewable Energy Secure Communities (RESCO) program[312], which is supporting community-scale renewable energy projects at three stages of development: exploratory, pilot, and implementation.
  - The Community Renewable Energy Deployment (CRED) program with a similar goal is a cost-share program with the Department of Energy under the American Recovery and Reinvestment Act of 2009.
  - Another program supports renewable-based decentralized advanced power generation and combined heat and power.
  - The Energy Commission released a follow-up research program for community-scale renewable energy development, deployment, and integration projects that demonstrate optimized community-specific renewable energy systems and develop tools and models to quantify impacts and benefits of increasing local renewable energy penetrations in California.

- Provided web-based tools on planning and permitting resources for renewable energy systems that will help streamline permitting of renewable energy projects. Also, the Energy Commission worked with other state agencies, stakeholders, and local governments to develop a model ordinance to help streamline permitting for distributed generation solar photovoltaic systems in California, which was adopted by the California County Planning Director Association in 2012.

- Published an Energy Commission staff report in April 2011 (*Developing Renewable Generation on State Property: Installing Renewable Energy on State Buildings and Other State-Owned Property*) to encourage expansion of such development. The report recommended a goal of 2,500 MW of renewable energy on state properties.

- Published the *Renewable Power in California: Status and Issues* report in 2011, which, along with the recent IEPR, recommended overarching strategies for achieving the Renewable Portfolio Standard requirement of 33 percent renewable energy by 2020, achieving the Governor's goal for 12,000 MW of localized renewable energy resources and increasing investment in renewable energy in California.

- The Energy Commission's research program has funded projects designed to develop tools for improved environmental (ecological) evaluations and for the identification of sites that would minimize environmental impacts in order to streamline renewable energy permitting. Some of the research data and siting tools are already in use and additional research is on-going or will start in the near future.

- Demand Response continues to grow with over 2,300 megawatts of available load reduction capacity created by state utility reliability and price-responsive programs.

- The Energy Commission, California Public Utilities Commission and California Independent System Operator have been collaborating on efforts to significantly increase the amount of DR available to offset the need for additional fossil generation. This collaboration has resulted in a number of targeted efforts to achieve this goal:

    - The Energy Commission, in the 2013 IEPR[313], builds on prior policy direction on DR that reduces peak load to focus near-term efforts that expand "fast-response" DR that can provide additional ramping and ancillary services capacity that will be needed as more renewable resources come online.
    - The CPUC released a new Demand Response OIR (R.13-09-011)[314] that is intended to review and rethink the current utility DR program designs and coordinate CPUC direction on procurement rules and program design with emerging system needs and CAISO market products as they are developed
    - The CAISO has released a "Roadmap" for expanding DR and EE participation and is has initiated a number of working groups to develop market products that are

more aligned with customer load reduction capabilities and emerging system needs.[315]

- In February 2013, CPUC released “A Review of Current Issues with Long-Term Resource Adequacy”.[316]

- Under direction of the CPUC, SCE is developing and executing a resource plan and regulatory strategy to meet reliability needs in the Los Angeles basin resulting from the retirements of existing generators with once through cooling systems (“OTC”) and the San Onofre Nuclear Generating Station (“SONGS”). The plan includes developing a framework for integrating preferred resources, such as Energy Efficiency, Demand Response, and Distributed Generation along with Energy Storage, transmission and conventional generation into local reliability planning. This effort to replace the lost generating capacity from SONGs with preferred resources is their “Living Pilot Program”.[317]

  SCE’s plan involves a collaborative effort with the California Public Utilities Commission (“CPUC”), Energy Commission, California Independent System Operator (“CAISO”) and other stakeholders to develop and implement the “Living Pilot Program” to procure up to 400 MW of additional, competitively priced preferred resources, including demand response, to meet local reliability needs in the areas impacted by the retirement of the region’s coastal plants. The pilot will include CAISO determined performance attributes to support reliability needs; metrics, measurement, and evaluation protocols to report the efficacy of the various preferred resources; and methods for applying lessons learned for future improvements.

- The California Public Utilities Commission (CPUC) has been implementing the provisions of Assembly Bill 2514 (AB 2514)[318] to continue momentum for energy storage by Adopting a 1,325 MW Energy Storage Procurement Target by 2020 which is approximately 2 percent of statewide peak demand. The Decision continues a number of legal, regulatory and policy efforts in California to encourage the development and growth of energy storage technologies and markets. In 2009, the CPUC added advanced energy storage projects to the technologies eligible for Self-Generation Incentive Program payments. AB 2514 also requires the state’s publicly owned utilities to consider adoption of energy storage procurement targets. Gov. Brown’s June 2010 Clean Energy Jobs Plan[319] called for adding approximately 3,000 MW of energy storage to the grid to meet peak demand and support renewable energy generation.

- Demonstrated the ability of microgrids to increase the penetration of renewables, improve energy efficiency and accelerate the integration of electric vehicles onto the grid. These features were demonstrated on actual microgrids located on the campus of the University of California San Diego[320], the Santa Rita Jail, and on the distribution networks of San Diego Gas and Electric and the Sacramento Municipal Utility District[321]. Microgrids also allow for continuous local operation during power outages.

Supporting Energy-Related Research

In the last decade, the Energy Commission research programs have been the state's premier energy RD&D programs. They have advanced science and technology in the fields of smart grid, energy efficiency, renewable sources of energy, distributed generation, energy storage technologies, pipeline safety, and climate vulnerability and adaptation for the energy sector. To accomplish this, the Energy Commission enlisted businesses, utilities, energy companies, public advocacy groups, and world-class scientists at California's universities and national laboratories. In the last 15 years the Energy Commission has invested more than $830 million to bring to market energy technologies that provide environmental and economic benefits to California's ratepayers. Even though primarily designed to improve efficiency, lower cost and reduce environmental impact of energy use, these innovations can also help reduce vulnerability of the energy sector to climate change by improving energy management, increasing efficiency, and developing and demonstrating a diverse suite of energy technologies as noted in the other energy adaptation sections. The following are among the many research highlights:

- Supported research on natural gas safety. For example, a research project is currently investigating the vulnerability of the natural gas infrastructure in the Delta to sea level rise.
- Participated in and helped fund a multi-state agency contract with the National Academies of Science to conduct a Sea Level Rise Assessment for the West Coast.[322] The study produced sea-level rise projections for California, Oregon, and Washington for 2030, 2050, and 2100. This study corroborated the results from prior Energy Commission studies on this topic.
- Assessed the impacts of climate change on the electricity system through a research project with Lawrence Berkeley National Laboratory for the 2012 California Climate Change Vulnerability and Adaptation Study[323]. This is the most comprehensive study conducted in the United States and suggests that the current electricity infrastructure is more vulnerable to climate change than previously believed but that a rapidly evolving electricity system offers an opportunity to substantially reduce its vulnerabilities.
- Identified the following key findings relevant to the energy sector in the 2012 California Climate Change Vulnerability and Adaptation Study:
  - Higher temperatures – Higher summer temperatures will notably increase the annual and peak household electricity consumption for air conditioning. Because inland areas will warm more, and are often home to less wealthy populations, energy use will grow most in the hottest areas where those who can least afford it reside. Power outages during extreme heat waves could put some groups (particularly elderly and small children) at greater risk when access to air conditioning fails. Increased temperatures would also reduce the efficiency of thermal power plants, substations, and transmission lines, leading to less available electricity for ratepayers.
  - Reduced snowpack – Hydropower contributes on average about 15 percent of the in-state generation in California and provides critical low-cost power in the hot months of the year during peak electricity demand. The snowpack in the Sierra Nevada has played a central role in hydropower generation because it acts as a

natural water reservoir with relatively predictable flow. Decreased snowpack would reduce hydropower generation, even with seasonal adjustments in dam operations.

- Sea level rise – About 20 coastal power plants and about eighty substations are at risk of at least partial flooding due to sea level rise. Petroleum refinery and storage facilities occur primarily in coastal areas subject to higher maximum high tides. Sea level rise combined with increased winter flows into the Sacramento/San Joaquin Delta will also increase the potential for levee failures, especially after 2050. There are substantial energy infrastructures – such as substantial underground natural gas storage facilities, gas pipelines and electrical transmission lines – in the Delta that could be affected.
- Extreme events (heat waves, wildfires, flooding) – The probability of exposure to wildfire on some transmission lines is expected to increase by as much as 40 percent as a result of warmer temperatures. Extreme heat and high electricity demand caused a local power line in Ohio to sag into trees, which helped trigger the massive 2003 blackout in the northeastern U.S. and Canada that affected 55 million people. Transformers are also more likely to fail in these conditions. Climate change in California is expected to increase the frequency and magnitude of extreme heat events and therefore the risk of blackouts.

The Water-Energy Nexus

Water delivery, treatment, and use constitutes one of the largest sources of energy demand; at the same time, energy generation consumes large amounts of water. Therefore, conservation and efficiencies in one resource can leverage great savings in the other. The Air Resources Board's (ARB) 2013 Scoping Plan includes recommendations for further reducing water-related greenhouse gas emissions.[324] Recommendations for enhanced water use efficiency are further discussed in the Water section of this document.

ACTIONS NEEDED FOR SUFFICIENT, RELIABLE AND SAFE ENERGY

The state will need to continue enhancing California's energy adaptation efforts and ensure that California has a sufficient, reliable, and safe energy infrastructure to meet current and future energy demand as well as the state's clean energy goals. In implementing any of the adaptation strategies, consideration will also be given to other socio-economic and environmental objectives, such as habitat protection, ecosystem services, environmental justice, public health, and economic feasibility. Further collaborative work that is needed includes the following:

Protect existing energy facilities and consumers from impacts of climate change

- Conduct vulnerability and adaptation studies for the energy sector in coordination with private entities managing energy resources with the goal of generating actionable research products; make research results available with a geographical context via Cal-Adapt.
- Support the energy component of local cross-sector adaptation efforts, such as expanding the CaLEAP (California Local Energy Assurance Planning) website.

- Promote use of sustainable woody biomass materials for power generation to reduce fire risks to transmission lines and hydropower watersheds consistent with the 2012 Bioenergy Action Plan.
- Install smart grid and microgrid technologies to better protect reliable operation of the grid during extreme climate-related events.
- Evaluate the cost effectiveness of potential measures to maintain the efficiency of thermal plants during heat waves or other extreme climate-related events.
- Evaluate hydropower adaptation options to accommodate reduced or increased runoff and storage and evaluate operational changes or investment options (e.g., more pumped storage) to maintain the value of California hydropower resources even with climate change.
- Continue development of the Integrated Forecast and Reservoir Management (INFORM) project in coordination with private entities and DWR to demonstrate its ability as a modern decision support system for management of major water reservoirs to both private entities and DWR.
- Investigate strategic use of high temperature, low sag conductors for transmission lines where climate change impacts make conventional conductors vulnerable.
- Explore the use of seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation for the forthcoming summer season (*Summer Electricity Supply and Demand Outlook* – a CEC annual publication).

<u>Diversify energy supply to reduce vulnerability to extreme weather-related events and climate change</u>

- Diversify the energy supply portfolio as needed by: (1) enhancing the local utility distribution grids with smart grid features and expanding distributed generation; (2) exploring and developing energy storage technology applications; (3) evaluating state properties and buildings (and other government properties) for distributed and centralized power generation options; (4) encouraging in-state and out-of-state transmission system expansion and upgrades to reduce vulnerability to extreme events and long-term changes; and (5) expanding transmission access to renewable resource areas in preferred geographic locations consistent with the Renewable Action Plan developed as part of the 2012 IEPR Update proceeding.
- Explore post-2020 greenhouse gas emissions targets for the energy sector (including transportation, electricity generation, and the rest of the energy system) that are compatible with the 2050 goal of reducing GHG emissions by 80 percent from 1990 levels.
- Improve our understanding of the environmental and public health implications of potential energy scenarios for California to avoid unintended consequences, such as negative impacts to wildlife, habitats, air quality, and water quality.
- Adopt environmentally benign and cost-effective options to maintain the efficiency of thermal power plants during heat waves. Improve environmentally acceptable and cost

effective approaches for dealing with the efficiency of thermal power plants on extreme hot days.

- Improve our understanding of how climate change impacts the estimation of energy demand and assessments of energy supply (e.g., availability of hydropower in the summer).

Promote energy demand side measures that facilitate climate adaptation

- Investigate all available measures that will allow the delivery of high quality energy services at the lowest costs and with the minimum amount of energy feasible, such as deep energy efficiency retrofit programs with an integrated regulatory paradigm across water, electricity, and natural gas, green buildings, cool roofs, cool pavement, cool vehicles, urban greening, demand-side management and automated demand response, smart grid, permanent load shifting (from peak to off-peak), energy conserving land use practices, and zero net energy homes.
- Promote the expanded use of smart energy meter data to provide residential and commercial customers better access to their energy use profiles and allow them to take advantage of improved energy management systems that promote higher energy efficiency and better overall energy management. Suitable protections and policies should be put in place to protect vulnerable and low-income households from cost impacts, including time-of-use pricing, in order to ensure, among other things, access to air conditioning for heat emergencies.
- Broaden the use of automated demand response capabilities and systems to make it easier for future residential, commercial, and industrial end users to participate in demand response programs and tariffs.
- Retrofit existing buildings through the Energy Commission's AB 758 program.
- Implement Executive Order B-18-12 that directs state agencies to take immediate steps to green the state's buildings, reduce greenhouse gas emissions, and improve energy efficiency.
- Explore the feasibility of considering climate change in cost-benefit analyses of energy efficiency standards for buildings (Title 24) and appliances (Title 20), such as increased ambient temperatures in the 16 climatic zones used to set building standards rather than the current practice of using historical climate data.

Enhance energy-related climate change research

- Coordinate climate change research with all the state agencies supporting or using climate change science via the Climate Action Team (CAT) Research Working Group.[325] The Energy Commission will continue to provide leadership to the CAT Research Working Group. This group will also assist with the coordination of research activities with federal agencies.
- Continue to support and enhance the State Climate Change Research Catalog, which will provide basic information about past and current climate change research projects that have been or are supported by the State.

- Specify energy-related research in the California Climate Research Plan (the Research Plan) being developed by the CAT Research Working Group. This plan will represent a unifying vision on how the different state agencies intend to support climate research, forming a well-coordinated and integrated overall research program for California. Likely energy-related topics will be to:
  - Continue climate monitoring, analysis, and modeling for development of down-scaled climate change scenarios for California to support improved vulnerability assessments for energy and other sectors, better energy forecasts, and adaptation planning by local governments and private entities.
  - Improve vulnerability assessment methods for existing energy infrastructure and update assessments to inform more targeted adaptation options in the short- and medium-term based on the revised climate change scenarios.
  - Continue development and testing of supply and demand forecasting methods, such as seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation and new hydroelectric supply forecasting methods.
  - Continue the legacy of research, development, and demonstration for successful adaptation that also reduce GHG emissions, strengthen the green economy and maintain California's leadership in energy technology innovation, including transportation. Examples include energy storage, renewable energy efficiency, microgrid resilience, and efficiency improvements for buildings and vehicles, and low carbon transportation fuels. The discussion in the Research Plan will be fully compatible with efforts in this area in the Energy Commission and the CPUC via the Electric Program Investment Charge (EPIC) and research supported by the Air Resources Board and others on this topic. The strength of the Research Plan will be in its capability to show how the different programs support each other.
  - Identify and find solutions to regulatory, legal, institutional, and socio-economic barriers that can hamper the implementation of promising adaptation measures.

Box 34

California Energy

Several state entities play an important role with respect to energy in California. The state also has important federal, local and private sector partners with respect to energy.

- California Energy Commission (CEC) is the state's primary energy policy and planning agency. CEC is primarily responsible for forecasting energy needs, promoting energy efficiency, supporting public interest energy research, developing renewable energy resources, licensing thermal power plants larger than 50 megawatts, and planning for and directing state response to energy emergencies.
- California Public Utilities Commission (CPUC) regulates privately owned electric and natural gas companies. The CPUC serves the public interest by protecting consumers and ensuring the provision of safe and reliable utility service at reasonable rates.

- California Independent System Operator Corporation (CAISO) is a nonprofit public benefit corporation that manages the flow of electricity across the high-voltage, long-distance power lines that make up 80 percent of California's power grid.
- California Department of Conservation (DOC) regulates the operation of oil and natural gas wells and geothermal resources in California mainly through its Division of Oil, Gas and Geothermal Resources.
- Office of the State Fire Marshal (SFM) regulates the safety of approximately 5,500 miles of intrastate hazardous liquid transportation pipelines and acts as an agent of the federal Office of Pipeline Safety with respect to the inspection of more than 2,000 miles of interstate pipelines. This office also has operational oversight regarding restoration of petroleum product pipeline service following temporary closures associated with pipeline failures or leaks.
- California State Lands Commission (SLC) develops and oversees compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS). These standards apply to all existing and new marine oil terminals in California, and include criteria for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, and fire, piping, mechanical, and electrical systems. The purpose of these standards is to increase the integrity of existing facilities to better withstand earthquakes and tsunamis, thus reducing the risk of petroleum spills and temporary loss of the ability to receive and export transportation fuels at marine terminals.

California has an number of important federal partners, including:

- Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines. FERC also licenses hydropower projects.
- Nuclear Regulatory Commission (NRC) formulates policies and develops regulations governing nuclear reactor and nuclear material safety and security.
- U.S. Department of Energy (DOE) is responsible for establishing national energy policies and for the safe handling of nuclear materials. DOE is one of the major sponsors of energy research and conducts research through multiple national laboratories.

FORESTRY

INTRODUCTION

Forests can help absorb carbon dioxide and counteract the emissions that cause climate change, but, as further described below, California forests are also in need of protective actions to prepare them to withstand mounting climate threats such as increasing temperatures, drought, increasing risk of pest infestations, and increasing risk of severe wildfires. Studies are currently underway to investigate fire and frequency trends. Furthermore, forests can provide many other benefits, besides absorbing carbon dioxide, which will assist with climate problems. For instance, trees and forests help anchor soil and absorb rain and snowmelt, so flooding and landslides are less severe. Forests also help regulate the timing and magnitude of water runoff and water flows; and they have very significant impacts on water quality, because they provide a filtering function that prevents impurities from entering streams, lakes, and groundwater. *(See* Box 35 *"Ecosystem Services" – Smart Land Use to Save Money and Create More Sustainable Communities)* In addition, forests provide critical habitat for wildlife and fish that will be increasingly stressed by climate impacts (see Biodiversity and Habitat chapter). Sustainably managed forests may also provide forest products like lumber that provide long-term carbon storage, as well as woody material or 'biomass' for energy production. Trees in urban environments, or 'urban forests', capture and store carbon dioxide and are capable of providing significant shading and other cooling benefits that can reduce urban temperatures and energy needs. Urban forests can also help filter air pollutants and can help absorb rainfall that would otherwise run over streets and wash pollutants into nearby waterways that are already under increasing stress from climate threats.

California forests are managed by a number of different entities including federal, state, local and private land owners. In many cases, forest management activities are regulated by a variety of federal, state, and local agencies. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. For more information, see Box 43Box 43 labeled "California Forestry" at the end of this chapter. Management of wildfire risk and post-wildfire recovery are further discussed in the Emergency Management section of this document.

Box 35

"Ecosystem Services" – Smart Land Use to Save Money and Create More Sustainable Communities

There is a growing trend in the United States for cities to invest in improving the management of rural watersheds where drinking water supplies for those cities originate. This trend not only offers significant cost savings over other approaches (i.e. building and operating urban water treatment plants), but can also offer other environmental benefits (such as habitat restoration and flood protection) and economic benefits (such as providing materials to support bioenergy production). These programs serve as an important way to identify the value that rural ecosystems provide for urban areas and to direct payment for those services (so called “ecosystem services”) to rural landscapes, in a mutually beneficial exchange that promotes a more sustainable future for both rural and urban communities. Following are examples of communities or organizations that have successfully developed and implemented ecosystem services approaches or are actively engage in development of approaches to valuing ecosystem services.

The City of New York signed an agreement in 1997 that included rural communities in the Catskill/ Delaware watersheds.[326] The Catskill/Delaware watershed covers 1,600 square miles and provides about 90% of New York’s water supply.[327] New York City chose to implement a comprehensive watershed protection program to preserve and restore natural filtration services as a more cost effective means of maintaining water quality than building a filtration facility estimated to cost $8-10 billion to construct and $1 million per day to operate and maintain.[328] Enhancements to natural watershed filtration were combined with other measures such as upgrades to wastewater treatment systems.[329] After five years, 93% of Catskill farmers were participating in the program, utilizing more environmentally friendly farming techniques and reducing farming-related water pollution, and the significant cost savings played a critical role in helping to stabilize water and sewer tariffs, providing major benefits to low-income, urban households.[330]

Similarly, the Denver Water utility, which provides water for the 1.3 million people in the Denver, Colorado metropolitan area, is taking an active role in collaborating in watershed protection efforts. Denver Water’s key collection and delivery infrastructure receives water from snowpack and streams on U.S. Forest Service lands, and is highly dependent on healthy forests and watersheds. A partnership has been established between Denver Water and the Rocky Mountain Region of the U.S. Forest Service, Department of Agriculture, to support mutual efforts to improve forest and watershed conditions. Denver Water plans to match the U.S. Forest Service’s $16.5 million investment, totaling $33 million, toward forest treatment and watershed protection projects over a five-year period in priority watersheds critical to Denver Water’s water supply. Forest treatment and watershed protection activities can help minimize sedimentation impacts on reservoirs and other water infrastructure by reducing soil erosion and the risk of wildfires, thereby protecting water supplies and water quality. This work will also provide other public benefits such as wildlife habitat and recreation opportunities. Colorado and Wyoming contain headwaters for rivers that supply water to 13 Western states, including California.[331]

The San Francisco Public Utilities Commission (SFPUC) also has a 10-year, $50 million Watershed and Environmental Improvement Program. SFPUC is a department of the City and County of San Francisco that provides retail drinking water and wastewater services to San Francisco and wholesale water to three Bay Area counties. The Program includes the Peninsula, Alameda, and Upper Tuolumne Watersheds, and manages watershed activities and resources to protect source water quality and protect and restore terrestrial and aquatic species and their habitats. The Program is funded in part by Water System Improvement

Program Measure A bond funds and in part by operating funds.

Climate Change Impacts and California Forests

Climate change threatens California forests with more frequent and severe wildfires, pests, disease, increased temperatures, and changing precipitation and water availability. As described below, these threats may decrease forest growth, cause geographic shifts in tree distribution and forest types, and result in forest loss and tree mortality. These threats also overlay traditional pressures for the conversion of forested lands to alternate land uses and fragmentation. In addition, fire suppression activities and lack of fuels management have left California forests in a particularly vulnerable and weakened state *(See* Box 36 *"Forest Science: Evolving Understanding of Fire and Forest Landscapes").* Forest losses due to climate change not only threaten carbon storage and emissions from forests but also threaten water resources, energy transmission (as further discussed in the Energy section of this document), the survival of fish and wildlife, and human health -- such losses will also negatively impact tourism, recreation opportunities, and the timber industry. Efforts to improve forest health not only make forests more capable of withstanding climate impacts (and avoids the negative impacts associated with forest losses), but those efforts will also increase the long-term carbon storage capacity of forests and aid in fighting climate change.

Box 36

Forest Science: Evolving Understanding of Fire and Forest Landscapes

California's forested landscapes evolved with fire over thousands of years. This pre-European, forested landscape was created by the full range of fire regimes from low-intensity/severity, slow-spreading wildfires to high intensity/severity, fast spreading fires and a mixture of both extremes. Plant and animal species in the forest evolved with fire, and many of these plant and animal species depend on wildfires to reproduce and grow. For instance, low-intensity, slow-spreading wildfires can help keep tree density at optimal levels for tree growth and productivity, fire can help return nutrients from plant matter back to soil, the heat from fire is necessary to the germination of certain types of seeds, and remnants left behind by fires can create habitat conditions that are beneficial to wildlife. The ecological function of fire in naturally fire-dependent or fire-adapted landscapes was poorly understood for much of the 20th century. Vigorous fire suppression programs were implemented with the belief that such programs would protect property, human life, and forests. Fire suppression programs, combined with a lack of active forest management activities to reduce vegetation, contributed to a situation in which high frequency fire regime forests became unnaturally dense, often with many, smaller trees crowded between older, larger trees (Collins et al 2011).

Bear Creek Guard Station, Plumas National Forest, top photograph taken in 1915 (showing surrounding forest prior to fire suppression) and bottom photograph taken 2002 (showing surrounding forest after years of fire suppression).

Source: USDA Forest Service
Overcrowded or 'overstocked' forests are susceptible to a number of threats. First, an overcrowded forest contains far more flammable material, with little spacing between trees; fires that do start in these conditions tend to be higher-intensity, fast-moving, harder to contain, and generally more catastrophic to both plant and animals species and to human communities.

Source: National Interagency Fire Center (showing forested landscape after catastrophic fire)

Secondly, trees in overcrowded forests compete for scare water, soil nutrients and sunlight. Overall tree health and resilience may decline, and overcrowded forests are additionally more vulnerable to the spread of tree diseases and tree pests (Oliver and Larson 1990).

Climate change in California presents new threats to forests with longer, hotter summers, changing water availability, the spread of invasive species, and more tree mortality due to the spread of pests that were previously kept in check by colder, longer winters. These climate changes will likely contribute toward a longer, more challenging fire season in California and this will present escalating danger to homes and people located near forest wildland areas, particularly in the vicinity of forests that may be overcrowded due to past fire suppression practices and lack of management activities.

There are a variety of techniques for returning overcrowded forests to a healthier, more natural state. Prescribed burning is one method. In prescribed burning, a fire is planned, ignited and managed by professional fire managers. Prescribed fire is only undertaken with appropriate conditions, such as appropriate weather conditions. Steps can be taken to minimize smoke impacts from prescribed fires on nearby communities. Other techniques for addressing overcrowded forests include measures to reduce density by ‘thinning’ the forest (typically by removing brush and smaller trees), either using mechanical means or by hand. Sometimes, it may be appropriate for overcrowding to be addressed using a combination of management techniques. Treatments may need to be repeated periodically to maintain desired conditions. Reducing overcrowding in forests is sometimes referred to as ‘fuel reduction’ because plant materials that fuel catastrophic wildfires are being removed.

As noted below, California forests are located on a mix of federal, state, and private lands. Any successful fuel reduction program in the state will be heavily dependent on coordinated action among federal, state and private forest land owners. Fires do not respect political or legal boundaries, and any overstocked lands will present a threat to any adjacent forested lands and any nearby structures. Overcrowded stands are found on the lands of all forest ownership classes. There is a good track record of using multi-agency and private landowner collaborative planning processes to identify strategic opportunities to reduce fuels and maximize fire hazard reduction benefits. While public agencies for the most part have adequate authorities to conduct fuels reduction projects, funding is a significant barrier for both initial treatments and follow-up maintenance treatments. Sustainable biomass energy programs that utilize materials from forest thinning may be part of the solution for redressing overcrowding caused by past forest fire suppression programs.

The role of forests in California climate solutions and the need to protect forest resources from climate threats has been recognized in the 2006 Scoping Plan and the 2009 Climate Adaptation Strategy. As described below, some progress has been made with respect to preparing for climate risks to California forests, but a more comprehensive forest climate strategy and the resources to implement such a strategy are needed in order to fully prepare for the myriad threats posed by forest and tree loss due to climate change.

Ownership of California Forestlands: California has 33,387,000 acres of forestland, which cover about 32% of the State. Predominantly held by the federal government (over 57%), these forest resources are located on state, federal, and private lands (Box 37). This distribution of land owners means that coordination between the state, private land owners, and federal agencies will be important to the success of any comprehensive forest climate strategy in California.

Box 37

California forestland ownership.

Ownership Category	Acres of Forestland	Percentage
Private	13,131,000	39.3 %
Federal	19,171,000	57.4 %
State	711,000	2.1 %
Local	374,000	1.1 %
Total	**33,387,000**	**100 %**

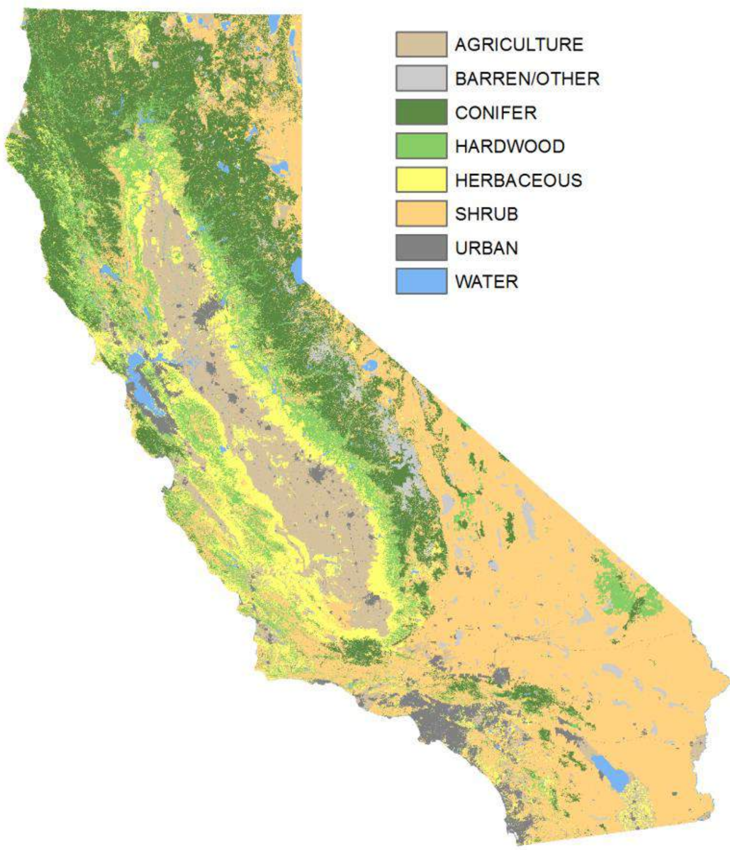
California Department of Forestry and Fire Protection 2010.

Box 38

National Forest Watersheds: The 20 million acres of National Forests in California play a crucial role in providing California's water. These lands, while comprising about 20 percent of the area of the state, provide almost half of the State's surface water supply, owing to their location in mountainous headwaters.[332] Stewardship of these lands to protect water quality and quantity will become increasingly important as California's water supply comes under stress from climate impacts including loss of snow pack, changing precipitation patterns, increased temperature and drought. For more information on climate impacts to California's water, please see the Water section of this document.

California Tree Types and Geographic Distribution: California is also home to a wide variety of tree species including, but not limited to, many types of conifers (e.g. Douglas-fir, ponderosa pine, sugar pine, incense-cedar, redwood, giant sequoia, etc.) and also many types of oaks (e.g. blue oak, coast live oak, etc.) (Box 39) Not all California tree species will be equally affected by climate change. For instance, in the Sierra Nevada, scientist predict that tree growth may decrease by as much as 19% by 2100 - but white fir, cedar and Douglas-fir are expected to decline the most, with smaller reductions in growth rates for ponderosa pine and sugar pine.[333]

Box 39

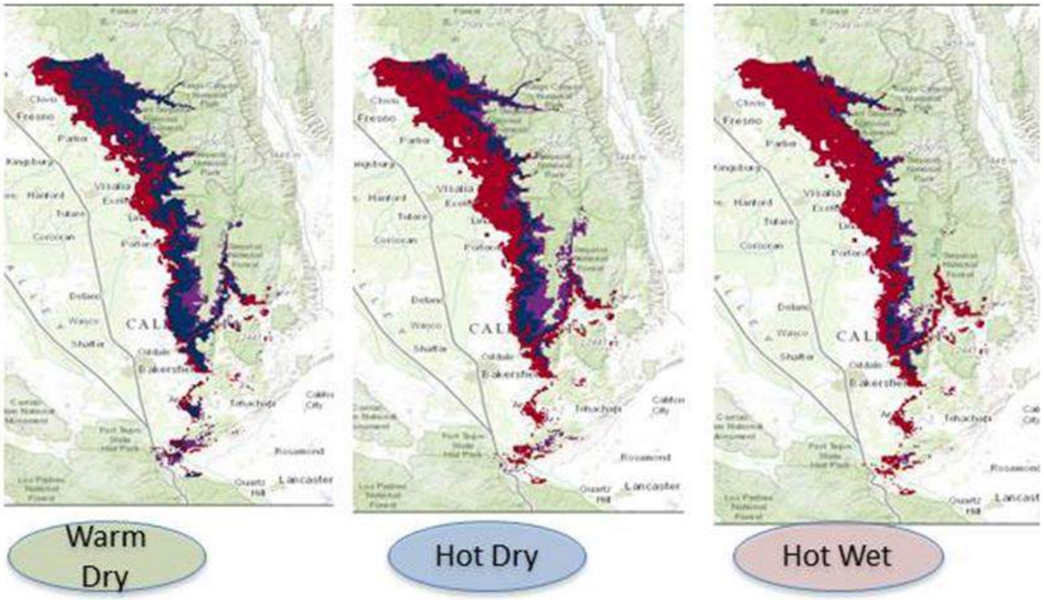


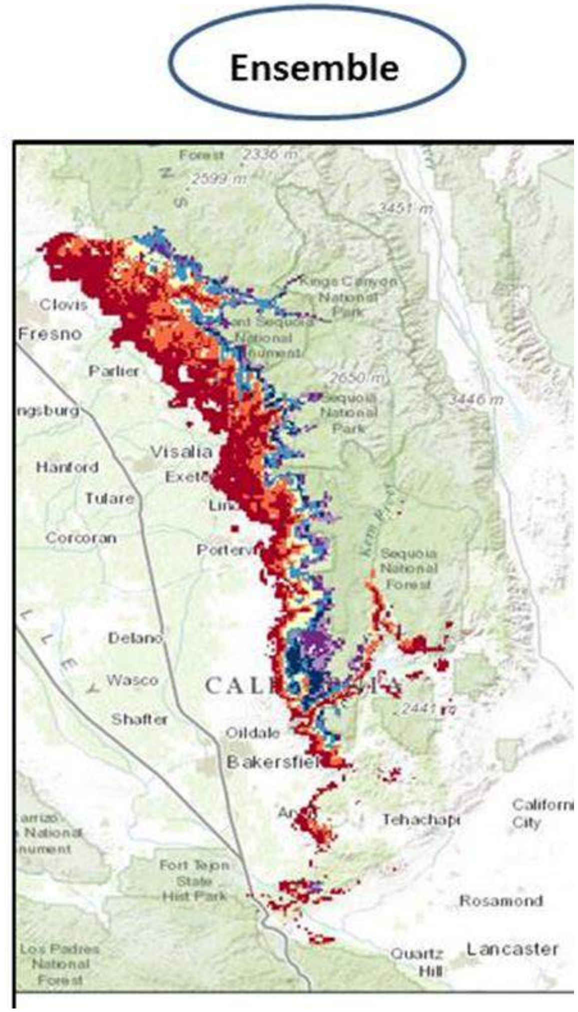
Distribution of California conifer and hardwood forest and other vegetation types

As average temperatures and precipitation patterns change, the climatic conditions suitable for different types of tree species in any given region will also change - and this will lead to geographic shifts in tree distribution and forest types. In general, geographic shifts will tend to be northward and toward higher elevations as average temperatures rise, although the Southern Sierra may be a particularly significant area of refuge due to the higher elevations found there (for more information on the importance of refugia in the era of climate change – please see the Biodiversity and Habitat section of this document). High elevation tree species that are dependent on historical temperature ranges at those elevations will be particularly vulnerable to species loss and extinction. Although estimates of the magnitude and direction of geographic shifts continue to be refined and improved over time, some modeling of these types of trends and predictions has been done for certain species. [See Box 43: Southern Sierra - Blue Oak Climate Scenarios courtesy of The Nature Conservancy] Some California timber companies are already preparing for these types of impacts in their long range planning efforts. [See Box 41: Mendocino Redwood Company and Humboldt Redwood Company - Climate Change and Forest Management Considerations in the Redwood Region.]

Box 40

Southern Sierra Nevadas – Blue Oak Climate Scenarios





The top three maps show blue oaks under possible 'hot-wet', 'warm-dry', and 'hot-dry' climate scenarios. Red areas indicate potential future climate stress. Blue areas indicate potential stable climate zones (i.e. refugia). Purple areas indicate expansion of potentially new suitable climates.

Color saturation indicates level of agreement between 11 Global Circulation Models (A2).

The larger map on right is an ensemble forecast, which considers the potential responses of blue oaks to a wide range of climate futures simultaneously (2045-2065).

These forecasts suggest that blue oaks in the southern Sierra may be climate stressed in the lower elevations; however large tracts of potential climate refugia are also identified at mid elevation. Additional work is needed to better understand potential management that may facilitate adaptation to changing climates.

Credit: Jason MacKenzie, The Nature Conservancy

Box 41

Mendocino Redwood Company
Humboldt Redwood Company

Climate Change and Forest Management Considerations in the Redwood Region
By Mike Jani – Chief Forester and President of Mendocino Redwood Company

Foresters, by nature and training typically think and plan in terms of decades and generations, as trees take a much longer time to grow than traditional row crops. This is further enhanced in the redwood region of California, where we are dealing with a tree species that can live thousands of years and has the capacity to regenerate itself, once cut or burned, by resprouting, and regrowing its genetic duplicate. Planning for climate change manifests around a few central themes. Even with all the uncertainties over the exact regional effects of climate change, a number of immediate responses to these themes appear to be prudent. These responses may, in time, prove to be beneficial both ecologically and in terms of long-term economic stability for our region.

Fire

Projections for the eastern portions of our ownership indicate hotter, drier summer weather patterns and increasing winds leading to higher fire risk. We are taking the following measures to mitigate for this:

-Over the entire property, we are growing significantly more than we harvest. This leads to larger diameter trees over time. Larger trees are far more fire resilient, especially redwoods.

-In our tree improvement program, we are selecting for trees that appear to have drought tolerance.

-Pre-commercial and commercial thinning to optimize spacing of our trees. This leads to increased growth (see point above), but also keeps forest canopy below a density where it can support catastrophic crown fire. Also, research being done in the region suggests that the projected increase in carbon in the atmosphere has added to the growth of large, old redwood trees, perhaps even resulting in a doubling of their growth over the last 50 years.

-Treatment of hardwood species in understory to break up dangerous ladder fuels and restore organic layer in soil mantle (water holding capacity).

-Construction and maintenance of shaded fuel breaks from which to be able to fight and stop fires.

-Maintenance of road network in passable condition for firefighting equipment.

Unpredictable weather patterns

Highly variable weather fluctuations caused by climate change lead to unpredictable rainfall patterns and intensities (which might include both more extended dry periods and more severe storms). We do the following to offset these impacts:

-Increase the miles of road surfacing with rock to reduce sediment generation and water quality degradation.

-Road upgrades: increasing stream crossing openings to be able to handle higher peak winter flows.

- Out-sloping roads to quickly move water off road surfaces.

Changing in-stream conditions

Drier weather projections may lead to lower stream flows and higher stream temperatures leading to degradation of water quality for fish. We have implemented the following:

-Maintaining very high tree canopy adjacent to flowing streams to maintain low stream water temperatures.

-Drill and utilize wells to reduce the need for drafting water out of streams for road watering and construction.

-Construct off-stream water tanks for storage to reduce need for drafting from fish-bearing streams.

Forest Carbon Storage

The largest portion of commercial redwood forests in California are Forest Stewardship Council certified and are growing significantly more than is being harvested. Add to that all the redwood forestland that has been put into parks and preserves, including thousands of acres of old-growth forest, and you have a tremendous carbon sink, providing that we can protect it, and manage it in such a way that it does not burn up in a catastrophic forest fire. Our forests at the Humboldt Redwood Company and the Mendocino Redwood Company are already storing over one million tons of forest carbon each year. What's more, wood products from harvested trees can continue to store carbon for decades to come (and many redwood forest products and by-products are particularly long-lived).

Climate change is not to be ignored. In the redwood region, decisions and actions that we undertake today, will have significant impacts over many decades to come. Our business view is to manage the impacts of climate change in a positive fashion, including storing more carbon annually for years to come. Just as managing a commercial forest for ecological health is good business, so too is planning for the effects of climate change for the future.

Mendocino Redwood Company, LLC (MRC®) and Humboldt Redwood Company, LLC (HRC™) collectively manage 440,000 acres of redwood and Douglas-fir forestlands along the north coast *of California. From the beginning, MRC and HRC's stated purpose has been to demonstrate it is possible to manage productive forestlands with a high standard of environmental stewardship, and also operate as a successful business. The company names were chosen to reflect the nature of the business and to pay homage to the important role of the local community associated with a timber business. MRC and HRC protect old growth trees in their forest, harvest through selective logging whenever feasible, and are managing for the unknown but expected future effects of climate change.*

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Following the adoption of the 2008 Scoping Plan, an Interagency Forest Working Group was established (the "IFWG") to help provide technical assistance and recommendations for achieving the forest sector goals discussed in the 2008 Scoping Plan. The IFWG has included the following participating agencies: the California Board of Forestry and Fire Protection, the California Department of Forest and Fire Protection ("CAL FIRE"), the California Department of Fish and Wildlife, the California Department of Water Resources, the Sierra Nevada Conservancy, the California Energy Commission, the California Natural Resources Agency, the California Air Resources Board, the California Environmental Protection Agency, and the U.S. Forest Service.

Forest Carbon Inventory

The California Air Resources Board maintains a forest sector greenhouse gas emission inventory as part of its responsibility to prepare and maintain a statewide inventory of greenhouse gas emissions. The forest sector inventory tracks the net carbon balance from the forest sector in California. The inventory includes both the absorption of carbon dioxide by California forests and rangelands, and the release, or emission, of carbon dioxide and other GHGs associated with fires, harvesting materials from forests, the conversion/development of forested land for other land uses, and the decay and decomposition of woody materials.

A 2004 California Energy Commission study helped provide the first forest sector carbon balance data. That study focused on the period from 1994 to 2000 and was geographically limited to the northern part of the state, with statewide estimates extrapolated from the available data. Since 2004, there has been one update to the forest inventory. That update was issued in 2011 and included data gathered from 2000-2009.

In 2011, ARB contracted with researchers from University of California (UC) Berkeley to develop a new data-driven methodology for assessing carbon stock changes for all land in California except agricultural and urban areas. The new methods use California specific land based data sets and satellite remote sensing data. The covered ecosystems include forests, woodlands, shrub lands, grasslands, and wetlands. Data sources for the new method include Forest Inventory and Analysis (FIA) ground-based data (vegetation type, tree species and dimensions, percent canopy cover, etc.) from the USDA-Forest Service, remote sensing products from

NASA's MODIS sensor, geospatial vegetation data (vegetation community type, canopy height, percent canopy cover) from the federal Landscape Fire and Resource Management Planning Tools Project (Landfire), geospatial fire and harvest occurrence data from CalFIRE, and ancillary data on shrub lands and grasslands.[334]

The new data-driven method enables analysts to retrospectively assess ecosystem carbon stock changes resulting from fire, human activities, and other processes. It will enable monitoring of changes on the land over time and periodic quantification of the GHG flux associated with changes in ecosystem carbon stocks. The research has generated a wealth of new data to support a planned update to the GHG inventory.

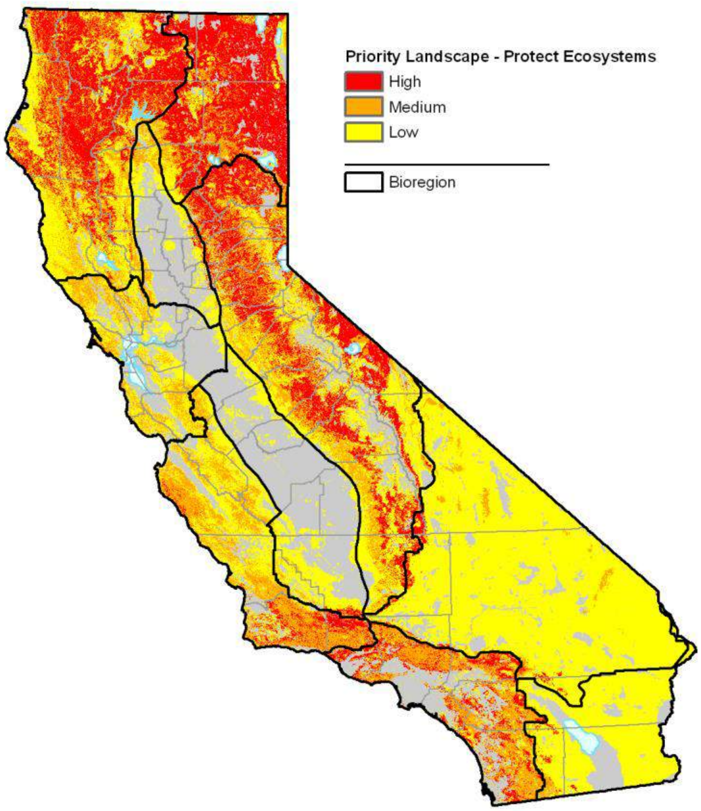
Additional work is needed to evaluate the data provided by the UC Berkeley research, to incorporate additional new data, and to identify further research needed to expand use of these tools. The sources and methods for quantifying ecosystem carbon and GHG flux in this sector are complex. Continued refinements will advance carbon quantification, attribution of GHG flux by disturbance process, and reduce uncertainty.

Broader Forest and Rangeland Resource Assessments – including vulnerability assessments

The California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP) produces periodic assessments of the state's forest and rangeland resources, on both private and publically managed lands. Like prior assessments, the 2010 Forest and Rangeland Resources Assessment[335] included extensive information regarding fire threats, socio-economic conditions, working lands, threats from pests and disease, and water quality and quantity protection and enhancement. However, for the first time, the 2010 Assessment included a dedicated chapter on climate change threats and opportunities, as well as a chapter on the role of urban forests and trees in energy conservation and air quality.

Through the FRAP forest and rangeland assessment process, the Department of Forestry and Fire Protection has identified priority landscapes where high value carbon stocks and forest ecosystems are at risk (see Box 42). The results of the assessment suggest that California forests will continue to grow and provide net carbon storage through mid-century. In the later decades of this century, climate models are less certain, but model predictions suggest dramatic warming will add additional stress on California forests. Absent changes in management, the National Forests in California could become a net emitter of carbon dioxide in the second half of the century as a result of expected increases in wildfire, diseases, and other disturbances.[336] Carbon emissions from wildfires, insects and diseases are expected to be much greater than carbon loss due to the conversion of forested lands to other land uses.

Box 42



Priority landscape for preventing wildfire threats to maintain ecosystem health (California Department of Forestry and Fire Protection 2010)

Healthy forests, that are most resilient against the spread of pests, tree diseases, and catastrophic fires, have an optimal tree density. Wildfires serve a function in high frequency fire regime forest ecosystems to maintain such optimal tree density. However, in the past, the function of wildfires in a natural fire regime was poorly understood, and wildfires were "suppressed" or put out. This has led to many high frequency fire regime forests in the American West being "overcrowded" or filled with trees beyond the optimal forest density. As a result of trees being crowded together, pests and diseases are able to spread more rapidly. In addition, when wildfires do start and burn in overstocked forests, the fires consume much more woody material ("fuels") and the fires are larger and more severe. Thinning overstocked forests and using prescribed fire can help restore the forests to a more natural fire regime and healthy state. Forest resilience is especially important in the face of expected climate impacts such as increased temperatures, drought, and spreading pests and tree diseases

Analysis by CAL FIRE of Forest Inventory and Analysis ("FIA") plot data collected by the U.S. Forest Service indicates that there may be as many as 1.2 million acres of forested land in

California that would benefit from thinning. In addition, FIA data indicates that there may be as many as 3.1 million acres of timberland in California on which replanting or "reforestation" could occur in order to boost forest sector productivity and carbon storage.

CEQA Guidelines on Climate Change & Timber Harvest

In 2007, Senate Bill 97 ("SB 97") was enacted to require the development of CEQA Guidelines to address the analysis and mitigation of greenhouse gas emissions. The CEQA Guideline amendments adopted pursuant to SB 97 required that CEQA lead agencies make a good-faith effort, based on available information, to estimate the greenhouse gas emissions resulting from a project. The lead agency has discretion to select a model or methodology for calculating such emissions, provided it supports its decision with substantial evidence and explains the limitations of the model or methodology. To this end, CAL FIRE developed a Greenhouse Emissions Calculator which is available online for those preparing timber harvest plans. The Calculator is designed to assess short-term and long-term emissions from a single project, and it can also be used to estimate greenhouse gas emissions associated with a series of harvests under a management plan.[337]

2010 Strategic Fire Plan for California

The 2010 Strategic Fire Plan was the first fire plan ever released for public review and comment during development; the plan benefited from excellent stakeholder input. The Plan recognizes the threat climate change presents for more frequent and severe wildfires, and presents a vision for a natural environment that is more resilient and man-made assets that are more resistant to the effects of wildland fire through local, state, federal and private partnerships.[338]

2012 Bioenergy Action Plan and Sustainable Forest Biomass Utilization Guidelines

The 2012 update to the Bioenergy Action Plan included the goals of increasing environmentally and economically sustainable energy production from biomass residues, including but not limited to forest-derived wood waste, while also reducing the risks and impacts of wildfires in forested regions.

Within the framework of the IFWG, the California Energy Commission has been soliciting stakeholder input and funding research to help define scientifically-based guidelines for achieving sustainable forest landscapes when woody materials from forests or "forest biomass" is utilized for energy or fuel production.

State Tree Nursery Program

The purpose of the State Nursery Program is to provide an adequate, reliable supply of seed and seedlings to safeguard the genetic variety of California tree species, provide insurance against poor seed crop years, and assist in the restoration of native trees lost to wildfire, insects, disease, and other climate impacts. Unfortunately, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been dwindling. The Magalia Reforestation Center in Butte County closed in June 2011 and nursery services have been suspended, although seed processing and storage continues at the L.A. Moran Reforestation Center located in Yolo

County in Davis, California. The L.A. Moran Reforestation Center stores more than $4 million worth of seed owned by the State of California and by private companies. CAL FIRE staff at the L.A. Moran Reforestation Center continues to provide seed for reforestation purposes and technical assistance to government agencies and private landowners on cone and seed matters and seed collection activities. CAL FIRE is also working with federal and local partners, such as the USDA Natural Resources Conservation Service, the U.S. Forest Service, and the Placer County Resource Conservation District, as well as private reforestation nurseries, to increase the availability of appropriate reforestation stock.

Forest Management and Fire Hazard Reduction Assistance

CAL FIRE works to foster health and sustainability of private forestlands through its forestry management assistance and fire hazard reduction (so called "fuel treatment") programs. Through these programs, such as the California Forest Improvement Program, CAL FIRE provides technical assistance, grants, and, at times, direct project assistance for activities such as the development of sustainable forest management plans, implementation of forest improvement projects such as thinning or tree planting, and reduction of high levels of vegetation that pose a significant fire hazard.

Urban Forestry

The CAL FIRE Urban and Community Forestry Program promotes the expansion and improved management of trees and vegetation in communities throughout California. Urban trees directly capture CO_2 and provide long-term storage of carbon. As noted above, trees in urban environments, or 'urban forests', are capable of providing significant shading and other cooling benefits that can reduce urban temperatures and energy needs. Urban forests can also help filter air pollutants, prevent soil erosion, and absorb rainfall that would otherwise run over streets and wash pollutants into nearby waterways that are already under increasing stress from climate threats. In addition to providing public health benefits, and benefits to air, soil and water, urban forests can also provide habitat for wildlife and improve property values for communities.

Urban forestry is also otherwise being incentivized through the Urban Forest Projects Compliance Offset Protocol in the California cap-and-trade program. Grants and technical assistance in support of urban tree planting, urban tree inventories, urban forest management plans, educational and innovative urban forestry projects also have been provided by the California Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) and the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002 (Proposition 40). However, this funding ended in June, 2013.

In December 2012, CAL FIRE's Urban and Community Forest Program, along with USFS and EcoLayers (a web-based platform for integrated resource planning), also launched a web-based tool, ecoSmart Landscapes (www.ecosmartlandscapes.org) that allows homeowners to calculate present and future carbon and energy impacts of existing and planned trees. As further discussed below and in the Public Health and Energy sections of this document, urban tree planting can offer significant, cost-effective energy and public health benefits which will become increasingly important in the face of anticipated climate impacts. The ecoSmart Landscapes tool uses a Google Maps interface, and its carbon calculations are based on the Climate Action Reserve's Urban Forest Project Protocol. In addition, the Strategic Growth Council's Urban Greening program coordinates with CAL FIRE and other agencies on urban forestry investments.

Improved Forest Management, Fire Risk Reduction, Forest Conservation and Reforestation
The Board of Forestry has adopted regulations to create a modified timber harvesting plan for fuel hazard reduction.[339] The availability of the modified timber harvest plan for fuel hazard reduction is meant to encourage forest landowners to manage their forests to increase spacing between trees and reduce fuels in the understory with the objective of reducing the rate of spread, duration and intensity of any future fires and creating more fire resilient forests.

The Compliance Offset Protocol for U.S. Forest Projects in the California cap-and-trade program is providing market based incentives for projects including improved forest management projects, avoided conversion projects, and reforestation projects.

The Forest Conservation Program, administered by the Wildlife Conservation Board ("WCB") with funding from Proposition 84, has also provided funding for forest conservation and restoration, with additional consideration given to projects that can demonstrate an ability to reduce forest carbon emissions or promote additional forest carbon storage. CAL FIRE's Forest Legacy Program, conducted in partnership with the US Forest Service, works in concert with the WCB to develop working forest conservation easement projects and provide funding for easement purchase.

Proposition 40, now fully expended, provided cost-share funding for private, non-industrial forestland landowners for the development of forest management plans and the implementation of management practices to reduce the threat of wildfire, enhance watershed function, and improve forest health.

Forest Resources: Carbon Sequestration (Assembly Bill 1504 or "AB 1504")
AB 1504 was signed into law in 2010, recognizing the "unique role forests play in combating climate change" by helping to store carbon emissions. The bill requires BOF to ensure that its rules and regulations for harvesting commercial species consider the capacity of forest resources to meet or exceed the carbon goal for the forest sector specified in ARB's 2008 Scoping Plan.

Forest Resource Management Bill (Assembly Bill 1492 or "AB 1492")
AB 1492 was signed into law in 2012. Among other things, AB 1492 established an assessment on certain wood products to be deposited in a Timber Regulation and Forest Restoration Fund; upon appropriation by the Legislature, the moneys in the fund are to be used for administrative costs, supporting timber project/permit reviews, restoration and forest improvement, fire hazard reduction , and certain grants, including grants to local and state governments, tribes,

and non-profits for reducing greenhouse gas emissions and promoting adaptation or preparation for climate impacts.

State Responsibility Area (SRA) Fire Prevention Benefit Fee (Assembly Bill X1 29 or "AB X1 29")
AB X1 29 was signed into law in July 2011. The law established a new annual Fire Prevention Fee to pay for fire prevention services within the State Responsibility Area (SRA). The fee is applied to all habitable structures within the SRA. This fee funds a variety of important fire prevention services within the SRA including brush clearance around communities on public lands, along roadways and evacuation routes; and activities to improve forest health so the forest can better withstand wildfire.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA FORESTS

As discussed above, California's forests provide a broad range of benefits including clean water, clean air, flood protection, carbon storage, wildlife habitat, shading in urban settings, and recreational opportunities. However these benefits are imperiled by climate impacts such as increased temperature, declining snowpack and changing water availability, and increased risk of more frequent and more severe wildfires. Despite the success stories highlighted above, significant action is still needed to protect and maintain forest ecosystems and ecosystem processes on both protected and working forests to improve resilience and prepare California forests for climate risk. Sustainable management strategies should aim to maintain forest complexity and protect forests from human and natural agents of disturbance.

Funding support by grants, bonds, and fees for existing forest programs has, to date, been inadequate to support the types of innovative stewardship and restoration actions (further described below) which are needed to adequately prepare the forest sector for projected climate impacts. While AB 1492 and AB X1 29 may provide some new funding for these types of risk reduction efforts, as noted above, other funding sources for needed forest management, such as Proposition 40 and 84, will no longer be available; the continued availability of federal forest climate support (including research and forest management work) may also otherwise be imperiled by the government's fiscal state (which may itself be imperiled by climate impacts – see, for example, Box 48: "Flood Insurance" in the Ocean and Coastal Ecosystems and Resources section of this document). Additional, stable funding sources are needed to support actions to reduce climate risks to forests and to promote forest health and resilience. As further described below, market based solutions, such as cost-effective forest watershed investment programs, may offer a partial funding solution; however, additional funding sources will likely be required.

Improve Forest Management Practices and the Capacity of the Forest Sector to Withstand and Recover from Climate Impacts In Order to Protect the Value and Continued Productivity of Forest Resources

(1) Continue and Enhance Coordinated Efforts to Reduce Wildfire Risks and Promote Fire Safe Communities

As called for in the 2010 Strategic Fire Plan, the State continues to reduce wildfire risks and promote fire safe communities in a number of ways including:

a) By identifying, mapping, evaluating, and monitoring fire hazard threats under current and projected climate conditions;
b) Helping to articulate and promote the use of land use planning to help reduce fire risk;
c) Assisting in the development of local county and regional plans that address fire protection and landowner objectives and responsibilities;
d) Increasing awareness regarding wildfire risks and safety precautions (such as using fire resistant building materials and clearing vegetation and other fire hazards near buildings) in individuals and communities;
e) Working with federal and local partners to integrate fire management practices with community and landowner priorities;
f) Calibrating the level of resources devoted to protecting assets from wildfire risk according to community values identified in planning efforts; and
e) Addressing post-fire recovery actions to restore natural resources, minimize flooding, address impacts of silt, sand, gravel from denuded slopes on water quality (so called "sedimentation").

The State must continue to refine understanding of how climate impacts will change wildfire risk. As that understanding develops, education efforts to communities and individuals must reflect the best available science regarding anticipated climate impacts and the state of wildfire risk in California. A cost-benefit analysis should be performed to estimate the probability and magnitude of loss of property, injury and loss of life to wildfire, as well as the necessary investments and actions to reduce wildfire risk in the face of expected climate impacts. This type of analysis might be done as part of updates to the Strategic Fire Plan. Funding to support this type of expanded climate and cost analysis may be necessary, and collaboration with partners and stakeholders would be necessary.

Wood waste from needed fire hazard reduction efforts might be used for biomass energy. The Electric Program Investment Charge (EPIC), which is further described in the Energy section of this document, might help provide funding to support utilization of biomass generated from forest fire hazard reduction efforts, perhaps focusing on development of small distributed power/heating facilities that could utilize existing sawmill infrastructure as well as the workforce in rural communities. Any such funding would have to be consistent with the current EPIC investment plan.

(2) <u>Provide Funding to Support, Maintain and Expand Seed Banks and Revive State Tree Nurseries</u>
As noted above, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been diminishing, with the suspension of nursery services. In order to ensure the ability to undertake restoration work following fires, to maintain the genetic diversity of California forests, and to

protect tree species, including iconic species like the giant - continuing support for the State Nursery Program is critical. Seed processing and storage does not take the place of nursery production of seedlings (small immature plants); the availability of seedlings is particularly important for reforestation efforts following a fire.

With adequate funding, the State Nursery Program could:

- Maintain or expand seed banks to preserve genetic material from representative California tree species;
- Continue to promote the use of genetically appropriate native species in reforestation efforts; and
- Continue or expand work with the Natural Resources Conservation Service, Resource Conservation Districts, the US Forest Service, and private reforestation nurseries to increase the availability of reforestation seedlings available to small landowners.

More information about seed preservation efforts is contained in the Biodiversity and Habitat section of this document as well as the Agriculture section of this document.

(3) Assess and Implement Cost-Effective Forest Watershed Protection and Restoration
As noted in the above (for instance in Box 35: "Ecosystem Services" - Smart Land Use to Save Money and Create More Sustainable Communities), forests provide a broad range of ecosystem services, including flood protection, improving the quantity and quality of water supplies for downstream communities, shading and energy savings, and improvements to air quality. Investments in forest protection and restoration can be a cost-effective way of protecting communities from the impacts of climate change such as more extreme weather and changing water availability.

The State should help incentivize best management practices for land management for better upper watershed protection, and encourage further cost-benefit analyses; while such cost-benefit analyses would require funding and staffing support, implementation of cost-effective ecosystem investment programs could be self-sustaining.

The Department of Water Resources and CAL FIRE might work together to identify potential areas for collaboration, such as further cost-benefit analyses and integrated regional water management plans.

(4) Improve Understanding of Trade-offs Between Different Management Responses to Expected Forest Climate Impacts
As described in more detail in the Biodiversity and Habitat section of this document, the rapidly shifting impacts and conditions associated with climate change are fundamentally altering long-standing paradigms for natural resource management. Species are not only changing in response to climate change, but geographic locations of suitable habitat are also changing as temperatures and precipitation patterns change. Natural resource management efforts must

now occur in the context of these multiple shifting variables; various types of natural management approaches in response to unfolding climate changes are further described in the Biodiversity and Habitat section of this document. Continued research into the relative strengths and weaknesses of possible forest management approaches is needed and will help inform forest land owners, managers and regulators on how to best protect forest health and productivity in the face of climate impacts.

Certain public lands, such as National Forest System Experimental Forests[340] and CAL FIRE Demonstration State Forests[341], are particularly suitable for near-term and longer-term research into the efficacy of various forest management approaches in the face of climate change. These experimental and demonstration forests function as living laboratories for forest scientists. Enabling funding is needed to support necessary research into forest management options to protect forest health and resilience in the face of climate risks.

Iterative refinements to chosen management strategies will be necessary as both climate science continues to improve and knowledge about natural resource management in the face of climate change also improves (this type of iterative refinement is sometimes referred to as "adaptive management").

Statewide Assessment of Potential Cost Savings from Urban Forestry Investments

As noted above, urban forests provide myriad benefits, including cooling benefits that can reduce urban temperatures, public health impacts from climate change, and energy needs. Although research has been done on the quantification of potential benefits at the residential, project and city level, a thorough statewide assessment of potential opportunities, has yet to be done. A thorough assessment should include an evaluation of potential benefits as well as the cost of achieving such benefits. While the assessment would require funding, it could identify opportunities for urban forestry investments that might generate significant energy and cost savings for the State and California communities. A 2003 study by the USFS, Pacific Southwest Research Station, suggested that there were significant, cost-effective urban forest investment opportunities.[342] According to the 2003 study, planting 50 million trees in California to shade east and west facing walls could reduce peak energy demand by 4.5% over 15 years, for a savings of $7.6 billion (with projected cost of 50 million trees estimated to be $2.5 billion). The California Energy Commission is well positioned to lead this type of statewide assessment, in coordination with CAL FIRE, the California Department of Public Health and the California Environmental Protection Agency. Funding for a CEC assessment of this sort might come from the EPIC program, but would have to be consistent with the current EPIC investment plan. Any cost-justified recommendations suggested by the assessment would require funding support for implementation. CAL FIRE might help implement the urban forestry investments through its Urban and Community Forestry Program. CAL FIRE might also develop additional tools to help local and regional governments utilize urban forestry data for making planning decisions.

Improve Understanding of Forest Climate Impacts to Support Improved Forest Management Responses

(1) Improve Monitoring

Both the Forest Carbon Inventory and FRAP rely on data generated by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA), which is the nation's on-going forest census program. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.[343] FIA data necessarily has error estimates as results are extrapolated from sampled forest plots and measurements are only taken at periodic intervals; however, greater accuracy can be obtained by increasing the number of sampled forest plots (this is called "densification" of survey plots) and/or by measuring more frequently. State support for densification and increased frequency of FIA measurements of California forests would allow for better forest management that is more responsive to changing climate impacts. For instance, better data would allow for improved mapping of pest outbreaks, spread of invasive species, and tree mortality – which has implications for wildfire risks and forest management interventions. As noted below, improved monitoring will also aid in evaluating different management options that might be used to address expected climate impacts. Current estimates of carbon stocks on forest lands are highly variable and additional monitoring and research to refine methods are needed.

(2) Better Modeling of Vulnerabilities and Climate Impact Trends

As noted above, some research has been done to understand how expected climate impacts (changing temperatures, changing water availability, more frequent and severe wildfire, changes in pests and invasive species) will affect the geographic shifts of tree species in California, but more of this type of trend analysis is needed. This analysis will have important ramifications not only for California's commercial tree species, but also for California's biodiversity and habitat more generally. Better understanding of climate impacts and geographic shifts in tree species will help inform and improve forest management options. Having a better understanding of the potential cost ramifications of expected forest climate impacts (i.e. impacts to forest health and forest productivity, loss of property/injury and other health impacts/and loss of life from wildfire risks, impacts to water supplies, etc.) and better cost-benefit analysis of investments to make the forest sector more resilient against the impacts of climate change would also be helpful for prioritizing forest sector climate strategies.

As FRAP (the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program) already produces periodic assessments of the state's forest and rangeland resources and carbon stocks, FRAP could be enabled to undertake necessary forest climate vulnerability (including relevant economic analyses) and trend analysis to support improved California forest management. Additional funding or staffing may be necessary to enable this type of work.

(3) Identify Priority Landscapes and Support Actions to Increase Forest Resilience

As climate changes rapidly over the coming decades, species (including trees) will be stressed and forced to adapt to new conditions. Some areas of the state may be able to serve as safe havens, or areas of refuge (also called "refugia") for climate stressed species. For instance, as the Southern Sierra Nevadas – Blue Oak Climate Scenarios map in Box 39 illustrates, the mid-elevation areas of the Southern Sierra may be such an area of refuge for tree species that are unable to survive in higher temperature conditions that will start to occur in the lower elevation areas of the State.

CAL FIRE, through FRAP and in coordination with partners, should continue to identify potential niches in existing landscapes that may provide refugia for plants and wildlife in light of expected climate impacts. Listed species habitat requirements and diverse gene pool preservation needs to be considered to allow for species to respond to climate change. As noted in the Biodiversity and Habitat section of this document, preserving the biodiversity and limiting habitat fragmentation has important economic, public health and social dimensions. Additional funding or staffing may be necessary to enable this additional work to identify priority landscapes for protection.

Information Sharing and Education

As noted throughout this section, California has many key partners and stakeholders with respect to its forest resources. These partners and stakeholders include: the USFS, USDA Natural Resources Conservation Service, Resource Conservation Districts, local governments, industrial and non-industrial timberland owners, numerous nongovernmental organizations, and residents who enjoy and use California forests and forest resources. Information sharing and coordination with partners and stakeholders will continue to be important in order to monitor and protect forest resources in the face of growing climate threats such as fire, increased temperature, pests and invasive species, and changing water availability. Coordination may take the form of collaboration on research and management strategies, including fire risk reduction plans. Given the substantial federal ownership and management of California forest lands, coordination with federal partners, including USFS, will continue to be particularly important as climate impacts escalate.

Interagency collaboration on forests will also continue to be important, and should be reflected in the State's many on-going climates and energy related policy efforts and programs with a forestry nexus; these include the:

- California Forest and Rangelands Strategy Report and Assessment (CAL FIRE),
- Bioenergy Action Plan (California Energy Commission),
- Assembly Bill 32 Scoping Plan and Forest Carbon Inventory (California Air Resources Board),
- California Wildlife Action Plan (California Department of Fish and Wildlife),
- State Water Plan (Department of Water Resources),
- Public health and air quality programs which may be impacted by particulate matter from wildfires, and
- California Climate Research Plan and 4th Climate Assessment.

In order to assist incorporation of expected climate impacts into forest management decisions, education must be made available to forest land managers. With enabling funding, CAL FIRE and/or the University of California Cooperative Extension program could offer this type of technical, education assistance to forest managers.

Box 43

California Forestry

Several state entities play an important role with respect to forestry in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. (The work of entities, such as the Governor's Office of Emergency Services and the California Department of Insurance, that play an important role in management of wildfire risk and post-wildfire recovery is discussed in the Emergency Management section of this document.)

Board of Forestry and Fire Protection (BOF) The Board's mission is to lead California in developing policies and programs that serve the public interest in environmentally, economically, and socially sustainable management of forest and rangelands, and a fire protection system that protects and serves the people of the State.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, the Department provides varied emergency services in 36 of the State's 58 counties via contracts with local governments. CAL FIRE's mission emphasizes the management and protection of California's natural resources; a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive CAL FIRE Resource Management Program. CAL FIRE oversees enforcement of California's forest practice regulations, which guide timber harvesting on private lands. The department also supports sustainable management of private forestlands and reduction of wildland fire hazards through technical assistance, grants, and project collaboration. CAL FIRE manages eight Demonstration State Forests that provide for commercial timber production, public recreation, and research and demonstration of good forest management practices. CAL FIRE also supports "urban forestry", increasing the number and health of trees planted in cities (urban forestry is further described in the Public Health section of this document).

California Department of Parks and Recreation (California State Parks or CSP) manages 1.5 million acres of California landscape within 280 park units. Twenty percent of this land area is forested with iconic stands of coast redwood, sierra sequoia, and Torrey pines as well as mixed-conifer, mixed hardwoods, and forested riparian communities. CSP manages its forested lands using a variety of tools, including prescribed fire, to restore ecosystem processes, control exotic plant species, restore and maintain native plant assemblages, reduce fuel accumulation, and maximize biologic diversity. CSP also works with Cal FIRE, the United States Forest Service, and the National Park Service to protect cultural and natural resources during wildfire events.

Office of State Fire Marshall (OSFM) The mission of the State Fire Marshal is to protect life and property through the development and application of fire prevention engineering, education and enforcement. The Office of the State Fire Marshal supports the mission of the CAL FIRE by focusing on fire prevention, including providing statewide direction for fire prevention within wildland areas.

State Conservancies A number of State conservancies are also involved in forest protection and management activities. These include the **Sierra Nevada Conservancy (SNC)** which initiates, encourages, and supports efforts that improve the environmental, economic and social well-being of the Sierra Nevada Region, its communities and the citizens of California and the **California Tahoe Conservancy**, which is focused on restoring and sustaining a balance between the natural and the human environment and between public and private uses at Lake Tahoe, and has worked on forest fire hazard reduction in the Tahoe Basin.

As further discussed above, the federal government holds a significant amount of forested lands in California. Federal agencies, including the **United States Forest Services (USFS)**[344] and the **Bureau of Land Management (BLM)**, are important partners for the State of California with respect to forest management, wildland fire protection, and research. There is also very significant private ownership of California forest lands, and both industrial and non-industrial private owners are important partners for the State.

OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

INTRODUCTION

The policy guidance in this chapter is meant to help inform state decision makers regarding ocean and coastal issues when preparing for climate risks.[345] Three quarters of California's 38 million people live near our iconic 1,100 miles of coastline and San Francisco Bay's additional 500-mile[346] shoreline. Because of this geographic reality, a vast number of people can potentially be impacted by the ocean through rising sea levels brought on by climate change and direct impacts of human activities. A rising sea brought on by climate change puts vital infrastructure at risk. This includes roads, highways, bridges, commercial and residential buildings, sewage treatment plants, gasoline pipelines, power plants and power grid infrastructure, several of the busiest ports and airports in the world, and even emergency facilities like hospitals. Sea-level rise, coastal storms and erosion are also impacting natural and recreational assets such as beaches and tidal wetlands that are valued by Californians as part of the attraction of living in and visiting the coast and bay regions. That is why a multitude of federal, state, regional and local entities are working together to educate and advise decision makers on methods to prepare and plan for these large-scale, multi-decade changes. In order to lower vulnerability and exposure to economic losses and public health and safety risks, it is critical that California take actions now to ensure resilient communities.

While less visible, the impact of runoff, pollution, and carbon absorption on the ocean is a real and timely threat to waters that provide an abundance of seafood to not just our state, but places all over the world. What's more, the threat of fouling our waters isn't just a local one – it is a global crisis that can only be addressed through both local actions and work on all scales to reduce the pollution that is causing higher temperatures and changes in ocean chemistry.

Actions to address these threats have already started. California is tackling carbon pollution through a suite of climate policies to reduce greenhouse gas emission pursuant to the California Global Warming Solutions Act of 2006 (Assembly Bill 32 or "AB32"). Some progressive local and regional governments and state agencies have been working on innovative shoreline management plans including managed retreat (discussed further below) and investments in tidal wetlands which can provide cost-effective flood protection. The State has also developed guidance for incorporating sea-level rise, storms and shoreline change into planning and decision making for projects in California. Continued investments in climate-smart Ocean and coastal management can help protect the public health and welfare of Californians and bolster the resiliency of natural resources on which our communities depend.

More than forty years ago, grassroots environmental activism led to California passing some of the nation's first and strongest coastal management laws. These laws established that the coast and bay shoreline are important natural resources for the benefit and enjoyment of all of the people of California and that "it is the policy of the State to preserve, protect, and where possible, to restore the resources of the coastal zone for the enjoyment of the current and succeeding generations". California's commitment to protection of our shared coastal resources is at the heart of California's Coastal Management Program which has been hailed as a national and international model for coastal resource management. The state agencies who make up the Coastal Management Program include the Coastal Commission, San Francisco Bay Conservation and Development Commission and the Coastal Conservancy. All three of these state agencies are engaged in significant projects that integrate consideration of climate change into decision-making and providing leadership for reducing risks and preparing for changing conditions.

Many different entities play an important role with respect to protecting and managing California's ocean and coastal ecosystems and resources. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate impacts to help in identifying management gaps or determining which agency should take specific actions in the future. The key state agencies for management of coastal and ocean resources are listed at the end of this chapter, in Box 52. In addition, coastal assets and infrastructure are under the purview of various federal, state, regional and local agencies, and there are significant coastal assets under private ownership and management. As further discussed in various chapters throughout this plan, local governments have primary responsibility for land use planning and local infrastructure and play a key role in emergency management efforts; thus they have an important role with respect to California's ocean and coastal ecosystems and resources. Management and planning for climate impacts requires a high degree of coordination.

The 2009 California Climate Adaptation Strategy identified the following guiding principles for decisions on actions to address the impacts from climate change in the ocean and coastal regions:

- California must protect public health and safety and critical infrastructure.
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well-being depend.
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources.
- New development and communities must be planned and designed for long-term sustainability in the face of climate change.
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
- California must begin now to adapt to the impacts of climate change. We can no longer

act as if nothing is changing.

As described later in this chapter, the state plans on engaging in a public process to review these guiding principles and integrate them into a framework for improved action to reduce risks and support vibrant, healthy coastal and bay communities and natural landscapes.[347]

This chapter on ocean and coastal ecosystems and resources is organized as follows:

- Climate change impacts on ocean and coastal ecosystems and resources;
- Highlights of steps taken to date and success stories;
- Actions needed for safeguarding ocean and coastal ecosystems and resources;
    - Better understanding of climate impacts on ocean and coastal ecosystems and resources;
    - Improve management practices for coastal and ocean ecosystems and resources and increase capacity to withstand and recover from climate impacts;
    - Better understanding of evolving trends that may impact ocean and coastal ecosystems and resources; and
    - Information Sharing and Education.
- Box 52 – California Ocean and Coastal Ecosystems and Resources (description of state entities that play an important role with respect to California's ocean and coastal ecosystems and resources).

CROSS REFERENCES: While this section of the Safeguarding California Plan raises many topics relating to ocean and coastal resources, some of these topics are further described within the context of cross-related sections of this Plan. For instance, sea-level rise impacts relating to transportation infrastructure are further discussed in the Transportation section of this document. Flood hazard preparation is further discussed in the Emergency Management section of this document. Sea-level rise as the cause of salt water intrusion into drinking water supplies is further discussed in the Water section of this document.[348] Sea-level rise impacts on energy infrastructure are discussed in the Energy section of this document. Toxic releases, floods and other public health issues related to sea-level rise are further discussed in the Public Health section of this document. Climate impacts on ocean and coastal ecosystems are also discussed in the Biodiversity and Habitat section of this document.

Climate Change Impacts on Ocean and Coastal Ecosystems and Resources

Climate change presents new threats to ocean and coastal ecosystems and resources including, but not limited to, sea-level rise, extreme events, and ocean acidification.

Sea-level Rise, Storms and Erosion: Infrastructure and Property Damage, Permanent Submersion of Coastal Lands, Toxic Releases, and Risks to Water Supply

Climate change is causing global average temperatures to increase. This warming trend causes sea-level rise in three ways: 1) the oceans are warming, which causes sea water to expand, increasing ocean volume, 2) glaciers on land are melting and transferring water to the oceans, and 3) sea ice is melting.[349]

According to a 2012 report by the National Research Council[350], for the California coast south of Cape Mendocino, sea level is projected to rise approximately 5 to 24 inches by 2050 (relative to 2000) and 17 to 66 inches by 2100[351]. Communities, public and private property, infrastructure, natural habitats (including wetlands and marshes), coastal agriculture[352], and important cultural resources will be at increased risk from storm surges and flooding, permanent inundation and erosion. [See Box 44: Rising Seas Threaten California's Coastal Past] The risks to California's economy, its people, and its natural resources are substantial; and populations that are socially and economically vulnerable will bear a disproportionate burden. As discussed in the NRC study, it is the combination of sea-level rise and extreme events that are most likely to cause significant damage in the near term. As one example, the map in Box 45 shows the companies just in the Silicon Valley that are located in areas vulnerable to projected sea-level rise by the end of the century.[353]

Box 44

Rising Seas Threaten California's Coastal Past
by Molly Samuel (used with permission)

A site with evidence of more than 1,000 years of occupation is eroding due to high tides *hitting the base of the cliff. (Photo: Mike Newland)*

On a sunny day earlier this summer at Point Reyes National Seashore, I scrambled behind Mike Newland as he clambered across gullies and bushwhacked through thigh-high lupine. Once we got to the spot he was aiming for, on the edge of a sandy beach-side cliff, he stopped and started to pick through shells and stones.

"You can see, we've got sort of a handful of little guys here, popping out of the ground," he noted. "Some of these that we're going to see, they weren't here a year ago, when I came here last time."

Newland, an archaeologist at Sonoma State University and the president of the Society for California Archaeology, was hunting for Native American artifacts, clues about what life was like in coastal California before Europeans arrived. It was easy for him to find them; wind, rain and tides have eroded these cliffs and exposed the ancient trash piles and stone tools.

This site and these cultural resources — some of them a thousand years old or more — might not be around for much longer. These pieces of California's history are in danger of disappearing as the Pacific Ocean claws at the base of this cliff. Sea level rise is accelerating the problem.

It's not just that the tides will be higher. The cliffs are so soft, they could recede hundreds of feet back, with just a few feet of sea level rise.

"You know, this isn't just gonna be a matter of, the ocean's going to pop up and cover it up and then we can get back to it later," Newland said. "These sites are toast. And we're essentially losing them all at once."

Nick Tipon, a retired high school teacher and member of the Federated Indians of Graton Rancheria, whose territory includes Point Reyes, said he became aware of the extent of the erosion several years ago.

"In one part of the park, there's a layer of soil that indicates human habitation in that spot, and sticking out from the side of a cliff was a human skull," he said. When human remains are disturbed or exhumed, tribal policy is to rebury them as close as possible to where they were found. "So then we thought, 'How far inland do we have to go away from the cliff to find stable soil? So we don't have to do this 100 years, 200 years again? So that literally our ancestors can rest in peace?'"

Newland says there is evidence that people have lived in California for at least 11,000 years, and the soft sandstone cliffs on the coast have always been susceptible to erosion. Traditionally, Tipon said, the tribe would have let the ocean take burial sites, since it was a natural process. But now, with two million or so people visiting the park every year, they can't leave human remains exposed.

Meanwhile, climate change threatens to expose more of them. A tide gauge in the nearby Golden Gate has recorded eight inches of sea level rise in the past century. Scientists' project it could rise three feet in the next.

Just looks like a rock, right? Archeologist Mike Newland says, "This is a crypto-crystalline silicate cobble that was broken by native peoples, probably to get material for making stone tools. It comes from a high-risk site along the western edge of Point Reyes National Seashore." (Photo: Mike Newland)

Point Reyes contains more than 120 Coast Miwok settlement sites. (The Federated Indians of Graton Rancheria includes both the Coast Miwok and the Southern Pomo people.) The National Park Service works closely with Native Americans to protect graves and other important objects or sites. And the Park Service supports and conducts climate research and has programs to help mitigate and adapt to changes coming to the parks. But Mark Rudo, a National Park Service archaeologist, said the Park Service isn't prepared to deal with the scale of the threat that sea level rise presents.

"At the same time that we're trying to figure out what the impacts are, we're also trying to identify what we can do about them, so it's not an easy situation to work in," he said. It's a special challenge with archaeological sites. While it may be possible for natural resources, plants and animals, to migrate**,** Rudo pointed out that cultural resources, like archaeological sites that remain in the ground, can't be moved, even with help. "We're stuck," he said. "We can't hide or run away from the problem, or adapt to it."

But the park does have help measuring the extent of the problem. Newland is recruiting archaeologists from all over the state in a volunteer effort to survey sites along the coast in Marin, Monterey, San Diego and Del Norte Counties, and he hopes to continue expanding the project, to study the thousands of sites up and down the California coast.

"We have to be honest. Most of the sites are going to be destroyed," he said. "But we should at least know what we're going to lose. That's my goal." At Point Reyes alone, Newland has found that 54 of the 160 sites he studies are in danger of being erased in the next century, and most of the others face some level of threat from other climate change impacts. And he emphasized, this is going to be a problem everywhere. "We are in the process of losing all of our maritime sites as a species. Every place that we've launched off to go explore the world through the ocean is now at risk," Newland said.

Tipon, who's a tribal liaison to the parks, said they'll have to decide what to try to protect on a case-by-case basis, but he's less concerned about any given object than with people and culture. And that won't be washed away as easily.

“One of the questions I get asked a lot when I give speeches is, ‘How long have your people been here?’ And I go, ‘Well, you know, the archaeologists say that it’s 3,000 years, 7,000 years, 11,000 years,’” he said. “But the cultural response is: we’ve been here forever. So how long are we going to be around? We will be here forever.**”**

Molly Samuel joined KQED as an intern in 2007, and since then has worked at KQED as a reporter, producer, director and blogger. Before becoming KQED Science’s Multimedia Producer, she was a producer for Climate Watch. Molly has also reported for NPR, KALW and High Country News, and has produced audio stories for The Encyclopedia of Life and the Oakland Museum of California. She was a fellow with the Middlebury Fellowships in Environmental Journalism and a journalist-in-residence at the National Evolutionary Synthesis Center. Molly has a degree in Ancient Greek from Oberlin College and is a co-founder of the record label True Panther Sounds.

Sea-level rise will result in the inundation of some beaches; for gently sloping beaches, the general rule of thumb is that 50 to 100 feet of beach width will be lost for every foot of sea- level rise. Beaches and bluffs also will be exposed to greater and more frequent wave attack, due to the elevated seas as well as to a possible increase in the frequency and severity of storm waves. When the means of protecting existing structures involves building sea walls or other "hard armoring" of the coast, there will be an inevitable additional loss of beaches as a result. This is because shoreline protective devices halt the landward migration of the back of the beach, and continued flooding of the seaward beach results in a reduction in beach width, and its eventual loss entirely. The loss of beaches due to armoring and sea-level rise will in turn result in loss of public beach access, tourism losses, losses of marine mammal haul-out area and sandy beach habitat, and loss of beach buffering capacity against future bluff erosion.[354] By virtue of California's sovereignty, the public owns all of the coastline three nautical miles from what is known as "the mean high tide line."[355] The California Constitution mandates that these lands are held by the State in trust for the people and public access is a key part of that mandate. As sea levels continue to rise, there may be jurisdictional shifts over areas of the California coast line; areas that were once beaches will become submerged lands and strategies will need to be developed to protect public access.

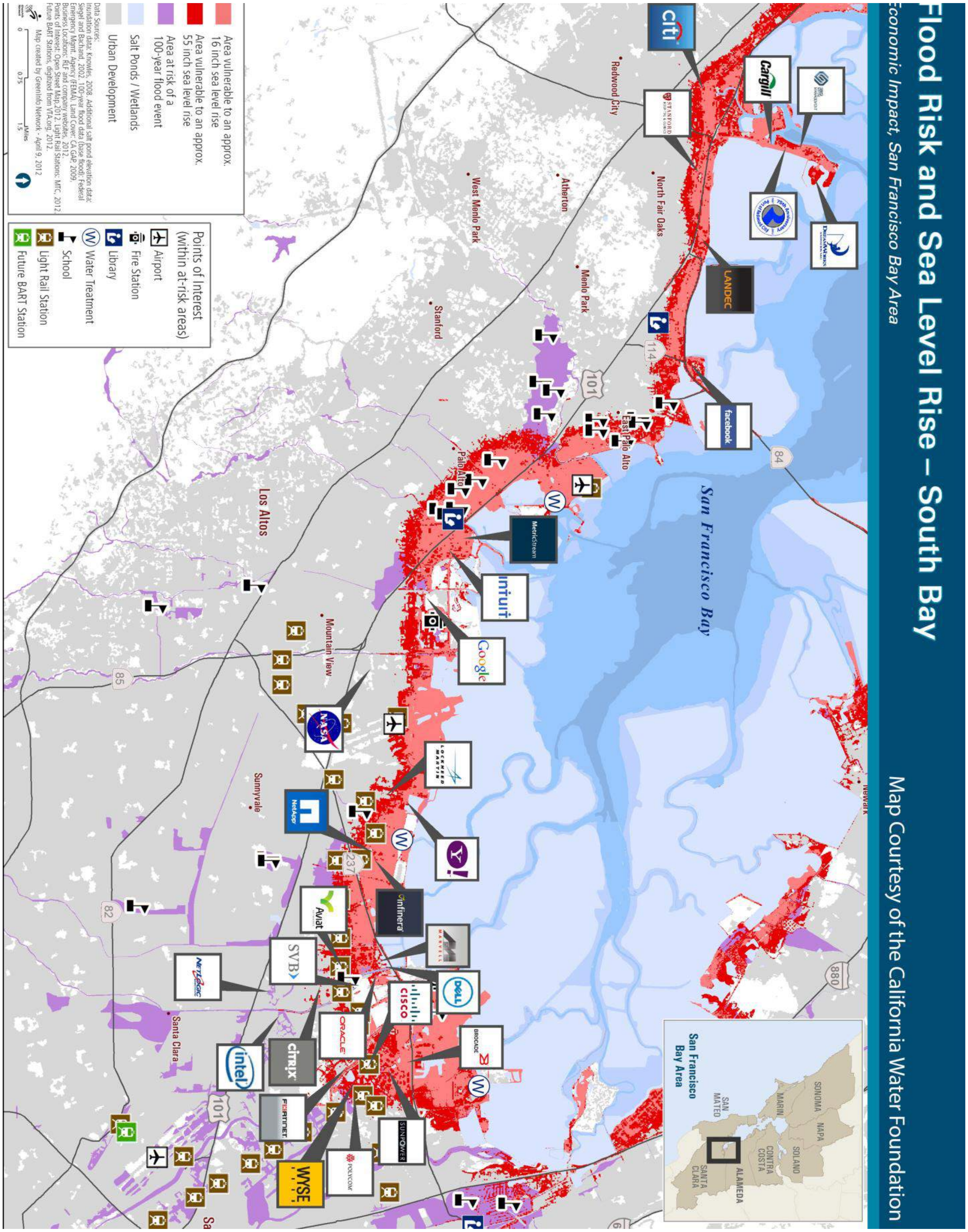
As noted in the Transportation section of this document, sea-level rise and coastal erosion also threaten ports and low lying airports, roads and highways, bridge supports, transit systems, and energy and fueling infrastructure. This has major implications not only for critical emergency evacuation routes and public health, but also for goods movement and the economy. For further discussion of these issues, please see the Transportation and Water section of this plan.

Sea-level rise and extreme events also threaten water supply and delivery, through salt-water intrusion into fresh water sources and through impacts to the Sacramento-San Joaquin Delta. Saltwater intrusion in groundwater supplies is caused by the landward and upward movement of sea-water and is further discussed in the Water section of this document. The waterways in the Delta are at sea level and are affected by ocean tides. The Delta consists of a network of channels and sunken "islands" that cover—together with Suisun Marsh—about 1,300 square miles. This combination of islands and channels support not only water supply conduits, but also other important infrastructure elements: major arteries of the state's electrical grid; natural gas fields, storage facilities, and pipelines; highways and railways; and shipping channels, all surrounded by an increasingly urban landscape. Inundation and higher flood risk associated with sea-level rise and storm events might affect operations of the Central Valley Project and State Water Project, impacting water supply and delivery. Communities within the Delta are at high risk from sea-level rise; the Surging Seas study by Climate Central showed that with four feet of sea-level rise, Stockton has the largest total exposed population in the state and Sacramento is the city with the fifth largest exposed population. This same study concluded that the counties with the largest total exposed populations included the following Delta counties: San Joaquin (2nd), Sacramento (5th), and Solano (10th).

Sea-level rise and coastal erosion also threaten other infrastructure and property including wastewater treatment and storm water management facilities[356], hospitals, schools, and homes and businesses. For more on the state's hospital preparedness program, please see the discussed in more detail in the Public Health chapter. Sea-level rise presents very significant fiscal risks.[357]

The presence of facilities or land containing hazardous materials in coastal areas susceptible to either flooding or permanent inundation presents toxic exposure risks for human communities and ecosystems. Hazardous materials can contaminate flood waters, drinking water supplies, buildings and property, and ocean-based food sources. For more information on public health risks from climate change, please see the Public Health section of this document. A 2009 CEC PIER funded study evaluated sites containing hazardous materials at risk from sea level rise in California.[358] The study evaluated a range of sites monitored by the U.S. Environmental Protection Agency for hazardous materials including: "Superfund" sites and brownfields (regulated under the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), hazardous waste generators, facilities required to report emissions for the Toxic Release Inventory, facilities regulated under the National Pollutant Discharge Elimination System, and facilities with permits under Title V of the federal Clean Air Act for hazardous air pollutants. In 2009, 130 such sites were already located in high flood risk areas, but with a 55- inch sea level rise, the high risk flood area along the California coast will expand - and the number of sites at risk will increase 250% - with an estimated 330 hazardous waste facilities and sites at risk.[359] A more recent 2013 report from the Adapting to Rising Tides ("ART"), a project led by the San Francisco Bay Conservation and Development Commission that worked collaboratively with local governments to "field test" planning to be resilient to sea level rise found that there were eight types of contaminated lands within the ART San Francisco Bay Area sea-level rise study area alone, primarily concentrated in Oakland and Emeryville; these lands include two Federal Superfund sites, 450 leaking underground storage tanks, 112 Department of Toxic Substances Control (DTSC) sites and 24 active and closed landfills.[360]

Box 45



Flood Risk and Sea Level Rise – South Bay
Economic Impact, San Francisco Bay Area
Map Courtesy of the California Water Foundation
San Francisco Bay
Area vulnerable to an approx. 16 inch sea level rise
Area vulnerable to an approx. 55 inch sea level rise
Area at risk of a 100-year flood event
Salt Ponds / Wetlands
Urban Development
Points of Interest (within at-risk areas)
Airport
Fire Station
Library
Water Treatment
School
Light Rail Station
Future BART Station
Redwood City
North Fair Oaks
Atherton
West Menlo Park
Menlo Park
Stanford
East Palo Alto
Palo Alto
Los Altos
Mountain View
Sunnyvale
Santa Clara
San Francisco Bay Area
SONOMA
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN MATEO
ALAMEDA
SANTA CLARA

Box 46

Imagining California's Future Coastline - California King Tides Initiative

A "king tide" is a popular term used to describe a phenomenon that occurs when the orbits and alignment of the Earth, moon, and sun combine to produce the greatest tidal effects of the year.[361] King tides are a normal occurrence several times a year in coastal areas.

Because king tides can reach 6 or 7 feet, they are useful for envisioning future everyday water levels expected to occur as a result of climate-driven sea level rise. King tides can cause flooding and can be particularly damaging if coupled with storms and strong waves.

Coastal communities around the world including communities in Australia, British Columbia, and in a variety of U.S. states, have begun documenting king tides in photographs to inspire action to reduce coastal hazards and impacts from sea-level rise. The California King Tides Initiative is such an initiative and engages citizens to photograph king tides, or the highest winter tides, along the entire California coast, including bay areas.[362]

Vista Del Mar, December 24, 2011 by Cassidy Teufel. Photo courtesy of California King Tides Initiative – license to use this photograph does indicate an endorsement of this document.

Box 47

“Wetlands” - Nature’s Flood Protection

Wetlands are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is often covered by shallow water during some parts of the year. There are many types of wetlands, but some major categories of wetlands include: tidal wetlands, freshwater wetlands, and freshwater forested wetlands (including meadows).[363] Sea-level rise will result in changes to some coastal ecosystems, including by converting some freshwater wetlands into more salty tidal wetlands by changing the elevation of the freshwater- saltwater interface.[364]

It is now understood that wetlands not only provide habitat for fish, birds and other species, but wetlands also play an important role in water quality, water supply, flood control, and, in some cases, aid in the storage of greenhouse gas emissions. Wetlands absorb and filter pollutants that could otherwise degrade ground water or the water quality of rivers, lakes, and estuaries. Some wetlands recharge aquifers that provide urban and agricultural water supplies. Wetlands also absorb and slow flood waters, reducing the size and destructiveness of floods.[365]

In the past, the function of wetlands was poorly understood and such lands were viewed as marginal, unproductive lands or breeding grounds for mosquitos and malaria. As a result, many wetlands were drained, filled, and converted to other uses. Estimates of wetlands that historically existed in California range from 3 to 5 million acres. The current estimate of wetland acreage in California is approximately 450,000 acres; this represents an 85 to 90 percent reduction - the greatest percentage loss in the nation.[366] The World Bank has estimated that the drainage of 1,800 km2 (about 450,000 acres) of wetlands in the Sacramento – San Joaquin Delta alone has released some 0.9 GtCO2 (Giga tons, or billion tons of carbon dioxide), a mass of about one quarter of the total above ground pool of carbon in Californian forests, over the last century.[367]

A 2013 report by the Bay Institute[368], an environmental organization, studied the potential for integration of tidal marshes in to multi-purpose shoreline management regimes in the San Francisco Bay Area in the light of expected climate impacts. According to the study, hybrid levees which fortify traditional earthen levees in The San Francisco Bay with tidal marsh restoration are not only extremely cost effective, they offer many additional benefits. Because plant root systems in marshes expand over time, the marsh can function as a “self-maintaining levee” which grows vertically over time and can help the entire system keep pace with sea-level rise assuming marsh restoration efforts are initiated in a timely way. Tidal marshes also provide significant flood protection benefits by reducing destructive wave energy during storms, and marshes provide significant habitat benefits as well.

As further discussed below, there are some exciting projects underway to restore wetlands to aid future generations in coping with climate change stressors like impacts to water quality, changing water availability, and increased threat of floods. See South Bay Salt Pond Restoration Project description below and DWR's Twitchell Island Project in the Biodiversity and Habitat section describing how wetlands can reduce subsidence in the Delta and in turn reduce pressure on levees that can lead to levee failure and flooding. Many more opportunities for additional wetlands protection and restoration work still exist.

Box 48

Flood Insurance

The availability of private flood insurance is extremely limited, since private sector insurance companies have long viewed the risk of flood events as uninsurable.[369]

The National Flood Insurance Program (NFIP), established in 1968, is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses. Participating in the NFIP is based on an agreement between communities and the Federal Government. The program is administered by FEMA and provides flood insurance protection to property owners, renters, and business owners in communities that participate in the program.[370] Homes and buildings in "high-risk" flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance. High-risk flood areas have a 1% or greater chance of flooding in any given year, which is equivalent to a 26% chance of flooding during a 30-year mortgage. (See Box 18: "What is a 100-Year Storm or a 100-Year Flood" in the Emergency Management section of this document.) However, homes and buildings in moderate-to-low risk areas file over 20% of NFIP claims and receive one-third of disaster assistance for flooding. (Disaster relief is further discussed in the Emergency Management section of this document; as noted in that section, disaster relief funds, when available, must generally be repaid with interest.)[371] Although NFIP collects over $3 billion dollars in premiums annually[372], in four of the past eight years, claims will have eclipsed premiums - in 2005, the year of Hurricanes Katrina, Rita and Wilma, claims totaled $17.7 billion.[373]

In July 2012, The Biggert-Waters Flood Insurance Reform Act was signed into law, reauthorizing NFIP through 2017, and instituting some premium reforms and provisions for updated flood mapping.[374] The intent behind the 2012 reforms was, in part, to ensure more accurate assessment of flood risk so that investment in infrastructure and real property that is or will be underwritten by the Federal Government is not based on flawed or outdated hazard analysis. The 2012 reforms authorized increasing insurance premiums based on the new risk assessments in an effort develop a solvent fund source that could reliably respond to flood disasters. As part of the 2012 reforms, a new Technical Mapping Advisory Council, made up of federal, state, and local experts, was formed to review current flood hazard risk mapping standards and to recommend new standards to FEMA based on evolving new scientific and technological data. FEMA is required to report annually to Congress on how it is acting on those recommendations and whether it has deferred action on any recommendation.[375] As of November 2012, NFIP debt was approximately $20 billion, no principal has been paid on the debt since 2010, and premiums are not likely to generate sufficient funds to repay the debt.[376]

According to the Congressional Research Service, although the full economic cost of Hurricane Sandy, which occurred in October 2012, will not be known for years - NFIP payouts are estimated to be between $12 billion and $15 billion. "In the immediate aftermath of Sandy, this amount quickly exceeded the $4 billion in cash and remaining borrowing authority from the Treasury Department [for NFIP]. By January 2013, the NFIP had processed more than 140,000 claims for Sandy-related damages totaling about $1.7 billion. To protect the financial integrity of the NFIP and ensure that the NFIP has the financial resources to cover its existing commitments following the devastation caused by Sandy, the Obama Administration requested that Congress pass legislation to increase the NFIP's borrowing authority. On January 4, 2013, Congress passed, and the President two days later signed into law, H.R. 41 to provide a $9.7 billion increase in the NFIP's borrowing authority, from $20.725 billion to $30.425 billion, to pay flood claims related to Hurricane Sandy."[377]

The U.S. Government Accountability Office (GAO) has added limiting the federal government's fiscal exposure to climate change to its 2013 list of high-priority areas.[378] As of August 2012, California had 260,000 NFIP policies in force, representing coverage of $68 billion of assets.[379]

Repetitive Loss

Structures built and rebuilt in flood prone areas may be vulnerable to being damaged or destroyed multiple times; in many areas, climate impacts will increase the likelihood of such 'repetitive loss'. In 2004, a program was instituted to try to reduce the repetitive loss of structures insured under NFIP. The Severe Repetitive Loss (SRL) grant program provides Federal cost-share funding for States, Territories, and Federally-recognized Indian tribes for strategies for addressing existing properties subject to repetitive loss and preventing the building of new structures in areas prone to repetitive loss.[380]

As further described below, some California coastal communities are already developing, new innovative approaches to managing the many risks of sea level rise. (See Highlights of Steps Taken to Date: Innovative Shoreline Management in California and accompanying Box 51: Innovations in Shoreline Management in California) As noted below, additional work remains to reduce the risk of loss of life and property.

In addition to these planning efforts, the California Environmental Quality Act (CEQA) requires environmental impact reports "evaluate any potentially significant impacts that could result from locating development in areas susceptible to hazardous conditions (e.g., floodplains, coastlines, wildfire risk areas) as identified in authoritative hazard maps, risk assessments or in land use plans addressing such hazards areas."[381] If there are potentially significant direct and indirect impacts to the environment as a result of locating a project in high risk areas, these impacts must be considered and where feasible, mitigated.

For more information on insurance and climate risks, please see Climate Change and Insurance in the Emergency Management section of this document.

In addition to sea-level rise and its associated impacts, there will be additional impacts to ocean and coastal ecosystems and resources. These include changes in temperature, more extreme weather, potential increases in water contamination, ocean acidification and hypoxia. These impacts are further described below.

Changes to ocean function affecting global climate regulation & more extreme weather

As noted above, oceans play a key role in the global climate system, storing and moving heat and carbon, and also playing an important role in the water cycle. Ocean circulation is central to global climate regulation (and is also important to the distribution of nutrients in the ocean), and is influenced by a number of factors, including temperature and salinity. Climate models generally predict that there will be large changes to ocean circulation as a result of continued greenhouse gas emissions and associated temperature changes and ice sheet melting (which affects ocean salinity).[382]

For every 1-degree C (1.8 degrees Fahrenheit) rise in temperature, the amount of moisture that the atmosphere can contain rises by 7 percent; the increased moisture in the atmosphere means more rain, and climate models predict that there will be more extreme rain events.[383] But precipitation is not spread evenly around the globe, and some places might actually get less precipitation than they used to get due to shifts in air and ocean currents.[384] Extreme storm events coupled with sea-level rise will intensify flooding risks, salt water intrusion and erosion[385] and could also negatively impact coastal tourism.

More Extreme Weather: Increase in Pollution Runoff & Ocean Water Contamination

As noted above, sea-level rise may lead to flooding, especially when coupled with extreme storm events, and flooding may lead to water pollution. Extreme storm events may also increase pollution run off from urban, suburban and rural lands (e.g. oil, pesticides, litter, nitrogen fertilizers, etc.). Polluted storm water runoff in ocean water can cause serious public health problems including earaches, sinus problems, diarrhea, fever and rashes,[386] as well as illness, death and reproductive failures in marine species.[387] Runoff of fertilizers can also result in algae blooms; algae blooms can produce toxins or deplete oxygen levels in ocean water; this may cause illness or death in marine species, including fish and shellfish species that are consumed for food.[388]

Extreme storm events may also increase releases of raw sewage into marine environments either due to accidental spills from aging, cracked, and leaking sewer systems or due to overflows of untreated or partially treated wastewater from combined sewer systems.[389]

Salt water draining into sewer lines as part of extreme weather flooding may poison the biological systems at treatment plants and result in further releases of sewage.[390] Accidental spills and overflows can contain untreated human and industrial waste, toxic materials, and debris; this can, in turn, cause serious public health risks and ecological damage.[391]

As further discussed below, enhanced monitoring, infrastructure relocation, repair or redesign (including use of green infrastructure), continued work to control sources of land-based pollution, and public health risk communications programs will be important to address these issues.

Ocean Acidification

The chemistry of the world's oceans are changing as increasing carbon dioxide, and other waste gases from human activities, are absorbed into the surface water. This results in a decline in pH, a process known as ocean acidification. Ocean acidification is considered a global threat to marine ecosystems, and has the potential to impact various economic sectors (e.g. fisheries, aquaculture, tourism) and coastal communities in California, and may also have indirect effects on food security and biodiversity. The current rate of ocean acidification is unprecedented over the past hundreds of millions of years; similar past events have been accompanied by major marine extinctions.[392] While oceanic uptake of carbon dioxide from the atmosphere provides a valuable service to human societies by moderating the severity of climate change, it is having a profound long-term impact on marine chemistry and biology.[393]

In addition to atmospheric gas absorption, small-scale processes like nutrient runoff into coastal waters from land-based sources can lead, through biological processes, to especially low pH (and hypoxic – see section below) water at very local scales.[394] The coastal regions off the west coast of North America are also strongly influenced by seasonal upwelling, a natural process that brings carbon dioxide-rich, offshore waters to the surface ocean. With decades of human inputs of carbon dioxide to the atmosphere, the water that upwells now (which has been out of contact with the atmosphere for approximately 50-100 years), has even lower pH than in the past, resulting in localized "hotspots" of ocean acidification around upwelling regions. For example, the acidification conditions in upwelling-driven northern California coastal waters in 2008 were similar to what are predicted to occur in open-ocean surface waters in 2050.[395]

Many biological processes, such as growth, reproduction, and survival of many species are affected by shifts in seawater pH.[396] For instance, with increasing ocean acidification, many calcifying organisms have difficulty forming and maintaining their shells and skeletons (See Box 8: Ocean Acidification; Implications for Biodiversity in the Biodiversity and Habitat section of this document.) Calcifying organisms such as coral reefs, shellfish and zooplankton are among the first to experience impacts, and early life stages of marine organisms may be particularly vulnerable. However, there is significant variation in the sensitivity of marine organisms, and a growing body of evidence to suggest some species may have the capacity to adapt to future ocean chemistry.

There is potential for ocean acidification to impact wild fisheries that are of great economic importance to California. The first direct impact on humans may be through declining harvests and fishery revenues from shellfish and their predators.[397] (See Box 49: First Person Narrative: Seeing is believing: shellfish growers confront ocean acidification.) Overall, marine crustaceans (crab, lobster, shrimp) appear broadly tolerant to the seawater acidification expected by 2100. Urchins may be more sensitive to acidification due to the vulnerability of their early stages, though new research indicates they may be able to adapt. Fished species are also embedded in marine food webs that are sensitive to changes in environmental conditions. Evidence suggests that the demographics, size, and nutritional content of some species can change in response to changing carbonate chemistry; these effects are likely to influence food web structure and function. The abundance of fished species can vary as the food web changes. A project linking spatially and temporally explicit ocean chemistry forecasts from regional ocean models with scenarios of the response of species in the California Current ecosystem to acidification will be completed in December 2015.[398]

Box 49

FIRST PERSON NARRATIVE: Seeing is believing: shellfish growers confront ocean acidification

By Mark Wiegardt [used with permission]

“My family has been farming Pacific oysters for five generations. We know good and bad seasons are normal. But we never dreamed that the seawater itself would start killing our oysters in their first days of life.

At that age, oysters, clams and mussels are tiny and vulnerable. That’s why scientists and shellfish farmers learned to rear young shellfish in tanks until they are hardy enough to survive, when they are then transferred to the wild. At the Whiskey Creek Shellfish Hatchery in Oregon, we sell larvae by the tens of millions to growers up and down the West Coast. When wild oysters have a bad reproductive season, a handful of hatcheries like ours have kept farms in business. The tasty shellfish end up on dinner plates all over the country—perhaps even yours.

But in 2007, batch after batch of oyster larvae died in our tanks. Our business was on the verge of bankruptcy. Shellfish growers feared they would be next; without seed, a farm can last only a few years. Nobody knew what was clobbering the young oysters.

Alan Barton, an oceanographer by training and manager at Whiskey Creek, solved the mystery. He knew the fish in his home aquarium tank were sensitive to changes in water chemistry, so he began measuring pH in the water we pumped into our hatchery from the ocean. When the acidity was high, our larvae died.

I was skeptical at first – how could the very water we depend on now bring us to our knees? But scientists from Oregon State University and the National Oceanographic and Atmospheric Administration (NOAA) confirmed Barton's insights. Their findings appear in a new scientific paper[399] published last week.

Thanks to this experience, I've learned that our business is on the front line of what scientists call ocean acidification. Carbon dioxide from smokestacks, tailpipes and chimneys is pumped into the air and absorbed by the ocean, reacting with the sea water and making it more corrosive. The scientists have showed us that the acid resulting from increasing fossil fuel emissions combines with natural acid in the deep, carbon-rich water that upwells along the Pacific Northwest. The combination kills young oysters.

Lately some writers are looking for ways to dismiss ocean acidification as no big deal. I wonder how good these experts are at keeping tiny young oysters alive in corrosive water. This isn't theory or speculation—this is happening right now, to my livelihood. And it's not just one business. In Washington alone, the shellfish industry employs 3,200 people and is worth $270 million to the state's economy.

At Whiskey Creek, we've learned that when you're fighting to save your business—and your seafood supplies— it helps to know what you're up against. We now carefully monitor the acidity of the water, and avoid spawning oysters when carbon dioxide concentrations are high enough to kill them; we also treat the water to reduce its acidity. This has enabled us to stay in business for now.

But there are other signs of concern. Barnacles and wild mussels used to clog our pipes so fast that we had to replace them three times every summer. Now the pipes barely need cleaning; a worrying sign that changes in ocean chemistry impacts more than oysters.

We need more states to learn from those of us on the front lines of ocean acidification. The governor of Washington recently convened an expert panel of scientists, stakeholders and policymakers to advise the state's leaders on how to understand, mitigate and adapt to acidification. That's a good beginning and it's a model that other states can follow, to address ocean acidification head on."

Mark Wiegardt and his wife Sue Cudd run the Whiskey Creek Shellfish Hatchery near Tillamook, Oregon

Expansion of Areas of Low Oxygen ("Hypoxic") Waters

Hypoxia (low oxygen levels) can have profound effects on marine ecosystems leading to large-scale die-offs, local damage to fisheries, and long-term loss of biodiversity. While some areas of hypoxic waters – particularly in deep ocean waters – are natural and important parts of marine ecosystems, climate change and other human activity may now expand hypoxic waters into areas closer to the ocean surface.[400] Multiple factors may contribute to this phenomenon:

- Increasing sea-surface temperatures results in less oxygen taken up at the ocean surface and hinders mixing into the deeper ocean.
- Nutrient inputs into coastal waters, including nitrogen (both from air pollution emissions and water pollution runoff from land), can lead to especially hypoxic and acidified water at very local scales.

Expanding hypoxic zones have been occurring off the California coast during the past 20 years.[401] Effects on marine species and ecosystems include altered microbial processes, changes in predator-prey dynamics, and shifts in the abundance and accessibility of commercially and recreationally fished species. Increases in the frequency, duration, intensity, and spatial extent of rapid intrusions of hypoxic waters are also likely; and tracking these events and their impacts will be important.[402]

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

In the last five years, there has been significant action on many scales to address climate impacts to ocean and coastal resources. Almost all coastal and bay counties are involved in some level of climate-related planning initiatives and efforts, some more broadly focused than others. There are a number of guidance documents, modeling and mapping, vulnerability assessments, and funding opportunities that are emerging in tandem with regional climate change collaboratives that support research, monitoring, and implementation at multiple scales including local, regional, and state wide efforts. Some actions with wide-ranging policy impacts that have been taken by the State are highlighted below.

Sea-level Rise Studies Funded by the California Energy Commission's Public Interest Energy (PIER) Program - PIER was not reauthorized in 2011, but during its existence, it helped to fund a number of critical studies relating to sea-level rise in California. In addition to the August 2009 report on anticipated sea-level rise scenarios for California discussed above, there was also a companion report entitled The Impacts of Sea Level Rise on the California Coast which identified vulnerabilities and cost impacts of anticipated sea-level rise. That report included demographic analysis that indicates large numbers of Californians are at risk from impacts of sea-level rise, including low-income households and communities of color. The report also found nearly $100 billion (in year 2000 dollars) worth of property, measured as the current replacement value of buildings and contents, at risk from a 100-year flood event with a 55 inch sea-level rise if no actions are taken -

with an overwhelming two-thirds of that property concentrated on San Francisco Bay and the majority of the at-risk property is residential. [403]

Follow-up PIER studies produced reports on The Impacts of Sea Level Rise in the San Francisco Bay,[404] Characterizing Uncertain Sea Level Rise Projections to Support Investment Decisions,[405] Impacts of Predicted Sea Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region,[406] City of Santa Barbara Sea Level Rise Vulnerability Study,[407] Coastal Flooding Projections: 2000-2100,[408] and Adapting to Sea-Level Rise: A Guide for California's Coastal Communities.[409]

2012 Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future - National Research Council Report ("NRC report") - California Executive Order S-13-08 directed state agencies to plan for sea-level rise and coastal impacts, and it also requested the National Academy of Sciences to establish a committee to assess sea-level rise to inform these state efforts. The states of Washington and Oregon, the U.S. Army Corps of Engineers, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey joined California in sponsoring a study to evaluate sea-level rise in the global oceans and along the coasts of California, Oregon, and Washington for 2030, 2050, and 2100. The results of the study were released in 2012, and have informed California's Sea-level Rise Guidance Document (described below).

2013 State of California Sea-level Rise Guidance Document - The Coastal and Ocean Working Group for the California Climate Action Team (CO-CAT) has developed guidance for incorporating sea-level rise projections into planning and decision making for projects in California. The guidance document recommends scenario-based planning and decision-making aimed at reducing risk.

Sea-level Rise Resolution - On March 11, 2011, the OPC unanimously adopted a Sea-Level Rise Resolution to support state agency integration of sea-level rise into decision-making. Outreach was conducted to over 45 state agencies, commissions, and other governmental bodies and entities implementing projects or programs using state funding or on state property, including on lands granted by the Legislature. It was urged that consideration of the risks posed by sea- level rise are incorporated into all decisions regarding areas or programs potentially affected by sea-level rise. The work of integrating of sea-level rise considerations has begun at entities like the Sacramento-San Joaquin Delta Conservancy, the Strategic Growth Council, and other entities named in this document; however, additional integration is still needed.

Coastal Commission Sea-Level Rise Policy Guidance - In October 2013, the California Coastal Commission released a Draft Sea-Level Rise Policy Guidance document which provides recommended steps for addressing sea-level rise in Coastal Commission planning and regulatory actions. The guidance document will be finalized in 2014.

Guidance on Incorporating Sea Level Rise in Transportation Project Planning – These types of guidance documents developed by Caltrans are further described in the Transportation section of this document.

First-of-its-kind Statewide Network of Marine Protected Areas - On December 17, 2012, 19 Marine Protected Areas (MPAs) became effective in the Northern California coastal region, completing the nation's first statewide coastal system of marine protected areas. The key agencies leading MPA development and oversight are CDFW, FGC, OPC, State Parks, and Parks and Recreation Commission.

The coastal portion of the statewide network of MPAs now includes 119 MPAs of varying designations, five recreational management areas and 15 special closures, that combined cover approximately 16 percent of all open coast state waters. Approximately half of California's new or modified MPAs are multiple use areas, with the remaining in no-take areas. The MPAs were developed to be consistent with California's landmark Marine Life Protection Act (MLPA), the first statutory mandate of its kind in the nation. The MLPA required that California's MPAs be redesigned based on the best available science, with identified goals and objectives, and with the advice and input of stakeholders and experts to create a statewide network.

The north coast MPA regulations include a provision for federally recognized tribal members to continue harvesting and gathering fish, kelp and shellfish as they have been doing since time immemorial. The provision will allow non-commercial take to continue where there is a record of ancestral take by a specific tribe, consistent with existing regulations, in MPAs other than State Marine Reserves.

Because climate impacts such as ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on marine and coastal habitats such as pollution and overfishing - MPAs are increasingly recognized as a key tool for aiding marine and coastal habitats. MPAs are also important areas for continued scientific research on climate impacts on marine and coastal ecosystems.

OceanSpaces is an online community that has been developed to steward and share MPA monitoring data and results, and better facilitates communication among the diverse audiences interested in the health of California's ocean.[410]

[See Box 50: Aerial photo sequence below by Charles C. Benton of restoration images from 2008 – 2010; used with permission.]

Box 50

South Bay Salt Pond Restoration Project - Under the leadership of Senator Dianne Feinstein, the South Bay Salt Ponds were purchased in 2003 from Cargill Inc. Funds for the purchases were provided by federal and state resource agencies and several private foundations. The 15,100 acre purchase represents the largest single acquisition in a larger campaign to restore 40,000 acres of lost tidal wetlands to San Francisco Bay. CDFW, California State Coastal Conservancy, and the U.S. Fish and Wildlife Service conducted a four-year public process to design a restoration plan for the property. The final plan was adopted in 2008 and the first phase of restoration started later that year. This large restoration effort is designed to establish a thriving wetland ecosystem, provide a critical natural buffer against the effects of climate change and sea-level rise, and provide carbon storage benefits.

Aerial photo sequence by Charles C Benton of restoration images from South Bay Salt Pond A21 Plateau. Used with permission.

April 2008 Sept 2009 May 2010 Oct 2010

Installation of Equipment to Aid Flood Monitoring and Forecasting DWR's Enhanced Flood Response and Emergency Preparedness program and NOAA's Hydrometeorology Test bed program and have collaborated in a $25 million project to improve monitoring and forecasting of "atmospheric rivers" (or the powerful winter systems, sometimes called "pineapple express" storms) that are responsible for most of California's major floods. Construction of four coastal observatories in 2013 – in Eureka, Bodega Bay, Big Sur, and Santa Barbara – will improve flood watch and flood warning information that can be provided to local emergency responders. The Western States Water Council has called for West-wide of expansion of this 21st century observing system for extreme precipitation, recognizing the value of what has been installed in California and the potential for additional West Coast offshore observations to further improve forecasting capability.

California Coastal Commission - Local Coastal Programs (LCPs) are basic planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs are submitted to the Coastal Commission for review for consistency with California Coastal Act requirements. The Coastal Commission is working with local governments to address climate change through LCPs and planning to reduce risks from climate change. Recent certified LCPs that have incorporated policies to minimize risks from sea-level rise impacts include Dana Point, Marina Del Rey, and Redondo Beach. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. In addition, the Ocean Protection Council has approved $2.5 million in grant funds for local governments to update LCPs to address sea-level rise and as of June 2013, the Conservancy, OPC, and Coastal Commission are in the process of administering the new grant program. In addition, Governor Brown and California Legislature approved an augmentation of $4 million to the fiscal year 13-14 budget of California Coastal Commission ($3 million for state operations and $1 million grant to local governments) for local governments and the Coastal Commission to prepare, update, amend and review Local Coastal Programs including an emphasis on climate change issues. The Coastal Commission is working with the Administration to provide information to support long-term funding to address the critical need to update LCPs and include climate change adaptation. Continued funding for this work is necessary to be successful.

Bay Conservation & Development Commission-Sea Level Rise Vulnerability Assessments
The San Francisco Bay Conservation and Development Commission was one of the first coastal management agencies in the country to work collaboratively with the U.S. Geological Survey and the PIER program to prepare regional vulnerability assessment to rising sea levels that included evaluating public policy implications and identification and adoption of enforceable policies regarding resilience to sea level rise as part of its permitting process.

California Current Acidification Network (C-CAN) is a collaboration of interdisciplinary scientists, resource managers, industry and others from local, state, federal, and tribal levels dedicated to advancing understanding of ocean acidification and its effects on biological resources of the U.S. west coast.

The West Coast Ocean Acidification and Hypoxia Science Panel - California and Oregon have signed a Memorandum of Understanding to jointly sponsor a high-level science panel to help address the issue of ocean acidification and hypoxia. The panel will provide state-level decision makers with the knowledge needed to evaluate and develop action plans for these complex issues. The science panel will also identify the research and monitoring needed to contribute to a West Coast-wide assessment of ocean acidification and hypoxia, and address information and data gaps critical to resource management decisions.

Monterey Bay Shoreline Management Planning
The Monterey Bay National Marine Sanctuary (MBNMS) is a federally-protected marine area offshore of California's central coast and encompasses 276 miles of shoreline. The Sanctuary must authorize and can place conditions on any Coastal Commission permit for sea wall or

"armoring" projects below mean high tide. MBNMS convened a workgroup in 2003 with representatives from the Coastal Commission, U.S. Geological Survey, Caltrans, California Department of Boating and Waterways, U.S. Army Corps of Engineers, and scientists from local institutions to develop an action plan for a proactive, holistic, regional approach to coastal armoring. The plan includes a pilot program to investigate and assess environmentally sound alternatives to coastal armoring.[411]

Box 51

INNOVATIONS IN SHORELINE MANAGEMENT IN CALIFORNIA

Managed retreat at Surfer's Point
The Surfers' Point Shoreline Managed Retreat project is an effort in the City of Ventura to remove infrastructure near the coast and restore the natural beach. The project will provide more beachfront area for recreational use and function as a natural storm buffer. The California State Coastal Conservancy helped plan and fund the construction of this project. Other important project partners that worked with the City were Surfrider Foundation, State Parks, Ventura County Fairgrounds, and the Coastal Commission. Federal transportation funding helped construct the project. The project is a comprehensive response to severe shoreline erosion in the face of sea-level rise. The project is in the City of Ventura and involved relocating a bike trail, parking long and other access amenities away from the shoreline and restoring the beach and sand dunes.

Pacifica State Beach Managed Retreat, Beach and Estuary Restoration
Coastal erosion at Linda Mar State Beach threatened critical infrastructure and oceanfront property; while at the same time flood hazards from nearby San Pedro Creek caused periodic flood damage to the City of Pacifica. A managed retreat strategy was developed and implemented through a partnership of agencies, including the California State Coastal Conservancy, City of Pacifica, community groups, scientists and engineers. The project aimed for a combination of managed retreat and estuary restoration goals to reduce the coastal flood hazards. It is one of the first beaches to utilize managed retreat as a method of shoreline protection. In addition to sand replenishment (also called "beach nourishment"), it has restored habitat for four threatened and endangered species and enhanced public access with expanded trails and parking lots.

San Francisco Bay Living Shoreline-Nearshore Linkages Project
Living shoreline projects utilize a variety of structural and organic materials to stabilize to reinforce the shoreline, minimize coastal erosion, and maintain coastal processes while protecting, restoring, enhancing, and creating natural habitat for fish and aquatic plants and wildlife.[412] An innovative pilot project was constructed in the San Francisco Bay in 2012 to test the implementation of living shorelines as an adaptive method to provide habitat functions and values, as well as cope with sea-level rise and other environmental changes related to climate change. The project includes a comparison of multiple techniques to restore critical eelgrass and native oyster habitat at two sites. The California State Coastal Conservancy is leading this project which was designed and implemented

through a multi-agency partnership.

ACTIONS NEEDED FOR SAFEGUARDING OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

Improve Management Practices for Coastal and Ocean Ecosystems and Resources and Increase Capacity to Withstand and Recover from Climate Impacts

(1) Hazard Avoidance for New Development

In order to minimize the adverse effects of sea-level rise and storms, it is important to carefully consider decisions regarding areas vulnerable to flooding, inundation and erosion. The state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea-level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need (*e.g.* coastal-dependent marine terminals or marinas that must necessarily be sited in areas at risk). If the state is building or planning to build, lease, or permit structures that will require additional new expenditures for sea-level rise protection during the expected life of the new structures, the state should ensure that the project proponent:

a) Minimizes risks through siting, design and engineering;
b) Ensures viable funding sources for building, monitoring and maintaining the new sea-level rise protections;
c) Ensures that any new protections must consider how risk changes over time, ensures that actions to reduce risk in the short-term do not increase risk in the long-term; and ensures that any new protections are capable of being augmented over time;
d) Designs protection in a manner that maximizes conservation of natural resources and public access.

As discussed in the Emergency Management section of this document, it is important to note that actions to reduce risk in the near term (such as developing protections for near-term sea-level rise) may encourage development patterns that actually increase risk in the longer term. Development must be carefully considered in light of local vulnerabilities, principles laid out in this section, and any recommendations resulting from the State Coastal Leadership Group described below.

(2) Encourage Innovative Design of New Structures/Infrastructure in Areas Vulnerable to Sea-level Rise

Where there is a compelling need for structures and infrastructure in areas susceptible to sea- level rise, storm surge and erosion, best available material science and structural design should be utilized to minimize pooling water on roadways, ensure maximum durability and public safety, and otherwise incorporate expected impacts into building plans.[413] The State should propagate relevant design standards for engineering and construction in areas susceptible to sea-level rise, storm surge and erosion and priority should be given to development of green or nature-based infrastructure when appropriate. Efforts in other states affected by hurricanes (Florida, Georgia, Louisiana, etc.) should be studied to illuminate the potential impacts of severe storms in California.

(3) Enhance Integration of Climate Risk Considerations, Including Extreme Weather Events and Sea-Level Rise, into Emergency Management Activities

For a discussion of the integration of climate risks considerations into emergency management activities, please see the Emergency Management section of this document.

(4) State Coastal Leadership Group

Although there is a lot of work in California to address sea-level rise, coastal storms and erosion, the urgency of the situation requires more active management and coordination to understand what is working on local, regional and state levels that can be expanded and to leverage resources and better integrate work in an on-going manner. The OPC will lead an inclusive, collaborative, science-based process to inventory existing actions to reduce risks from sea-level rise, storms and erosion and to collaborate with others to improve the capacity of entities at multiple scales to more effectively act to reduce these risks. OPC will work with the California Coastal Zone Management Agencies (Coastal Commission, BCDC and Coastal Conservancy), the state coastal land owners (State Lands Commission, Department of Parks and Recreation) and other state entities and with consultation with local land use planning authorities, tribes, federal partners, and other stakeholders.

This process will involve activities such as:

- Conducting a science needs assessment in partnership with the CA Ocean Science Trust and the OPC's Science Advisory Team to identify key information needs and the opportunities for existing and new science to inform management and reduce risks.
- Engaging state partners to assess progress and future plans and leverage resources.
- Engaging non-state entities working on many scales to learn what is working, what could be expanded and what else needs to be done.
- Collaborating with FEMA, NOAA, USGS and the Army Corps of Engineers and state agencies such as the Coastal Conservancy, Coastal Commission, BCDC and the Department of Water Resources on improving mapping of areas at risk of flooding due to sea-level rise, storms and shoreline change.
- Bring resources and expertise to assist the State Lands Commission, Coastal Commission and others address the issue of changing boundaries between public trust lands and private lands.
- Providing resources on funding sources and mechanisms for supporting actions to understand and reduce risks on many scales.
- Describing a range of tools that can be utilized to reduce risk while maximizing conservation of natural resources and public access, consistent with the public trust doctrine.
- Supporting state agencies to have the capacity to take effective action.

- Improving coordination and sharing of information needed to leverage resources and improve consistency and effectiveness.

The OPC will consider how to support innovative practices including managed retreat and use of natural processes and habitats to reduce risk from flooding, inundation and erosion; and will also address expected impacts to public access and use of beaches, trails and recreational areas along the coast.

(5) Support Pilot Projects for Innovative Shoreline Management Techniques
Particularly during the State Coastal Leadership Group described above, the state should continue to support local and regional governments and other entities implementing innovative shoreline management projects. Pilot project may provide valuable insights into best practices for managing shorelines in the era of rising sea levels and storm surges.

(6) Continue to Study and Support Investment in Cost-Effective Green Infrastructure to Reduce Flood Risk and Stormwater Runoff and to Maximize Associated Co-Benefits
As noted above, there can be significant cost savings and co-benefits associated with the use of green infrastructure, such as wetland restoration and urban forestry, to improve water quality and flood protection. Co-benefits may include greenhouse gas reductions that can reduce the pace and scale of climate impacts, habitat for wildlife, and improved air quality. For example, wetlands have the potential to reduce subsidence in the Delta, thus reducing pressure on levees which in turn reduces risk of levee failure and flooding. *See DWR's Twitchell Island Project in the* Biodiversity and Habitat *section for more information.*

(7) Addressing Climate Impacts in Local Coastal Programs and General Plan Guidelines
Under existing law, Local Coastal Programs (LCPs) and General Plans are key tools for addressing sea-level rise, storms and shoreline change. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. Continued investments to update LCPs is necessary since most LCPs currently do not include plans for reducing risk from sea-level rise. In addition, the Governor's Office of Planning and Research (OPR) will also be providing a 2013 update to its General Plan Guidelines (GPG 2013). The GPG 2013 will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.[414]

(8) Support and Continue Progress Toward a More Integrated Ecosystem Approach to Management of Ocean Resources
Ocean acidification, changing ocean temperatures, rising sea levels, changes in oxygen levels, changes in ocean circulation, more extreme weather events, and cumulative and synergistic impacts, are rapidly changing marine habitats. Species ranges, species interaction, reproductive success, and many other variables are shifting. There is need to move away from a focus of only looking to management approaches that focus on single-species management. A more integrated approach might include the tenets of ecosystem

management, a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural needs of current and future generations. While recognizing the importance of a more integrated approach, it is important to recognize that managers will continue to work within the confines of existing regulatory requirements, laws, and responsibilities as they relate to single species.[415] A more integrated approach will be better suited to highly dynamic changing variables. For instance, the Pacific Fishery Management Council is developing an ecosystem-based approach to managing fish stocks in the offshore waters of Washington, Oregon, and California. Ecosystem-based management as defined by the Council "recognizes the physical, biological, economic, and social interactions among the affected components of the ecosystem and attempts to manage fisheries to achieve a stipulated spectrum of societal goals, some of which may be in competition."[416] The Pacific Fishery Management Council is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976.[417] In addition, the Delta Reform Act of 2009 adopted an ecosystem approach to restoring the Delta, along with the co- equal goal of improving statewide water supply reliability.[418]

(9) <u>Continued Development of State Sediment Master Plan and Sediment Management Activities</u>

The Coastal Sediment Management Working Group (CSMW) is a collaborative taskforce of state, federal, and local/regional entities, chaired by the U.S. Army Corp of Engineers South Pacific Division and the California Natural Resources Agency.[419] The CSMW is developing a comprehensive state Sediment Master Plan ("SMP") for the conservation, restoration, and preservation of valuable sediment resources along the coast of California. Sediment includes materials such as gravel, sand, silt and clay formed by natural erosion such as precipitation, wind, and stream flows. Humans have substantially altered natural sediment transport processes within California's coastal watersheds, reducing storm protection, habitat and recreation along the coast. The goal of the SMP is to reduce shoreline erosion and coastal storm damages, provide for environmental restoration and protection, increase natural sediment supply to the coast, restore and preserve beaches, maintain or improve coastal access, improve water quality along coastal beaches, and optimize the beneficial use of material dredged or excavated from ports, harbors, wetlands, and other sediment sources.[420] For instance, the types of hybrid levees discussed in Box 47: "Wetlands" - Nature's Flood Protection" would utilize dredged sediment from nearby flood control channels for marsh restoration. That dredged sediment is currently disposed of in landfills.[421] Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) Program is implemented by state, federal and local partners, including the Bay Delta Conservation and Development Commission (BCDC). BCDC is working, in part with the CSMW, to prepare sediment management plans that integrate the successful Long Term Management Strategy for dredging with flood control planning, wetlands restoration and other aspects affecting sediment processes throughout the San Francisco Bay system.[422]

(10) <u>Water Management Responsive to Saltwater Intrusion Issues</u>

For information about saltwater intrusion and water management activities, please see the recommendations for continuing to mainstream climate considerations into water management in the Water section of this document.

Better Understanding of Evolving Trends that May Impact Ocean and Coastal Ecosystems and Resources

(1) Better understand the impacts and opportunities associated with offshore renewable energy development

Renewable energy development helps to reduce greenhouse gas emissions from fossil fuel use and can help reduce the pace and scale of climate impacts on ocean and coastal ecosystems and resources. M arine renewable energy has the potential to play a role in meeting California's renewable portfolio standards and energy demand; however, marine renewable energy development can also have some negative impacts on coast and ocean ecosystems and resources including noise and light pollution and impacts on avian and other flying species. In response, the California Marine Renewable Energy Working Group; is an interagency group chaired by the California Ocean Protection Council was formed with the following goals:

- Address uncertainties in regulatory processes for marine renewable energy projects in California;
- Address the information needs of state agencies and stakeholders to inform potential impacts and user conflicts with marine renewable energy projects; and
- Facilitate the development of agreements and joint state-federal committees to improve coordination of state and federal permitting processes.

As noted above, it will be important to understand the benefits and impacts of ocean renewable energy development in the larger context of other expected climate impacts and traditional stressors on ocean and coastal ecosystems and resources.

(2) Support Reform of Federal Flood Insurance Program

As noted above, there were $68 billion of California assets insured under the Federal Flood Insurance program as of August 2012. However, continuing issues with respect to the financial integrity of NFIP may pose serious threats to the economic well-being and health of Californians. The State should support appropriate continuing reform of NFIP and implementation of the 2012 Biggert-Waters Flood Insurance Reform Act[423] while engaging in risk communication efforts and other efforts described in this chapter.

Better Understanding of Climate Impacts on Ocean and Coastal Ecosystems and Resources

(1) Further Vulnerability Assessments and Cost Analyses

Additional vulnerability assessments and cost analyses are needed to fully assess California's risks to climate impacts and appropriate responses to reduce those risks. Every community potentially impacted by sea-level rise will need to prepare vulnerability and cost assessments that include but are not limited to consideration of recreational and environmental losses to the evaluation of cumulative and synergistic impacts, the importance of hazard avoidance, and the importance of adequately accounting for the environmental and recreational costs and benefits of strategies. Appropriate resources are needed for local governments and communities to not only prepare vulnerability assessments and cost analyses but also for the training and tools to apply the results to adaptation planning and implementation. Specifically, local vulnerability assessments are needed at scales that enable and inform planning and project implementation. The State has already invested significant resources to conduct and support vulnerability and cost assessments across sectors and a sampling of additional needs are listed below. An Adaptation Planning Guide for local and regional governments has also been developed.[424]

a) Water Supply, Wastewater and Stormwater: An assessment of the state's wastewater and stormwater facilities is needed to identify vulnerabilities of aging infrastructure and system capacities in light of more extreme weather events and sea-level rise projections in the NRC report and as incorporated into the OPC's guidance to state agencies on planning for sea-level rise. Any such assessment should include cost analysis of system upgrades and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
b) Hazardous Waste Sites and Facilities: An assessment is needed for toxic release vulnerabilities from the state's hazardous waste facilities and hazardous waste sites in light of more extreme weather events and sea-level rise projections in the NRC report. The assessment should include recommendations for addressing vulnerabilities, including cost analysis of recommendations and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
c) Underground Storage Tanks (USTs): An assessment is also needed to address toxic release vulnerabilities from the state's USTs, not just in coastal areas, but also in inland areas susceptible to flooding. This need is further described in the Water section of this document.
d) Energy and Transportation Infrastructure: Additional needs with respect to vulnerability studies for energy and transportation infrastructure are described in the Energy and Transportation sections of this report.
e) Cumulative and Synergistic Impacts: As noted above, ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on ocean and coastal habitats and resources such as pollution and overfishing. Development of ocean renewable energy projects, and other offshore energy development, may also present new stressors on ocean and coastal habitats and resources. The cumulative impact, and any synergistic dynamics among the stressors, is not well understood, and the potential implications for commercial fish and shellfish species and human health are also not fully understood. A more robust scientific understanding of cumulative and synergistic impacts, accompanied by a science-informed trade-off analysis framework, is critical to supporting innovative management

techniques that are responsive to the new, and rapidly changing, marine conditions. Further, there is a need for OPC to continue supporting data layers within the California Geoportal to underpin decisions that will be made by permitting agencies. Funding support to enable studies of such cumulative and synergistic impacts is needed.

f) Economic Costs to Californians. As noted above, there have been some studies to date of the economic impacts of sea-level rise to some California communities, and there has been some study of potential impacts from more extreme weather events. However, more information about the cost of expected climate impacts is needed to inform and evaluate management options. Needed economic cost studies include resource economics studies that study the value of services provided by ocean and coastal investments (e.g. improved water quality, enhanced soil stability, recreation and tourism opportunities, benefits from intact ecosystems, etc.). Funding support to enable such studies is needed.

g) Marine Species and Ecosystems. See Biodiversity and Habitat section of this document for information regarding the need for a comprehensive, state-wide vulnerability assessment for marine species and ecosystems in California.

(2) Continued Modeling Scientific models are tools used to generate predictions and explanations. Models must be built, tested for accuracy, and revised.[425] Models add greatly to our understanding of the possible outcomes from and consequences of changes to a system.

Along the coast, the main drivers of change will be changing water conditions (water level, waves, storms, extreme events, acidification, or temperature), and changes to the shoreline (sediment supplies, addition or removal of structures, development patterns). Models may be used to predict changes in the California shoreline, expected storm surges, pollution inputs, estuarine and near shore impacts, and sediment movement in coastal areas in the era of climate change. Modeling is important to examining the full extent of consequences associated with various sea-level rise projections along with storm wave conditions and the dynamics at coastal inlets. Continued development and refinement of models for climate impacts on California's ocean and coastal ecosystems and resources will be important. Funding to support such work will be needed.

(3) Continued Support and Investment in Monitoring Efforts
Monitoring changes to biological, chemical and physical processes is critical to continue advancing knowledge of climate impacts on coastal and marine ecosystems and resources and to support informed management responses that incorporate the best-available science on changing ocean and coastal conditions. Partnerships to enable funding and staffing of these efforts will be important. The Ocean Protection Council (OPC), in partnership with the Ocean Science Trust and the OPC's Science Advisory Team, will lead a process to identify priority monitoring needs to improve management of ocean and coastal resources under a changing climate. This process will address topics such as:

a) Ongoing monitoring and assessment of coastal inundation damages, for purposes of statewide flood planning;

b) Monitoring of offshore meteorological parameters and wave heights to obtain data for storm surge modeling and meteorological forecasting; and

c) Estuarine monitoring for changes to wetlands, sediment, changes in salinity, etc.

Information Sharing and Education

(1) Invest in Risk Communication Efforts, Emphasizing Disclosure of Risks that Have Not or Cannot Be Addressed in an Economically Feasible Manner[426]

The State should invest in efforts to raise public awareness and understanding of sea-level rise and accompanying risks of flooding, erosion, infrastructure and property damage, and permanent submersion of coastal lands, salt water intrusion, toxic releases and other public health impacts. The state should also invest in efforts to raise awareness of the limitations of flood insurance and disaster relief, and the costs associated with response and recovery efforts associated with various anticipated sea-level rise impacts. Finally, the state should invest in efforts to raise awareness regarding options to protect new and existing structures and infrastructure from sea-level rise; awareness raising efforts should include discussion of any relevant benefits from employing green infrastructure, cost estimates, awareness and support for protecting vulnerable communities, and funding sources for protective measures. For example, California State Parks are one important venue to communicate risk and disseminate information. There are 114 coastal units in the State Park System – encompassing some 340 miles of the coast, and including coastal portions of State Parks, State Recreation Areas, Natural Reserves, and State Beaches. In 2011, 34 million visitors attended coastal parks. Each of those visitors presents an opportunity to communicate about climate change.

(2) Improve Maps and Tools and Provide Training to Incorporate Best-Available Climate Science into Planning and Operation and Management Decisions for Assets at Risk from Sea-level Rise

As sea-level rise projections and storm surge projections continue to be refined, maps and tools reflecting those projections must be developed and updated to support flood management planning, hazard planning, capital investment and development decisions. Training in the use of these maps and tools must also be provided so that best available knowledge about expected impacts can be fully integrated into routine governmental decision making, for instance for land use planning, transportation planning and operation and management, and the siting and operation and management of energy infrastructure.[427]

(3) Sustainability Modeling Tools for Fishery Managers

Utilizing data collected from monitoring efforts, and best available understanding of cumulative and synergistic impacts from climate and other stressors, sustainability modeling tools should be developed to assist fishery managers. These tools should be consistent, to the extent it serves the State, with relevant ecosystem-based management approaches propagated by the Pacific Fisheries Management Council as described above. California's network of MPA's provide scientist with an unprecedented opportunity to utilize and create tools to assess trends in oceanographic conditions that fishery scientists and managers may then use to determine the effects of these changing conditions on fisheries.

(4) Public Health Risk Communication Efforts

As noted above, climate impacts to ocean and coastal ecosystems and resources have numerous public health implications. Flooding, permanent inundation, and more extreme weather events may cause: toxic exposures from USTs and hazardous waste sites and facilities, increased pollution from stormwater and wastewater systems, contamination of fish and shellfish, and serious property damage including damage to transportation and energy systems and critical infrastructure including hospital facilities. In-situ instrumentation will help provide better data to inform needed beach closures to limit health risk exposures and consumption advisories. CDPH and SWRCB already have programs in place that could be used for these continuing public health risk communication efforts.

Box 52

California Ocean and Coastal Ecosystems and Resources

Given the myriad facets of California's ocean and coastal assets, many different state entities play an important role with respect to California's ocean and coastal ecosystems and resources. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate impacts.

California Coastal Commission (Coastal Commission) was established by voter initiative in 1972 (Proposition 20) and later made permanent by the Legislature through adoption of the California Coastal Act of 1976. The California Coastal Commission works in partnership with coastal cities and counties and is committed to protecting and enhancing California's coast and ocean for present and future generations. It does so through careful planning and regulation of environmentally-sustainable development, rigorous use of science, strong public participation, education, and effective intergovernmental coordination. The Coastal Commission works in partnership with local governments to develop local land use plans and implementing ordinances, or Local Coastal Programs. The plans are developed by local governments and certified by the Commission, and are a key mechanism for addressing sea-level rise and other climate change impacts at the local level throughout the state.

California Department of Fish and Wildlife (CDFW) established in 1927, is the state agency designated to protect, maintain, enhance, and restore California's marine and terrestrial ecosystems and species for their intrinsic and ecological values. CDFW is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses. CDFW also prevents, prepares for, and responds to spills of oil and other deleterious materials, primarily in the marine and coastal environment.

California Department of Parks and Recreation (California State Parks or CSP) is a trustee agency responsible for managing 114 coastal parks that cover over 340 miles of the California coast. Those parks include state beaches with amenities such as campsites and picnic areas, as well as coastal rivers, estuaries, and dune systems, many protected as natural preserves and state wilderness areas. State Parks also provide access to state marine parks and other marine protected areas. In 2011, 34 million people visited state beaches and other coastal parks. CSP's Division of Boating and Waterways (DBW), is responsible for planning, developing, and improving facilities on state-owned and state-managed properties, and funds applied research on coastal waves, beaches, sea level, and climate change. CSP's mission is to provide for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity and its most valued natural and cultural resources while also providing opportunities for high-quality outdoor recreation.

California Department of Public Health (CDPH) was established on July 1, 2007, through enactment of SB 162, which vested responsibility for public health programs in CDPH. CDPH assists local health agencies in addressing microbiological contamination of beaches and recreational waters.

California Department of Toxic Substances Control (DTSC) which began as a unit within the Department of Health Services in the early 1970s, protects California's people and environment from harmful effects of toxic substances through the restoration of contaminated resources, enforcement, regulation and pollution prevention.[428]

California Department of Transportation (Caltrans) with origins dating back to 1895, is the state agency responsible for transportation planning, construction, and maintenance of the State Highway system. Caltrans oversees significant transportation infrastructure located in coastal areas, including highways and bridges.

California Department of Water Resources (DWR) established in 1956, is responsible for managing and protecting California's water resources and supplies. DWR includes a Division of Flood Management, established in November 1977, and has been instrumental in working on Enhanced Flood Response and Emergency Preparedness.

California Energy Commission (CEC) established in 1974, is the state's primary energy policy and planning agency. As further discussed in the Transportation and Energy sections of this document, the CEC aids in planning and managing energy resources that may be vulnerable to climate impacts including sea-level rise.

California Fish and Game Commission (FGC) established in 1870, is a Commission comprised of five members, appointed by the Governor and confirmed by the Senate. The Commission formulates general policies for the conduct of CDFW, but also has general regulatory powers, including deciding seasons, limits and methods of take for sport fish. The Commission also has responsibilities for invasive species; establishing/regulating use of Marine Protected Areas (MPAs); listing/delisting threatened and endangered species under the California Endangered Species Act; prescribing terms and conditions for issuance of licenses/permits by CDFW; and revoking or suspending privileges of those that violate

California Fish and Game laws and regulations.

California Ocean Protection Council (OPC) was established in 2004 pursuant to the California Ocean Protection Act. OPC is tasked with the following responsibilities: coordinating activities of ocean-related state agencies to improve the effectiveness of state efforts to protect ocean resources within existing fiscal limitations; establishing policies to coordinate the collection and sharing of scientific data related to coast and ocean resources between agencies; identifying and recommending to the Legislature changes in law; and identifying and recommending changes in federal law and policy to the Governor and Legislature.

California Ocean Science Trust (OST) is a nonprofit 501(c)(3) public benefit corporation established pursuant to the California Ocean Resources Stewardship Act of 2000 (California Public Resources Code Sections 36970-36973. OST's mission is to advance a constructive role for science in decision-making by promoting collaboration and mutual understanding among scientists, citizens, managers, and policymakers working toward sustained, healthy, and productive coastal and ocean ecosystems.

California State Lands Commission (SLC) The California State Lands Commission was created in 1938 and serves the people of California by managing and protecting over 4 million acres of sovereign land, including the beds of California's navigable rivers, lakes and streams, and the State's tide and submerged lands. The Commission's jurisdiction extends along the State's over 1,100 miles of coastline and offshore islands from the ordinary high water mark, as measured by the mean high tide line, except where there is fill or artificial accretion, to three nautical miles offshore. The Commission also has oversight authority over legislatively granted public trust lands, which includes the lands and waterways underlying California's major ports. All lands under the Commission's jurisdiction, granted or ungranted, are state assets held in trust for the benefit of the people of California and subject to the protections of the common law Public Trust Doctrine. The Commission also manages energy and mineral resource development and use under approximately 130 oil, gas, geothermal and mineral leases covering more than 95,000 acres of State-owned lands. The Commission is responsible for preventing oil spills by providing the best achievable protection of the marine environment at the State's 58 marine oil terminals through ensuring compliance with the State's Marine Oil Terminal Engineering and Maintenance Standards. Further, the Commission administers the State's Marine Invasive Species Program[429] and in that capacity is responsible for preventing or minimizing the release of invasive species in California waters from vessels that are 300 gross registered tons and above.

California Technology Agency (formerly the Office of the State Chief Information Officer) was established in 2007 and is a cabinet-level agency responsible for the approval and oversight of all state information technology projects, including Geospatial Information Systems (GIS) and the State of California Geo-Portal.[430] The California Geo-Portal includes maps of Marine Protected Areas, nautical charts, OPC's coastal viewer, and links to MarineBios an interactive map for users to visually explore marine and coastal spatial planning data held in the California Department of Fish and Wildlife, Marine Region, Geographic Information System.

Delta Protection Commission (DPC) The mission of the Delta Protection Commission is to adaptively protect, maintain, and where possible, enhance and restore the overall quality of the Delta environment consistent with the Delta Protection Act, and the Land Use and Resource Management Plan for the Primary Zone. This includes, but is not limited to, agriculture, wildlife habitat, and recreational activities. The goal of the Commission is to ensure orderly, balanced conservation and development of Delta land resources and improved flood protection.

Delta Stewardship Council (DSC) was created in legislation to achieve the state mandated coequal goals for the Delta. "'Coequal goals' means the two goals of providing more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." Since the waterways in the Delta are at sea level and are tidally influenced, and since may Delta islands are at or below sea level, the coastal effects of climate change will also affect resources within the Delta.

San Francisco Bay Conservation and Development Commission (BDC) is a state agency that was created by the California Legislature in 1965 with the charge of minimizing future unnecessary filling of the Bay and promoting its wise use and improving public access along its shoreline. BCDC has developed an extensive climate change adaptation program. Recent projects include new policies to address sea-level rise; a collaborative scientific study to characterize ecosystem services provided by wetlands and develop strategies to improve wetland resilience; and a collaborative project with NOAA to work with several local governments and special districts to identify the potential Bay-related impacts of sea-level rise and storms adaptation approaches that address identified vulnerabilities. BCDC is also working with the Association of Bay Area Governments collaborative planning and implementation process to develop a comprehensive regional resilient shorelines strategy that addresses rising sea level and storms as well as earthquakes.

State of California Coastal Conservancy (SCC) SCC, established in 1976, is a state agency that purchases, protects, restores, and enhances coastal resources, and works to provide access to the shore. SCC works in partnership with local governments, other public agencies, nonprofit organizations, and private landowners to develop plans and implement projects that protect and enhance coastal and marine habitats. In 2012, the Legislature specifically authorized the SCC to address the impacts of climate change including but not limited to extreme weather events, sea-level rise, storm surge, beach and bluff erosion, salt water intrusion, and other coastal hazards that threaten coastal communities, infrastructure, and natural resources.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards. The Ocean Unit of the SWRCB is responsible for the development of the California Ocean Plan and other significant regulatory documents for bays and estuaries. The Water Boards administer programs related to ensuring that beaches are safe to swim by regulating the discharge of waste and supporting the monitoring of coastal watershed and beach health. As further described in the Transportation section of this document, SWRCB's Underground Storage Tank (UST) Program protects public health and safety and the environment from releases of petroleum and other hazardous substances from tanks.

Governor's Office of Emergency Services (OES) OES is responsible for the coordination of overall state agency response to major disasters in support of local government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. OES includes the Public Safety Communications Office.

Coastal assets and infrastructure are under the purview of various federal, state, regional and local agencies, and there are significant coastal assets under private ownership and management. As discussed in this chapter, management and planning for climate impacts on such assets and infrastructure requires a high degree of coordination.

The National Oceanic and Atmospheric Administration (NOAA) is a federal agency with origins dating back to 1807. NOAA's mission focuses on scientific work to understand and predict changes in climate, weather, oceans, and coasts; dissemination of scientific information; and conservation and management of coastal and marine ecosystems and resources. The NOAA Coastal Services Center is dedicated to working with state and local coastal programs to determine data needs and deliver not only the data, but also the tools and training needed to turn these data into useful information.[431]

The Federal Emergency Management Agency (FEMA) also plays an important role in flood disaster planning and preparation and response and recovery. Both NOAA and FEMA are important partners for the State of California with respect to ocean and coastal ecosystem and resource management.[432]

As discussed in this chapter, local and regional governments play an important role with respect to California's ocean and coastal ecosystems and resources.[433]

PUBLIC HEALTH

INTRODUCTION

Climate change creates significant and evolving challenges to the health and well-being of California's diverse population of nearly 38 million people, leaving some Californians particularly vulnerable.[434] Even in our large urban areas, our health is closely linked to a healthy and stable natural environment - clean air and water, green spaces, healthy fresh food, and a balance in the use of natural resources.

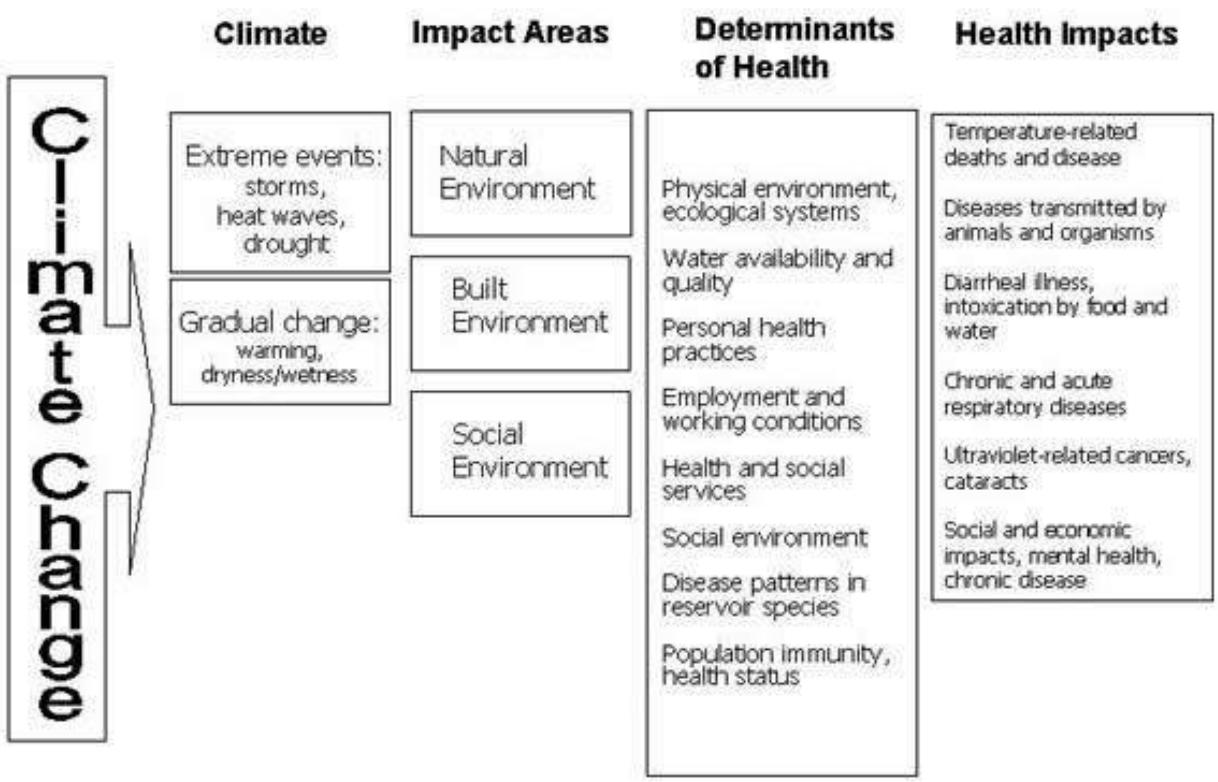
Climate change poses a variety of public health risks, including risks related to heat, outdoor and indoor air quality, water quality and availability, toxics, extreme weather events, flooding, workplace safety, mobility, infectious diseases, limitations on health services, and food safety and food security. Some of these risks are interrelated and interact with the underlying health status of different segments of our population. It is therefore important that climate adaptation planning efforts be integrated with ongoing health protection and health promotion efforts. California has begun to take significant steps toward addressing one of the leading effects of climate change, increasing temperatures and extreme heat, but much more remains to be done to protect and prepare our population. There are still actions needed to enhance our understanding of climate impacts on public health; to improve the capacity of communities to prepare, respond and recover from climate-related health risks; to better understand evolving trends – such as the increased use of energy efficient buildings or urban greening - that may impact public health in the era of climate change, and to continue information sharing and educational outreach on climate risks to public health.

Many different state entities play an important role with respect to public health in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. Short descriptions of these entities are provided below in Box 53: California Public Health.

Climate Change Risks to Public Health

As shown below in Box 53 there are a number of determinants of health that include the natural and built environment, health and social services, and socioeconomic conditions. Climate change will result in new, progressively changing, average conditions as well as more extreme weather events, and these changes create significant new public health risks including risks associated with heat-related illness and mortality, respiratory impacts, infectious diseases, and changes in socioeconomic conditions that may impact well-being. These pathways are shown below.

Box 53



from Public Health Agency of Canada - Sustainable Health Development Strategy 2007-2010: Dynamics of Climate Change and Public Health
http://www.phac-aspc.gc.ca/publicat/sds-sdd/sds-sdd2-b-eng.php

Box 54

Health Equity & Climate Change

Section 152 of the California Health and Safety Code charges CDPH's Office of Health Equity with strategic planning and implementation of activities to address health equity.[435] Health equity is based on the principle that all people have the same opportunities for health. Some people have experienced socioeconomic disadvantage or historical injustice or may be culturally, linguistically or geographically isolated which can lead to a lower quality of life and increased risk of disease, injury and death. Public health programs such as the Health in All Policies Task Force[436] as well as private initiatives are working to address health inequities and create more opportunities to enhance productivity and health for all of the state's residents.

Climate change poses immense challenges for achieving health equity because, while all people are impacted by climate, populations that are socially and economically vulnerable will bear a disproportionate burden. These communities already experience higher rates of chronic disease and lower life expectancy, and have fewer resources to plan and prepare for the additional impacts of climate change, presenting them with additional challenges for readiness, response and recovery. Health equity and environmental justice are therefore important goals in the state's climate adaptation and resilience planning efforts.

Increasing Temperatures and Extreme Heat

Increased heat in many parts of California will bring a greater risk from both higher ambient temperatures and extreme heat events. Higher ambient temperatures in California are already associated with increased mortality due to cardiovascular disease.[437] Extreme heat brings greater risk of death from dehydration, heat stroke, heart attack, and other heat related illnesses. In an extended California heat wave in 2006, over 650 deaths occurred.[438] By mid-century, extreme heat events in urban centers such as Sacramento, Los Angeles, and San Bernardino could cause two to three times more heat-related deaths than occurred in 2006.[439] Urban areas are more likely to experience "heat island" effects. Heat islands occur in urban areas where materials such as grass, trees, and soil are replaced by materials such as roads, buildings and other surfaces that increase absorption of sunlight and decrease the dissipation of heat.[440] Populations in cooler areas in California may also be at greater risk because individuals are less acclimatized to heat, people are less aware of behaviors that can reduce exposure (e.g. reduce activity level or go to an air conditioned location) or reduce physiologic stress (e.g. appropriate hydration), the built environment is not designed for warmer conditions (e.g. buildings lack adequate air conditioning), and such communities may not have plans for emergency heat mitigation measures.[441] In addition, the elderly and persons with chronic health conditions or who are on certain medications are at additional risk for heat illness.[442]

Box 55

Pictured: Community Cooling Center
http://www.epa.gov/climatechange/images/impacts-adaptation/WisconsinCoolingCenter.jpg

Air Quality Impacts

Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation. For example, temperature increases in the mid-range of what climate modeling suggests might be possible – would produce 75 to 85 percent more days with weather conducive to ozone formation in Los Angeles and the San Joaquin Valley. Air quality can be further compromised by increases in wildfires, which emit particulate matter, as well as any increased air pollution that results from any increased energy demands due to the changing climate.[443]

Changes in temperature, precipitation and extreme weather events, may also change the production, distribution, and dispersion of air-borne allergens ("aeroallergens") such as pollen, mold, and indoor allergens. While there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, models indicate that pollen will likely increase in many parts of the United States, there may be shifts in the seasonal timing of allergen production, while some allergen producing species may become extinct – new allergens may be introduced, and there may be increases in allergen content and potency. Allergies are the sixth most costly chronic disease category in the United States, collectively costing the health care system approximately $21 billion annually.[444] Pollutants and allergens can cause or aggravate a wide range of health problems including asthma and other debilitating and costly respiratory and cardiovascular diseases, which fall disproportionately on low income and persons of color.

Recent studies indicate that climate change may also negatively impact indoor air quality.[445] Outdoor air quality may worsen and intrude into buildings. Emissions from indoor sources, such as paints, pesticides, or building materials containing formaldehyde, may also be exacerbated by changing climate conditions such as increased heat. There may be more exposure to damp indoor spaces and exposure to mold, bacteria, and other biological contaminants as a result of increased extreme precipitation and flood events. Changing human behavior in response to climate change, such as increased air conditioning use, can also lead to poor indoor air quality, especially if heating and cooling systems are not properly maintained or if ventilation is poor.

Wildfire

As further described in the Forestry section of this document, more frequent and severe wildfires are projected to occur. This will not only impact air quality and create adverse effects on respiratory and cardiovascular health, as noted above, but may also cause property loss, displacement, injury and loss of life. Wildfire smoke affects not only the region in which a fire occurs but also creates hazards in adjacent areas through the transport of smoke.

Flooding

As further described in the Water and Oceans and Coastal Ecosystems and Resources sections of this document, both inland and coastal flooding are expected to increase as a result of climate change. This can lead to loss of life, injury, an increased mental health burden, loss of property and employment, displacement, economic disruptions, interruption of health services and mobility, and toxic or infectious exposures.

Changing Water Availability and Water Quality

As further discussed in the Water section of this document, the quality and quantity of water supplies available for drinking water, agriculture and other uses are threatened by various climate impacts including declining Sierra Nevada snowpack, salt water intrusion, changing precipitation patterns and flood risks.

Significant capital improvements are needed to continue to provide safe drinking water to the public. According to a national assessment of public water system infrastructure by U.S. EPA, California will require over $10 billion in capital improvements over the next twenty years for water systems to continue to provide safe drinking water to the public (including treatment and other infrastructure needs).[446] In the absence of climate change, California would still have significant need for infrastructure investments to continue to provide safe drinking water[447]; however, climate change is likely to make that need more acute. For instance, lower summer and fall flows may result in greater concentration of contaminants. These changes will challenge water treatment plant operations to produce safe drinking water.[448] In addition, any climate-related disruptions to electricity can also threaten the operation of electricity-dependent treatment plants and pumps.[449] U.S. EPA's national assessment is beginning to capture voluntary information regarding efforts to proactively address the potential effects of climate change at the water utility level, and has found relatively few projects are being undertaken to anticipate and prepare for climate risks.[450] U.S. EPA repeats the assessment every four years, continues to refine its methodologies, and will be undertaking a new assessment in 2014.

Also as discussed in the Water section of this document, climate impacts may lead to intensified groundwater usage – particularly in the absence of improvements to water management systems; intensified groundwater usage may, in turn, result in land subsidence (land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to movement of materials below the Earth's surface, such as the withdrawal of underground water[451]). The effects of subsidence may include strain on houses and other structures, increased exposure to flooding in lowland coastal areas, water well casing failures, and changes to the elevation and gradient of stream channels, drains, and other water transport structures.[452] Subsidence can also permanently reduce the capacity of aquifers to store water.[453]

As further discussed in the Water section of this document, flood waters can be expected to contain excessive turbidities, especially in watersheds that have experienced fires, and that will challenge many of the existing surface water treatment facilities. Improvements to chemical feed and solids handling facilities may be required to ensure that proper treatment is provided to meet drinking water standards during flood flow conditions. These flows will likely occur throughout the winter and spring precipitation periods.

Food Security - Impacts to Nutrition and Food Safety

As further discussed in the Agriculture section of this document, climate change may impact food production and that may impact food prices and nutrition. Food cost increases disproportionately affect low income households and may impact nutrition as consumers chose low-nutrition, low cost food options in place of more expensive fresh fruits and vegetables.

Ironically, food insecurity is linked to obesity, which increases vulnerability to heat events. Potential impacts to food safety from climate change are discussed in relationship to infectious diseases below.

Infectious Diseases

Infectious disease (or *communicable disease*) is defined as an illness caused by a specific *infectious agent* or its toxic product that results from transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or inanimate environment.[454] Climate change impacts public health and infectious disease morbidity and mortality, primarily in illnesses caused by vector-, water-, and food-borne diseases.[455]

Vector-borne Infectious Diseases

Some infectious diseases are transmitted to humans by insects or other animals (transmitting insects or animals are called "vectors"); and these types of diseases are called "vector-borne" diseases.[456] Vector-borne diseases are among the most complex of all infectious diseases to prevent and control.[457] This complexity is attributable to the many factors that can contribute to the transmission, rate of transmission and evolution

of such vector-borne diseases, including, but not limited to, the vector populations, the disease pathogens carried by the vectors, ecological and climate patterns, and human interaction with the vector population.[458]
As noted in the 2009 California Climate Adaptation Strategy, three vector-borne diseases are of particularly concern in California: human hantavirus cardiopulmonary syndrome, Lyme disease, and West Nile Virus.

Changes in temperature and precipitation associated with climate change may lead to changes in the spread of vector-borne diseases. Climate change may alter the number of disease-carrying vectors. For instance, in places where there is increased rainfall, there may be more standing water where mosquitoes can lay eggs.[459] Similarly in places where winters are becoming milder, tick season may be extended.[460] Climate change may also change the way a pathogen spreads. For instance, West Nile Virus may be both positively and negatively impacted by increased temperatures; warmer temperatures allow the West Nile Virus to move faster through the transmission cycle[461], but may shorten mosquito life-spans.[462] In addition to increased disease risk, there is a risk of introduced vectors becoming established, along with the diseases they carry such as dengue. For instance, invasive *Aedes* species mosquitoes have been detected and may become established in some regions of California.[463]

Hantaviruses are principally rodent-borne diseases. Climate change may impact rodent populations through influencing food availability. Increased intensity and frequency of extreme climatic events may interact with other factors contributing to the spread of hantavirus (like changes in human behavior leading to higher risk of exposure).[464]

Water-borne Infectious Diseases
In the United States and other developed countries, we enjoy a quality of life in which waterborne infectious diseases are no longer a constant threat as a result of high-quality water treatment and other measures, however waterborne diseases have not been completely eradicated.[465] In the United States from 1948 to 1994, heavy rainfall correlated with more than half of the outbreaks of waterborne diseases.[466] Changes in the severity or frequency of precipitation events may lead to an increase in waterborne diseases.[467] Climate driven increases in ocean surface temperatures may also be associated with an increase in harmful algal blooms (HAB) and proliferation of the *Vibrio* bacteria that can contaminate shellfish.[468] In addition to water-borne gastrointestinal infections, waterborne respiratory infections may also be affected by climate change. For instance, proliferation of *Legionella* bacteria, which is dispersed by cooling systems and potable water outlets (such as shower heads), may be linked to an increase in wet-humid and warm weather.[469]

Food-borne Infectious Diseases
Everyone, from the farmer to the consumer, has a role in keeping food safe. The U.S. food safety system is complex, being composed of many federal, state and local stakeholders, including agriculture, health and environmental agencies. It is not

uncommon for several agencies to play roles in assuring the safety of a single food commodity from farm to fork. Regulations governing the safety of animal and plant products at the production level are enforced by the U.S. Food and Drug Administration (FDA), CDPH's Food and Drug Branch, and CDFA's Milk and Dairy Food Safety Branch, Regulations governing food processing are enforced by the FDA, the USDA Food Safety Inspection Service, CDPH's Food and Drug Branch and CDFA programs including the CDFA Meat, Poultry Inspection Branch and CDFA Milk and Dairy Food Safety Branch. CDFA also works with egg producers, processors, academia and other agencies to proactively assure the safety of eggs, poultry and dairy products through voluntary quality assurance programs. FDA and CDFA also enforce regulations governing the use of animal health products in food animals and the safety of animal feed. And USDA Center for Veterinary Biologic has regulatory authority over veterinary biologics production, distribution and use in animals. The use of pesticides is regulated by U.S. EPA and the California Department of Pesticide Regulation.[470]

Because of the numerous factors governing food safety, a causal link between climate change and increased risk of food-borne diseases has not yet been well-established. However, Salmonella and Camplyobacter display a distinct seasonal pattern that has been associated with climate variability (increased temperatures, heat waves, and flooding) and may thus be exacerbated by climate change.[471]

<u>Climate Impacts on Health Services</u>

As noted in the Oceans and Coastal Ecosystems and Resources section of this document, hospitals and critical energy and transportation infrastructure are threatened by sea level rise and coastal erosion. Extreme events, such as wildfire and storms, may also threaten critical infrastructure important to the delivery of health and other vital services. State efforts to promote and coordinate hospital and healthcare preparedness and resilience are coordinated through the **Hospital Preparedness Program**, funded by CDC and administered by CDPH's Emergency Preparedness Office in collaboration with the California Hospital Association, California Primary Care Association, local public health departments and other partners. In recognition of these growing risks, the President's June 2013 Climate Action Plan, notes that the U.S. Department of Health and Human Services will "launch an effort to create sustainable and resilient hospitals in the face of climate change. Through a public-private partnership with the healthcare industry, it will identify best practices and provide guidance on affordable measures to ensure that our medical system is resilient to climate impacts. It will also collaborate with partner agencies to share best practices among federal health facilities."[472] California's emergency health services are further discussed in the Emergency Management section of this document.

<u>Mental Health and Stress-Related Disorders</u>

Growing evidence of global climate change and increases in extreme weather disasters due to climate change can lead to mental health disorders associated with social disruption, death or injury, economic losses, and geographic displacement, as well as cumulative effects from repeated exposures to extreme events. The effects of climate change impact the social, economic and environmental determinants of mental health, with the most severe consequences being felt by communities who were already disadvantaged prior to the event.[473] Common mental health conditions associated with extreme events may include, among other things, acute traumatic stress, post-traumatic stress disorder, grief, depression, anxiety disorders, somatic complaints, and drug or alcohol abuse. Those individuals already vulnerable to mental health disease and stress-related disorders are likely to be at increased risk. Furthermore, barriers to the utilization and delivery of mental health services may arise following extreme weather events.[474] In addition, children are at disproportionate risk of health impacts of climate change; a more thorough quantification of child-specific risk is needed.[475] These issues need much more attention including involving social scientists and mental health practitioners in understanding climate impacts on the mental health of different groups and their engagement in efforts to prepare for climate risks.

Vulnerable Populations

As discussed in the Emergency Management section of this document, not all communities and not all members of a community are equally vulnerable to climate events. Underlying health status ("sensitivity") and socio-economic conditions may vary and access to information, services and resources affects how impacts are experienced. Initial efforts to map population vulnerabilities in California are further described below and in the Emergency Management section of this document.

Box 56

First Person Narrative on Climate Change and Health
By Elizabeth Baca, MD, MPA (used with permission)

I remember reading about climate change and its potential effects when I was in graduate and medical school. Today those effects are coming to bear, and nowhere is this more evident than in human health.

According to the World Health Organization, health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. We know that social, economic, and environmental factors affect health.[476] There has been a great deal of research on how the social and physical environment "gets under the skin" to make one sick. Everyone is affected by these factors that influence life expectancy and health, but certain populations are more significantly impacted.[477] As a practicing pediatrician in a community health center in the Bay Area where ninety-three percent of our patients live below 200% of the federal poverty level, the children I see in clinic bring all the research to life. The young patients I care for are more susceptible to all the environmental health exposures. Many of these children have very difficult-to-control asthma and allergies, which has the potential to be exacerbated due to the current changes in our climate.

The anticipated health effects from climate change vary from disruptions to our food and water supply to disease pattern change. Yet impacts to public health are already being experienced. This is not surprising considering that the 12 warmest years on record have occurred in just the last 15 years.[478]

Extreme warm weather can have serious health effects. Not only does heat worsen pre-existing diseases such as heart disease, diabetes, and kidney disease, it also causes heat stroke and dehydration in healthy populations. Asthma, a common childhood illness, is worsened by diminished air quality resulting from increased temperatures. Although we have treatments that control asthma, when environmental factors like poor air quality persist, the condition becomes difficult to control.

Clinically, I am seeing more children with difficult to control allergies. In addition to more allergy symptoms, I would expect to see an increase in asthma exacerbations, since pollen is a major trigger. Any climate driven changes to air-borne allergens, such as increases in pollen counts or change in the seasonal timing of allergen production, will undoubtedly make allergies and asthma more difficult to control in the future.

In the long term, if we do not take action, we will see major disruptions to human health and well-being. Although the challenges before us seem daunting, we still have time to act. Solutions for a healthy planet, by promoting more forms of active transportation, using less and cleaner sources of energy, and taking steps to reduce our carbon foot print, are also solutions that improve health now and promote healthy and more resilient populations in the future.

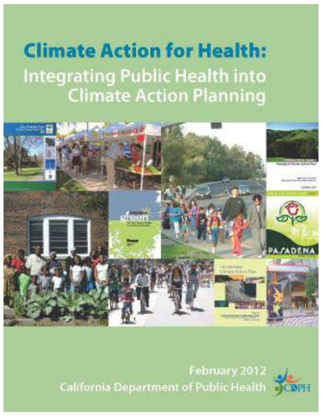
As a physician, I believe climate change is one of the biggest public health challenges we must address. Although all of us are affected by a changing climate, certain groups—such as children, the elderly, and socially or economically disadvantaged populations—are disproportionately at risk of its health impacts. It will take a multi-sector, innovative approach to confront climate change, but it is imperative that we do so now to secure the future of California and ensure a healthy environment for our children going forward.

Elizabeth Baca, MD, MPA received her medical degree from Harvard Medical School and her graduate degree from the Kennedy School of Government. In addition to teaching medical students, residents, and caring for patients, she works on state-level policy to create healthy, sustainable communities.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

CDPH and others have worked to create linkages and find ways to integrate climate mitigation and climate adaptation into today's health protection and health promotion programs at the state and local level in California.

Box 57



<u>Climate Action for Health: Integrating Public Health in Climate Action Planning</u> – In February 2012, CDPH developed this guide to assist local planners and public health agencies in incorporating targeted health elements into climate action plans and achieve health co-benefits while reducing greenhouse gas emissions.[479]

<u>State of California: Preparing California for Extreme Heat: Guidance and Recommendations</u>
In the wake of the hottest July ever recorded in the United States, California released a plan to deal with extreme heat caused by climate change. This broad Guidance document was developed by the Heat Committee of the Public Health Workgroup in the Climate Action Team, and provides recommendations for incorporating extreme heat projections into planning and decision making in California.[480]

<u>CDPH Climate Education and Training</u>
CDPH works to expand awareness and knowledge of the health impacts of climate change and how climate mitigation and adaptation strategies can be integrated with efforts to promote healthy and sustainable communities and protect vulnerable populations. CDPH has collaborated with the California Conference of Local Health Officials, the Public Health Institute (PHI), the Local Government Commission, UCLA Fielding School of Public Health, regional adaptation planning collaboratives, and others to offer a variety of climate and health educational activities. These efforts include:

> ***<u>Statewide Webinar series</u>*** - CDPH created a climate webinar series "***<u>Climate Change and Public Health: Building Healthy Communities and a Healthy Planet"</u>*** for public health professionals and community health advocates on how climate change is impacting health across California, especially within vulnerable communities. These and ongoing webinars are communicating the need for action at the local level, providing tools and identifying opportunities for improving health and addressing climate change.[481]
>
> ***<u>Climate Change as a Public Health Issue: Communication Lessons and Strategies for Local Health Departments</u>*** - In November 2010, CDPH and the California Conference of Local Health Officers co-sponsored two workshops in Los Angeles and Oakland on climate change and public health. The workshops featured Dr. Edward Maibach, a leading US researcher on public attitudes on

climate change, public health communication and social marketing.[482] In order to better understand public knowledge, attitudes on climate change as an important health issue CDPH conducted focus groups in English and Spanish with community health leaders in the Summer, 2013.[483]

Online Climate Change Health Data - CDPH's California Environmental Health Tracking Program provides a wealth of online climate and health data including maps of climate change vulnerabilities and surveillance data on heat-related illness and death. That climate change data may be found at: http://www.ehib.org/page.jsp?page_key=863

Be Prepared California - As further described in the Emergency Management section of this document, the CDPH Emergency Preparedness Office has developed the Be Prepared California online tool to help Californian's prepare for public health emergencies.[484]

Research on Climate Exposure and Socio-Economic Vulnerability of California Communities

The Third California Climate Change Assessment featured a number of studies on the exposure and vulnerabilities of California communities to climate impacts. These studies included studies of particular communities, like Fresno and San Luis Obispo, and the development of a climate vulnerability index to identify the areas of the State most vulnerable to climate impacts.[485] The climate vulnerability index combined 19 indicators into one overall climate vulnerability score and includes factors specifically related to climate impacts, such as air conditioner ownership, percentage of tree cover, and workers in outdoor occupations. [See Box 24 and Box 25 in the Emergency Management section of this document for State Climate Vulnerability Maps]

CDC Building Resilience Against Climate Effects (BRACE) Collaboration

In 2012, CDPH was awarded a four-year CDC climate change and health grant which will allow California to utilize the five-step CDC BRACE model (Building Resilience Against Climate Effects) to develop a comprehensive climate and health adaptation plan.[486]

Research on Mosquito Borne Viruses and Tools for their Surveillance and Control

The UC Davis Center for Vector Borne Diseases, Arborvirus Research Program conducts research on mosquito borne viruses and tools for their surveillance and control. Study areas have been established at multiple habitats within Riverside, Los Angeles, Kern and Sacramento Counties. UC Davis is collaborating with local agencies of the Mosquito and Vector Control Association of California as well as the CDPH Vector-Borne Diseases Section and Viral and Rickettsial Diseases Laboratory.[487]

California Mosquito-Borne Virus Surveillance and Response Plan

In April 2013, CDPH, the Mosquito and Vector Control Association of California, and the University of California released a revised enhanced surveillance and response plan for mosquito-borne viruses in the State of California.[488]

Box 58

Developing Climate and Health Initiatives at the Local Level

In California's largest county, the Los Angeles County Department of Public Health (LA Co DPH) has adopted an innovative "Five-Point Plan to Reduce the Health Impacts of Climate Change". Working with academic, governmental and community partners, the Department is striving to reduce health impacts of climate change while building healthy, sustainable and resilient communities, ensuring the climate change efforts are linked with ongoing health protection and health promotion in the county's diverse population.

The initiative includes five specific actions:

- Inform general public about the nature of climate change and the health co-benefits associated with taking action to reduce carbon emissions;
- Ensure that climate mitigation and health are incorporated into local planning and policies;
- Provide guidance on climate preparedness to local government and communities that can reduce risks and create more resilient communities;
- Build the capacity of LA Co DPH staff and programs to monitor impacts to improve climate preparedness and response; and
- Adopt practices within LA Co DPH demonstrating leadership in sustainable operations and facilities for department itself.

"Local public health officials have seized on an unprecedented opportunity to protect and improve population health. They are now playing a vital role in communicating the human health implications of climate change. But beyond the messages of protecting health, we must explain how actions to reduce carbon emissions and prepare for climate change also promote the development of healthy, sustainable and resilient communities."

-Angelo J. Bellomo, Director of Environmental Health, Los Angeles County Dept. of Public Health

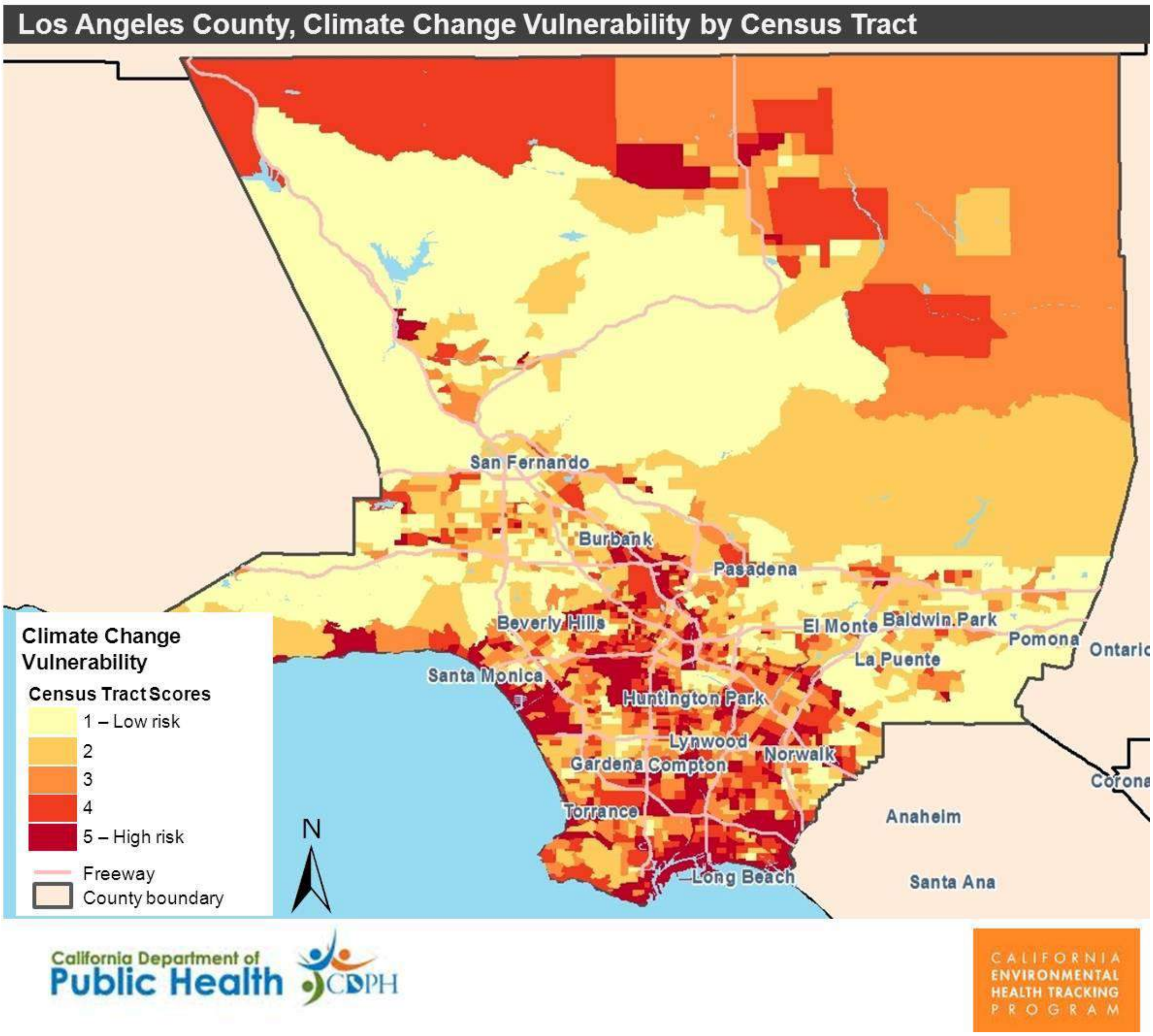
Association of State and Territorial Health Officials (ASTHO) Climate Change Population Vulnerability Screening Tool

CDPH's Environmental Health Tracking Program developed vulnerability assessment screening methods with the support of a grant from the Association of State and Territorial Health Officials (ASTHO).[489] The tool supplemented an existing environmental justice screening method[490] with metrics associated with climate change impacts and adaptive capacity, such as population sensitivities (e.g. elderly living alone; car access), air conditioning ownership, green space, and ecological risks (e.g. flood risk or fire risk).[491] Implementation of the screening tool was piloted in Fresno County and Los Angeles County and produced the maps in Box 59 and Box 60 below. Racial disparities were found in each county for climate change vulnerability. In Los Angeles, 46% of African Americans and 36% of Latinos reside in the two highest risk categories, as compared to 30% of whites; and in Fresno County, 49% of African Americans and 45% of

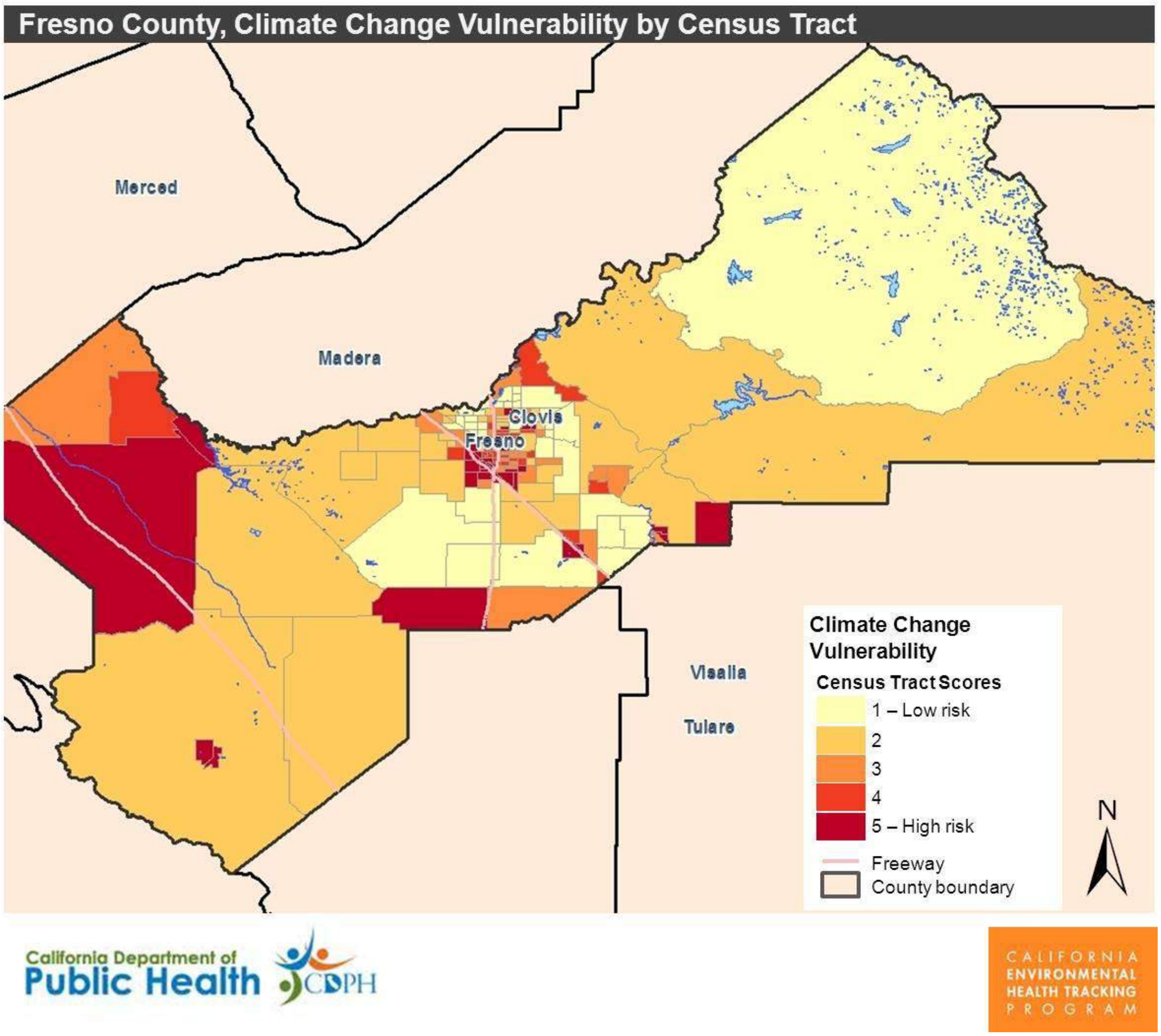
Latinos reside in the two highest risk categories, compared to 26% of Fresno's white population.

Final climate change population vulnerability scores, including cumulative impact polygons, Los Angeles County

Box 59



Box 60



Final climate change population vulnerability risk scores at the census tract level, Fresno County

California Communities Environmental Health Screening Tool, Version 2.0

In 2014, CalEPA and OEHHA announced the availability of the California Communities Environmental Health Screening Tool, Version 2.0 (CalEnviroScreen 2.0).[492] This tool presents the nation's first comprehensive screening methodology to identify California communities that are disproportionately burdened by multiple sources of pollution and presents the statewide results of the analysis using the screening tool. A report describing the methodology and results along with an online mapping application are available. Continued refinement of the tool over time is expected. Among other things, CalEnvirosScreen 2.0 will be used by the California Environmental Protection Agency to identify disadvantaged communities pursuant to Senate Bill 535 (2012) for the allocation of funds in the Greenhouse Gas Reduction Fund.[493]

Protecting Public Health During Drought Conditions

In 2010, CDC's National Center for Environmental Health (NCEH) released "When Every Drop Counts: Protecting Public Health During Drought Conditions – A Guide for Public Health Professionals"[494] to assist public health officials, practitioners, and other stakeholders in their efforts first to understand and then to prepare for drought in their communities. It provides information about how drought affects public health, recommends steps to help mitigate the health effects of drought, identifies future needs for research and other drought related activities, and provides a list of helpful resources and tools.

Transportation-related Progress Benefiting Public Health

The California Department of Public Health has made significant progress developing tools to quantify the health co-benefits of different transportation strategies to reduce greenhouse gas emissions. Models developed by CDPH demonstrate that physically active transportation – bicycling and walking – not only has the potential to significantly decrease GHG emissions, but also increases community resilience by reducing chronic diseases that create vulnerability to heat, pollution and other climate impacts. Per mile traveled, the health co-benefits of active transport appear to be many-fold greater than any other transportation strategy, including electrification of the automobile fleet.[495] As further described in the Transportation section of this document, progress has been made on cool pavements legislation to begin the work of addressing urban heat island effect. The Transportation section of this document also describes progress on smart growth, advanced clean car standards, low carbon fuels, and high speed rail that will help lower emissions from transportation and provide related health benefits that will be important in the face of climate risks such as more extreme heat events and worsening air quality.

Energy-related Progress Benefiting Public Health

As further described in the Energy section of this document, progress has been made on a variety of measures that will help prepare communities for enhanced energy resilience in the face of climate impacts including energy efficiency measures and Local Energy Assurance Planning[496].

Box 61

California Medical Association and American Medical Association Efforts on Climate Change

Health professionals are well positioned to help inform others in the health sector, the general public and policy makers about the relationship between human health and climate change. They have both the necessary scientific background and the communication skills to get the message across in an understandable way. [497]

In October 2012, the California Medical Association (CMA) House of Delegates adopted a resolution (Resolution 117-12) to support the ongoing implementation of California's landmark the California Global Warming Solutions Act of 2006 (AB 32) aimed at reducing the emissions that cause climate change. CMA noted that the California Air Resources Board and health professionals around the country have identified a number of health concerns related to air pollution and climate change, including increased heat-related illness and death, exacerbation of respiratory disease and a rise in cardiopulmonary mortality.[498]

The American Medical Association (AMA) has also supported the Environmental Protection Agency's authority to regulate and control greenhouse gas emissions in the United States.[499]

Emergency Management Climate Progress Benefiting Public Health

As further described in the Emergency Management section of this document, there has been progress toward integrating climate considerations into Emergency Management in California. The progress includes the development of tools like the California Adaptation Planning Guide (APG), to help local and regional governments with climate adaptation planning efforts. CDPH collaborated in the development of the health and social vulnerability sections of the APG, and provided examples of how this work intersects with Local Health Department public health preparedness and health equity efforts. Other efforts to integrate climate into emergency management efforts include the incorporation of climate change into the State Hazard Mitigation Plan.

Natural Resource Investments that Help Communities Prepare for Climate Risks

As further described in the Forestry, Biodiversity and Habitat, Oceans and Coastal Ecosystems and Resources, and Water sections of this document, there has been some progress on managing natural resources to reduce and prepare for climate risks. Fire hazard reduction, raising awareness about wildfire risks and safety precautions, and post-fire recovery actions have been helping to reduce public health risks from wildfire. Urban forests and urban greening help to provide shading, reduce energy demand, and reduce water contamination from stormwater runoff. Integrated regional watershed management has been helping to enhance water quality and availability in the face of climate impacts. Wetlands restoration and creation and enhanced flood monitoring have been helping to reduce public health risks associated with sea level rise and extreme weather. As further described in the Forestry, Biodiversity and Habitat, Oceans and Coastal Ecosystems and Resources, and Water sections of this document, opportunities exist for additional cost-effective investments in natural resources that promote resilient, healthy communities.

Preparing for Climate Risks to Agriculture

As further described in the Agriculture section of this document, some important progress has been made with respect to preparing for impacts to the agricultural sector in California. For instance, CDFA established a climate consortium to assist specialty crop growers prepare for the impacts of climate change. Opportunities for further work to ensure food security and food safety in the face of climate risks are discussed in the Agriculture section of this document.

ACTIONS NEEDED FOR IMPROVED READINESS FOR CLIMATE-RELATED PUBLIC HEALTH RISKS

While the activities highlighted above depict early efforts and progress made, further action is still needed to help California prepare for climate risks to public health.

Improve Capacity of Communities to Prepare, Respond and Recover from Climate-Related Health Risks

Planning for Climate Change and Water-Related Public Health Risks

Climate change will present new challenges to providing safe drinking water. Any new state plans for drinking water or infrastructure investments to provide safe drinking water should consider climate risk implications.

The state's Drinking Water Program, which was transferred from CDPH to the State Water Resources Control Board on July 1, 2014, has participated with US EPA, other states and representatives of several of California's water utilities on the USEPA National Drinking Water Advisory Council Climate Ready Utility Workgroup. The workgroup developed findings and recommendations relating to the development of a program enabling water and wastewater utilities to prepare long-range plans that account for climate change impacts. The findings and recommendations were published (Climate Ready Water Utilities, December 2010) and placed on the US EPA website.[500]

The state's Drinking Water Program will continue to work with public water systems in the State to evaluate and permit innovative new sources of drinking water such as desalinization plants.

California should also begin to examine and identify the vulnerability of its public water systems to climate risks such as salt water intrusion, sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses will be needed. These analyses should be coordinated with other state agencies, water agencies and local agencies. Other priorities include advancing the science and policy needed to expand the role of recycled water as a drinking water supply. This work involves developing regulations to guide the use of recycled water for recharging groundwater and surface water reservoirs subsequently used as drinking water sources ("indirect potable reuse") and, and eventually directly as a water source for drinking water systems ("direct potable reuse"). Emergency regulations regarding the use of recycled water for groundwater recharge were completed and became effective June 18, 2014. [501]

Evaluate Health Care Infrastructure Resilience

The Public Health workgroup of the Climate Action should convene a discussion with state agencies (including CDPH's Emergency Preparedness Office, the Office of Statewide Health Planning and Development and Emergency Medical Services Authority), healthcare industry partners and other stakeholders to discuss measures to improve resilience of the health care sector to climate impacts, and how such efforts can be coordinated with related federal efforts. Any assessment should also consider health care "surge capacity"—the ability to provide care to large numbers of patients in the immediate aftermath of an extreme event (heat wave, flood, storm, etc.) and the resilience of the health care workforce.

California should also begin to examine the vulnerability study of its health care infrastructure to climate risks such as sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses, and the implementation of any recommendations for reducing vulnerabilities, will be needed. A 2009 study funded by the Public Interest Energy Program at the California Energy Commission, indicated that a 55-inch sea level rise increase (which is within the range of sea level rise projections for San Francisco in 2100), would increase the number of health care facilities along San Francisco Bay that are at risk of a 100-year flood from 15 to 42.[502] (For more information on risks associated with sea level rise in California, please see the Oceans and Coastal Ecosystems and Resources section of this document.)

Support Implementation of Recommendations in the 2013 State of California Extreme Heat Guidance Document

As noted above, the State of California has developed *Preparing California for Extreme Heat: Guidance and Recommendations*. The State should support implementation of its recommendations. As the document notes, the implementation of some recommendations will require additional resources.

Support Development of Public Health Planning Tools for Local Communities

Enhanced climate and health-sensitive warning systems are needed. For instance, the California Environmental Health Tracking Program, which is a collaboration of the California Department of Public Health and the Public Health Institute, funded by the CDC, has conducted a study to determine if heat alerts accurately predicted times when people suffered the most heat illness[503] The methodologies that the National Weather Service (NWS) uses to issue heat alerts and warnings for local areas do not incorporate explicit health criteria. Working with the CDC, NOAA and the NWS, state and local health scientists can provide their expertise to enhance the sensitivity of NWS heat products so that California's population and health systems can be better warned and prepared to take countermeasures during heat emergencies.

Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.[504] Such surveillance can serve as an early warning system for impending public health emergencies; can document the impact of an intervention, or track progress towards specified goals; and can monitor and clarify the epidemiology of health problems, to allow priorities to be set and to inform public health policy and strategies.

Surveillance depends on the most accurate and latest data available. California's local health jurisdictions, CDPH, and the CDC employ a variety of public domain and commercial surveillance systems to capture syndromic and ongoing surveillance data. These systems vary from a simple system collecting data from a single source, to electronic systems that receive data from many sources in multiple formats, to complex surveys. When considering or employing a health surveillance system, jurisdictions should use the CDC's *Guidelines for*

Evaluating Surveillance Systems to address the need for a) the integration of surveillance and health information systems, b) the establishment of data standards, c) the electronic exchange of health data, and d) changes in the objectives of public health surveillance to facilitate the response of public health to emerging health threats (e.g., new diseases).[505]

Tools that provide public health data and information to public health officials will be an important part of efforts to detect, track, prepare, and respond to climate-related health risks. California should collaborate with federal and local partners to support development and enhancement of such tools.[506]

Better Understanding of Evolving Trends that May Impact Public Health in the Era of Climate Change

<u>Healthy Energy Efficient Buildings</u>
Constructing and upgrading buildings to be more energy efficient can provide tremendous benefits including lower utility costs, greater energy security, improved air quality, reducing emissions that cause climate change, and the creation of green jobs. However, if construction or upgrades are performed improperly, health risks may arise. For instance, if proper ventilation is not part of design, then indoor air quality may be compromised and can be exacerbated by changing climate conditions. US EPA released a 2011 document entitled “Guidelines to Ensure Healthy Indoor Air during Home Energy Upgrades”.[507] The Guidelines provide a step-by-step process for conducting assessments to evaluate indoor air conditions and the potential for risks that may arise during residential energy upgrades.
California includes in its 2008 and newly adopted 2013 Energy Efficiency Standards for New Residential and Nonresidential Buildings[508] ventilation requirements that meet or exceed current minimum state and national ventilation requirements. These requirements are consistent with best practices for the design of ventilation systems for newly constructed buildings, as well as, the additions and alterations of existing buildings. In June of 2013, the California Energy Commission (CEC) also published the draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings (the “Action Plan”) in order to meet the intent and requirements of legislation[509] that requires the CEC develop a comprehensive program to achieve greater energy efficiency in the state’s existing buildings. The programs and standards that are developed according to the final Action Plan may include strategies to meet or exceed national and state requirements for whole house and multi-family ventilation including: heating, ventilation and air conditioning (HVAC) systems and equipment; combustion safety; contaminant distribution and source ventilation that are identified in the EPA Protocols for Home Energy Upgrades. The Action Plan also establishes building industry outreach and education goals for job training that includes health and safety considerations. Support for implementation and compliance with the state’s energy efficiency standards and the Action Plan will be important to realizing all the benefits of energy efficient buildings. CDPH’s Division of Environmental and Occupational Disease Control (DEODC) includes the California Breathing Asthma Program, Childhood Lead Poisoning Prevention Program, Healthy Homes Program and Environmental Health Laboratories. The CEC and DEODC will work together during the implementation of the Action Plan.

Low Allergen or Nonallergenic Urban Greening to the Extent Feasible
As noted above, there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, but models indicated that pollen will likely increase in many parts of the United States and there may be shifts in the seasonal timing of allergen production and other changes to air-borne allergens. In order not to exacerbate public health issues associated with air-borne allergens, urban greening programs should consider low allergen or nonallergenic species to the extent that such species are otherwise regionally suitable.

Better Understanding of Climate Impacts on Public Health

Further Development and Support of Local Vulnerability Assessments
As noted above, some initial local vulnerability assessments, for communities, have been developed for selected communities, like Fresno, Los Angeles and San Francisco. However, all California communities face climate risks to public health, and there is still a need for further development and support of local vulnerability assessments for climate-change health risks (such as risks relating to heat, air quality, fire, flooding, and water availability and quality). Conducting geographically-specific vulnerability assessments and the identification of vulnerable populations can help guide efforts to design and implement strategies to address local risks and needs of high risk groups. The February 2012 ASTHO Climate Change Population Vulnerability Screening Tool discussed above should be revised to include improved data and additional stakeholder input; and vulnerability analyses for additional communities should be undertaken. CDPH's four year CDC BRACE grant will expand this planning for ten additional counties; however, funding to expand and support these efforts so that local public health partners can be actively involved may be necessary.

Increase Capacity to Monitor Climate-Related Deaths and Illnesses
Continued actions to improve disease reporting and surveillance will aid efforts to understand and respond to emerging climate risks to public health. These actions may include: coordinating with federal and regional rapid surveillance efforts; upgrading the California Death Registration System[510] to provide for continuous monitoring of abnormal death patterns, including heat-related death; and improving surveillance programs for infectious diseases including vector-borne, water-borne and food-borne diseases.

Social Vulnerability Mapping for Climate Change
Multiple screening tools for social vulnerability now exist, such tools reflect a variety of conceptual frameworks, methodologies, and data. These tools have varying strengths, weaknesses, assumptions and limitations. CDPH should convene a meeting with various state entities and other partners who have developed such social vulnerability tools in order to identify gaps that may be filled by collaborative research and to examine best practices for developing social vulnerability assessments for Cal-Adapt.

Regional Studies of Aeroallergens

Significant gaps still exist with respect to California's ability to monitor potential shifts in air-borne allergens. Funding to enhance allergen monitoring, identification and forecasting would support efforts to better understand how allergens are shifting in response to climate change, and would help support the development of policies to help reduce these health risks for Californians in light of these changing conditions.

Information Sharing and Education

<u>Capacity Building to Raise Awareness and Foster Action to Address Climate Risks to Public Health</u>

Outreach efforts are important to ensure that public health and medical professionals are prepared and educated on climate risks. Health professionals are uniquely positioned to help raise community awareness about risks to public health from a changing climate[511] and a health framing may help more members of the public to consider climate risks and actions.[512] In addition to capacity building efforts described in the Introduction to this document, a grant program for local health departments and professional medical and nursing associations could be established to support the development of courses on climate and California health risks for the staff and constituents of such organizations. Funding and adequate staffing to support such a grant program would be required. Any such capacity building courses for local public health, medical and nursing professionals should include information about the health impacts of climate change, as well as information related to the prevention and management of climate-related illnesses (e.g., heat illness) and promoting resilience.

<u>Public Education on How to Reduce and Prepare for Climate Health Risks</u>

The Public Health workgroup of the Climate Action Team together with other relevant state entities, should develop culturally and linguistically relevant educational materials for diverse populations (e.g., vulnerable communities, school-age children, businesses, and labor) using best practices in climate change education.[513] Materials should promote an understanding of various health risks associated with California's changing climate, including, but not limited to, risks associated with extreme weather, heat waves, heat and outdoor labor, air quality, aeroallergens, wildfire, floods and sea level rise, and drinking water, and describe strategies and actions that foster preparedness.

Public education campaigns should be designed to disseminate this information. The campaign should not only utilize existing resources to disseminate information (e.g., the bepreparedcalifornia.ca.gov website and public health advisories), but should also involve collaboration with partners and innovative modes for disseminating information. Additional funding and staffing will be needed for this effort.

Box 62

California Public Health

Many different state entities play an important role with respect to public health in California.

Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. Short descriptions of these entities are provided below:

California Department of Public Health (CDPH) is dedicated to optimizing the health and well-being of the people in California. CDPH includes an Emergency Preparedness Office which is further described in the Emergency Management section of this document. The Office of Health Equity is also within CDPH, and includes the Climate and Health Team. For more on health equity, please Box 54.

California Health and Human Services Agency (CHHS) oversees thirteen departments and one board that provide or coordinate a range of services, including medical care for low-income Californians (MediCal), emergency medical services, social and mental health services , food support programs (Snap Ed, Cal Fresh), alcohol and drug treatment services, income assistance and public health services to Californians from all walks of life. CDPH is a department within CHHS.

Many other state entities also play important roles with respect to health issues in California. These entities include:

California Air Resources Board (CARB) is dedicated to promoting and protecting public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state. CARB's major goals include providing safe, clean air to all Californians, protecting the public from exposure to toxic air contaminants, and reducing emissions that cause climate change.

California Department of Food and Agriculture (CDFA) works to serve the citizens of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Forestry and Fire Protection (CAL FIRE) and **State of California's Office of the State Fire Marshall (SFM)** is CAL FIRE is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, the Department provides varied emergency services in 36 of the State's 58 counties via contracts with local governments. CAL FIRE also supports "urban forestry", increasing the number and health of trees planted in cities. The mission of the State Fire Marshal is to protect life and property through the development and application of fire prevention engineering, education and enforcement.

California Department of Industrial Relations (DIR) enforces the state's labor laws to improve the workplaces of over 18 million wage earners and their employers; DIR includes the Division of Occupational Safety and Health, better known as Cal/OSHA, which protects workers and the public from safety hazards and the Division of Workers' Compensation which oversees the delivery of benefits and adjudication for work injuries, illness and death.

California Department of Insurance (CDI) works to foster an insurance market that is fair, competitive and accessible to all Californians.

California Department of Pesticide Regulation (CDPR) works to protect human health and the environment by regulating pesticide sale and use, and by fostering reduced-risk pest management.

California Department of Toxic Substances Control (DTSC) The mission of DTSC is to protect California's people and environment from harmful effects of toxic substances through the restoration of contaminated resources, enforcement, regulation, and pollution prevention.

Governor's Office of Emergency Services (OES) is responsible for the coordination of overall state agency response to major disasters in support of local government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards – natural, manmade, war-caused emergencies and disasters – and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. The work of OES is further described in the Emergency Management section of this document.

California Environmental Protection Agency (Cal/EPA) is dedicated to the protection of human health and the environment, and oversees six boards and departments, including CARB and the **Office of Health Hazard Assessment (OEHAA)**.

Department of Water Resources (DWR) is responsible for managing and protecting California's water. DWR works with other agencies to benefit the state's people, and to protect, restore and enhance the natural and human environments.

Labor and Workforce Development Agency oversees the six major departments, boards and panels that serve California businesses and workers, including the California Department of Industrial Relations' Division of Occupational Safety and Health.

State Water Resources Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards. SWRCB's mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

Strategic Growth Council (SGC) is a cabinet level council which ensures the consideration of health and health equity as part of the state's planning for sustainable growth. The Health-in-All-Policies Task Force, Health Community Indicators Project and grant programs for Sustainable Community Planning and Urban Greening all address health elements critical to the state's planning and policies for Strategic Growth.

The State of California also has a number of important federal partners with respect to public health issues. These federal partners include: **Centers for Disease Control and Prevention** (CDC) which collaborates to create the expertise, information, and tools that people and communities need to protect their health – through health promotion, prevention of disease, injury and disability, and preparedness for new health threats[514]; **the U.S. Environmental Protection Agency (US EPA)** which works to protect human health and the environment across a range of issues include air, water, waste and climate change[515]; **Federal Emergency Management Agency (FEMA)** which supports citizens and first responders to build, sustain and improve capability to prepare for, protect against, respond to, recover from and mitigate all hazards[516]; **U.S. Department of Health and Human Services (HHS)** which is the United States government's principal agency for protecting the health of all Americans and providing essential human services, especially for those who are least able to help themselves[517]; the **National Institutes of Health (NIH)** which is an agency within HHS and is the nation's medical research agency[518]; **National Institute of Environmental Health Services (NIEHS)** which is part of NIH and has a Climate Change and Human Health Program engaged in research and capacity building on human health impacts related to climate change and adaptation[519]; **U.S. Department of Food and Drug Administration** and the **U.S. Department of Agriculture** which help to regulate food safety as further discussed below;[520]and the **U.S. Department of Labor Occupational Health and Safety Administration** which works to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.[521] CDPH serves on or advises a number of national committees to develop knowledge, guidance and indicators to help the public health sector prepare for climate change including the National Drinking Water Advisory Council's Climate Ready Utility Workgroup[522]and the National Climate Assessment[523].

Local governments and sixty-one local public health departments also play a critical role in ensuring the public health of Californians.[524] Individuals and private sector actors, including employers, insurance companies, health care providers, educational institutions, and non-profit organizations, also play an important role in creating healthy and sustainable communities. For an example of collaborative efforts supporting public health initiatives at the local level, see Box 58: **Developing Climate and Health Initiatives at the Local Level** and Box 61**: California Medical Association and American Medical Association Efforts on Climate Change** above.

TRANSPORTATION

INTRODUCTION

Climate Risks to California Transportation

California's economy and its residents rely on a robust, multi-modal transportation system. California's transportation infrastructure includes extensive roads and highways, railways, ports, airports, transit systems, and a variety of supporting fueling and energy systems.

Billions of dollars of goods are transported through California on the State's diverse transportation system. California is a major global gateway for products entering and leaving the United States. Ports, railways, airports, and the State Highway System provide critical goods movement routes for the State and Nation. In addition to goods movement, the transportation system is also critical for the movement of people and delivery of services.

While the transportation sector is a source of greenhouse gas emissions, it is also vulnerable to a variety of climate impacts. Sea level rise and coastal erosion threaten ports and low lying airports, coastal roads and highways, bridge supports, transit systems, and energy and fueling infrastructure. [For more information on how the Port of San Diego is preparing for climate risks, please see Box 65: First Person Narrative: Ports by Cody Hooven below.] Climate change is expected to cause both coastal flooding and inland flooding which may compromise underground storage tanks for fuel, causing fuel delivery interruption, pipe ruptures, and toxic releases. Floods and landslides can also cause road closures, transportation hazards, and millions of dollars in transportation infrastructure damage. [See images below of flooding and infrastructure damage.] Extreme heat associated with climate change also threatens highways and railways. High temperatures cause road surfaces to expand, creating pressure that can cause pavement to buckle. Rail lines are also vulnerable to heat. Similar to roadway buckling, metal rail lines kink under extreme heat conditions which can lead to rail breakage and train derailment. Extreme storm events may damage energy and fuel distribution systems as well as transportation infrastructure; this can impair goods movement, including supplies for affected communities, and mobility for residents, including impacting evacuation routes for communities. [For more information about extreme events and impacts to transportation systems, please see Box 64: Transportation and Hurricane Sandy] If groundwater utilization intensifies in response to climate-induced changes in water availability, there may also be an increase in land subsidence events that threaten roads, railways, and bridges. [Please see the Water section of this document for more information on subsidence.]

Box 63

I-5, Sacramento, Oct. 13, 2009
Photo: California Department of Transportation

State Route 330, San Bernardino County, Dec. 27, 2010
Photo: California Department of Transportation

As further discussed below, California has already made significant progress with respect to addressing emissions from the transportation sector which cause climate change, as well as assessing vulnerabilities of the sector. California has adopted innovative smart growth measures (to contain sprawl), clean car standards, and a low carbon fuel standard. It has also begun the important work of assessing vulnerabilities of the transportation sector and addressing climate impacts.

More work is still needed to prepare California's transportation sector for anticipated climate impacts. Impending climate impacts not only have implications for decisions regarding the siting of new transportation infrastructure, climate impacts also have implications for maintenance and operation plans, and for design features of transportation systems, including system design for emergency planning and extreme weather events.

Box 64

Transportation and Hurricane Sandy

According to the August 2013 report issued by the Hurricane Sandy Task Force, the states impacted by Hurricane Sandy lost between $30 billion and $50 billion in economic activity due to extensive power outages, liquid fuel shortages, and near-total shutdown of the region's transportation system. Access to gasoline and diesel fuel in New York City and northern New Jersey was severely impaired following Hurricane Sandy. This was largely caused by flooding damage to major terminals and docks in the Arthur Kill area of New Jersey. These fuel shortages delayed first responders and other response and recovery officials. As a result, portable generators sat unused and lines at fueling stations were long and problematic while consumers struggled to identify which gas stations had power and were operational.[525]

Hurricane Sandy was the worst disaster for public transit systems (e.g., bus, subway, commuter rail) in the nation's history. On October 30, 2012, the morning after the storm made landfall, more than half of the nation's daily transit riders were without service. New York City's subway system was shut down on October 28, in advance of the storm, and remained closed through November 1. During that time, the City experienced traffic gridlock, and those who were able to get to work experienced commutes of up to several hours. Seawater breached many critical infrastructure systems, flowing into the Hugh L. Carey (Brooklyn-Battery) Tunnel, flooding eight of the New York City Subway tunnels, and damaging a variety of other transportation systems in the region.[526]

Response and recovery actions for the transportation sector required coordination between many entities. The Federal Emergency Management Agency is funding, under its Public Assistance program, repairs to airports, port and harbor facilities, and other publicly owned transportation systems not covered by the Federal Transit Administration or the Federal Highway Administration (FHWA) emergency relief programs. Other transportation systems, such as the intercity rail lines operated by Amtrak, and Federal assets at airports such as air traffic control towers and navigation systems, were funded or repaired by the Federal Railroad Administration or the Federal Aviation Administration, respectively. In a unique partnership with the National Park Service, the piers and docks on Liberty Island, which allow ferry access to the Statue of Liberty, were repaired by the Eastern Federal Lands division of FHWA.[527] The Hurricane Sandy Task Force has proposed recommendations to promote resilient infrastructure investments and to improve coordination between federal, state and local officials, as well as with members of the public, businesses, non-profits, and other community groups.[528]

Although the risk of a hurricane making landfall in California is very low, many California counties are at risk for storm damage caused by severe high winds and flooding.[529] Climate change and California storm risks are further described in the Emergency Management, Water, and Oceans and Coastal Ecosystems and Resources sections of this document.

Several state entities play an important role with respect to transportation in California. The state also has important federal, local and private sector partners with respect to transportation. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 66 *at the end of this chapter titled California Transportation.*

Box 65

FIRST PERSON NARRATIVE: Ports
By Cody Hooven, Senior Environmental Specialist
Port of San Diego

As a senior environmental specialist for the Port of San Diego, I have one of the best jobs at the Port. I work in an exciting field at the intersection of science and policy on environmental issues, and I am helping to pave the way for the Port to grow as an economic engine for the San Diego region.

The Port of San Diego encompasses almost 6,000 acres of state tidelands in and around San Diego Bay that have been entrusted to the Port since 1962. These lands span five cities, including San Diego, Coronado, National City, Chula Vista, and Imperial Beach. The Port's mission is to protect Tidelands Trust resources by providing economic vitality and community benefit through a balanced approach to maritime industry, tourism, water and land recreation, environmental stewardship, and public safety.

The Port's maritime industry is supported by four terminals, two dedicated to cargo, and two for cruise ships. There are also a number of maritime industrial businesses on our tidelands that build and repair ships and operate in other ways to keep goods moving in and out of the region. Many of these businesses also support the military, including Naval Base San Diego, one of only two major fleet support installations in the United States.

The Port plays a large role in the important tourism industry as well, managing hundreds of commercial leases, including visitor-serving hotels, marinas, restaurants and attractions. Our various roles influence our regional partnerships and the ways we engage with regional stakeholders.

In our role as an environmental steward, the Port has emerged as a regional and state leader in climate change planning. With support and direction from our executive leadership and Board of Port Commissioners, my colleagues and I have made substantial progress in "greening" the Port's activities – both our own operations and those of our waterfront businesses. Examples include installing a shore power system for cruise ships to reduce their emissions while at berth, building the world's first LEED Gold-certified cruise ship terminal, and implementing an innovative Green Business Network for waterfront businesses to increase their environmental sustainability. For these and other efforts, the Port was awarded the 2013 Climate Leadership award from the U.S. EPA.

Recently, in collaboration with regional colleagues and stakeholders, we began long-term climate adaptation planning for San Diego Bay. Of the many impacts predicted from a changing climate, sea level rise poses the most urgent need for action for the Port and its stakeholders. Some actions we're taking are studying sea level rise as a region with the *Sea Level Rise Adaptation Strategy for San Diego Bay* and developing adaptation strategies that can be incorporated into a long-term plan. Some of these strategies are beginning to be incorporated into development planning (e.g., elevating building pads or establishing habitat buffer zones). We're working to protect the valuable jobs, regional infrastructure and natural resources, and economic contributions that continue to make San Diego Bay a vital asset to California.

Considering these long-term impacts now will ensure that we are prepared for and resilient to future conditions and will help ensure our long-term success.

The Port of San Diego and our fellow California ports represent some of the largest port facilities in the nation, providing tremendous economic benefit to our local, regional, state and national economies. Over the last decade in particular, California ports have been fundamentally focused on improving environmental conditions in and around our port facilities. We've implemented innovative and exciting operational changes and environmental improvement programs that significantly exceed state and national standards.

Even with these efforts, much remains to be done. The Port of San Diego has taken the lead on planning for a changing climate and looking for ways to adapt, but we have a long way to go and can't do it alone. With ports playing such a vital role in goods movement and economic activity for the state and the nation, we need to continue working with our neighboring agencies, our regions, and our state leaders to protect these valuable assets.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

As noted above, the transportation sector is both a source of emissions that cause climate change, and vulnerable to expected climate impacts. As described here, the State of California has made progress on both fronts. This Highlights section is not a complete or exhaustive catalogue of all climate progress in the transportation sector in California. Many portions of the transportation sector are primarily under the jurisdiction of entities other than the State (e.g. local streets and roads, private freight rail lines, and ports and airports owned and operated by local entities); these parts of the transportation sector are largely beyond the scope of this report. However, it is anticipated that future, periodic updates to this Plan may include additional information on ports, airports, rail, and transit systems - as such information is generated by the type of inter-agency collaboration recommended at the end of this section (*See* the "Information Sharing and Education" recommendation below)

Progress on addressing vulnerabilities and climate impacts:

<u>Caltrans Progress:</u>
Following up on the 2009 California Climate Strategy, and in response to the current and anticipated effects of a changing climate, Caltrans has initiated both efforts to reduce the department's greenhouse gas emissions and various readiness measures. Caltrans is collaborating with partners and stakeholders. Measures to support readiness implemented by Caltrans to date include support of needed climate research, preparation of guidance to incorporate climate considerations into the planning and design of projects, and in the ongoing maintenance and operations of State Highway facilities. Below is a list of actions Caltrans has already implemented, and success stories to date:

- Published an April 2013 document titled: *Caltrans Activities to Address Climate Change* that quantifies the amount of greenhouse gas emissions reduced resulting from Caltrans' operations such as new pavement technology and the use of energy efficient roadway lighting systems.
- Participated in a multi-state agency contract with the National Academies of Sciences to conduct a Sea Level Rise Assessment for the West Coast. The study produced sea level rise projections for California, Oregon, and Washington for 2030, 2050 and 2100.

- Developed "*Guidance on Incorporating Sea Level Rise – For Use in the Planning and Development of Project Initiation Documents*", and "*Estimating Sea Level for Project Initiation Documents*" based on the results of the National Academies of Sciences sea level rise report. These documents ensure that Caltrans staff use consistent methodologies when analyzing potential impacts from sea level rise to existing infrastructure and for future projects.
- Formed the internal Caltrans Climate Change Workgroup to foster communications and coordination on various climate change and readiness efforts within the various Caltrans Divisions and District Offices.
- Collaborated with partners, including the Governor's Office of Planning and Research, the California Emergency Management Agency, and the California Natural Resources Agency, to develop the July 2012 California Adaptation Planning Guide to assist local and regional governments in preparing for climate impacts.
- The Caltrans' Office of Highway Drainage Design is developing new design criteria for bridges and culverts in tidally influenced areas. The intent is to update drainage design criteria to consider potential sea level rise in conjunction with flooding events and high tides to ensure bridge and culvert infrastructure (in coastal areas) can adequately facilitate the movement of water under the highway without flooding the roadway.
- Collaborated with the California Department of Fish and Game on the 2010 California Essential Habitat Connectivity Project: A Strategy for Preserving a Connected California. The project was focused on promoting a functional network of connected wild lands essential to survival of California's diverse natural plant and animal communities in the face of climate change and continued human development pressures. The fragmenting effects of roads on habitat are mitigated, while transportation and land-use planning are made more efficient and less costly, and dangerous wildlife-vehicle collisions are reduced. The Project was produced by a highly collaborative, transparent, and repeatable process that can be emulated by other states.
- Working with local municipalities to use recycled and reclaimed water to irrigate landscaped portions of the State Highway System when available. Old watering systems are being upgraded to new efficient Remote Irrigation Control Systems. These systems ensure plants are watered the appropriate amount at the most efficient times. These efforts promote both water and energy efficiency and greater water and energy security supports transportation readiness.
- Participating in an interagency working group developing an Extreme Heat Adaptation Guidance document and working on research and standards for "cool pavement" technologies. "Cool pavements" are paving materials that reflect more solar energy, enhance water evaporation, or have otherwise been modified to remain cooler than conventional pavements in order to reduce temperatures in urban settings.[530] This work is further described below.
- 2013 release of "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs". This document is intended to provide information to Metropolitan Planning Organizations (MPOs) and state designated Regional Transportation Planning Agencies (RTPAs) on possible steps to incorporate

climate change impacts into their long-range transportation plans, or regional transportation plans. This document helps distill down climate planning issues to assist small MPOs and rural RTPAs, given their small staffing levels. Whenever the opportunity arises, Caltrans staff will encourage smaller MPOs and rural RTPAs to consider incorporating climate change impacts into their long-range planning process.[531]

Characterizing Uncertain Sea Level Rise to Support Investment Decisions – Port of LA (PoLA) study

This report was issued in July 2012 as part of the State's Third Climate Change Assessment. The study examined the cost effectiveness of incorporating investments to address sea level rise during capital upgrades. The edge of PoLA's terminals currently lies about 12 feet above mean sea level, however for one of the four PoLA facilities, sea level rise investments during the next capital upgrade appears cost justified.[532]

Impacts of Predicted Sea Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region

This report was issued in July 2012 as part of the State's Third Climate Change Assessment.[533] The population of the Bay Area is almost 7.2 million, and residents take over 21 million trips per day on average weekdays; with 82% of all trips made by automobile, 12% by walking or biking, and 5% by public transit. The nine county Bay Area also has an economy of almost $300 billion, and that economy is highly dependent on goods movement and mobility. The Bay Area has important port, airport, and freight infrastructure in addition to transit and road infrastructure.

Among other things, the 2012 report updated prior analyses with improved data, and also examined how sea level rise, coupled with an extreme storm event, may impair the ability of first responder fire stations to reach communities.

Cool Pavements Bill (Assembly Bill 296 or "AB 296")

In October 2012, the Cool Pavements Bill was signed into law. The bill requires that the California Environmental Protection Agency develop a definition for the term "urban heat island effect"[534], and requires that Caltrans collaborate on research regarding cool pavement technologies and develop a standard specification for sustainable or cool pavements that can be used to reduce the urban heat island effect.

Progress on reducing emissions from transportation:

Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375 or "SB 375")

The Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375 or "SB 375") requires ARB to develop regional greenhouse gas emission reduction targets for passenger vehicles. ARB is to establish targets for 2020 and 2035 for each region covered by one of the State's 18 Metropolitan Planning Organizations. Each of California's MPOs then prepare a "sustainable communities strategy (SCS)" that demonstrates how the region will meet its greenhouse gas reduction target through integrated land use, housing and transportation planning. Once adopted by the MPO, the SCS will be incorporated into that region's federally enforceable regional transportation plan (RTP).

ARB staff released its methodology for reviewing greenhouse gas reductions for an SCS in July 2011, and has already reviewed and issued executive orders accepting Final SCSs from Sacramento Area Council of Governments (SACOG), Southern California Association of Governments (SCAG), and the San Diego Association of Governments (SANDAG).

Advanced Clean Cars
California has a long and successful history of adopting technology-advancing vehicle emission standards to protect public health. In January 2012, the California Air Resources Board approved a new emissions-control program for model years 2017 through 2025. The program combines the control of smog, soot and global warming gases and requirements for greater numbers of zero-emission vehicles into a single package of standards called Advanced Clean Cars.

Low Carbon Fuel Standard
Executive Order S-1-07, the Low Carbon Fuel Standard (LCFS) (issued on January 18, 2007), called for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020.[535] In 2009, the California Air Resources Board adopted a regulation to implement the LCFS. The first-of-its-kind regulation is aimed at diversifying the variety of fuels used for transportation. It boosts the market for alternative-fuel vehicles and will achieve 16 million metric tons of greenhouse gas emission reductions by 2020.[536] In December 2008, eleven states, citing California's LCFS, signed a letter of intent to begin work on a northeast/mid-Atlantic regional low carbon fuel standard.[537]

Alternative and Renewable Fuel and Vehicle Technology Program and Air Quality Improvement Program (Assembly Bill 118 or "AB 118")
Through passage of AB 118 in 2007, the State Legislature created the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) and the California Air Resources Board's Air Quality Improvement Program (AQIP). The ARFVTP and AQIP programs were reauthorized in September 2013, pursuant to Assembly Bill 8.[538]

The Energy Commission's ARFVTP has an annual program budget of approximately $100 million to support projects relating to the development and deployment of alternative and renewable fuels and advanced transportation technologies. ARFVTP provides funding for Zero Emission Vehicle technology fueling infrastructure, such as electric chargers and hydrogen fueling stations, ZEV technology trucks, and advanced technology low carbon biofuels produced from waste-based resources. The program helps spur innovation, attract green investments and business to California, create jobs, and create a safer California by helping the State achieve its climate goals. The California Air Resources Board's AQIP has an annual program budget of approximately $40 million per year, and provides incentive funding for commercially available electric and hydrogen fuel cell electric cars, and ZEV and hybrid trucks.

High Speed Rail

The California High-Speed Rail Authority (Authority) is responsible for planning, designing, building and operating the first high-speed rail system in the nation. By 2029, the system will run from San Francisco to the Los Angeles basin in under three hours. The high speed rail system is expected to relieve congestion related to other transportation modes and reduce greenhouse gas emissions that cause climate change.

The Authority has released a Call to Industry: Sourcing Renewable Power Supplies to solicit guidance and insight about purchasing renewable power sources. To meet the Authority's 100 percent renewable energy goal, the Authority will procure or produce enough renewable energy to offset the amount of energy it takes from the state's power grid to operate trains and facilities. This net-zero approach will increase the environmental benefits and reinforce California's commitment to the renewable energy economy.

The Authority is also working with regional partners to implement a statewide rail modernization plan that will invest billions of dollars in local and regional rail lines to meet the state's 21st century transportation needs.[539] Among the projects in the rail modernization program, is the electrification of Caltrain in the San Francisco Bay Area.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO THE TRANSPORTATION SECTOR

Further collaborative work is needed to continue to enhance transportation readiness in California.

Better understanding of evolving trends that may impact transportation systems

In addition to changing climate conditions, transportation continues to evolve in California. Preparing for climate impacts on California's transportation system must be considered in conjunction with the evolving landscape of California's transportation sector. For instance, there might be a need to:

(1)Better understand the impact and opportunities associated with vehicle electrification and other advanced clean cars on timing and demand for energy supplies (at the same time that climate impacts are occurring and causing changes to energy demand) and better understand the reliability of energy supplies for all vehicles in the face of expected climate impacts. The California Energy Commission already does some of this type of work, for instance in its Energy Demand Forecast, and could further this type of analysis in collaboration with other agencies.

(2) Better understanding of likelihood of land subsidence events that may compromise transportation systems and steps that can be taken to avoid such subsidence if possible. This type of enhanced knowledge will likely take collaboration between a number of entities including the California Department of Water Resources (DWR), Caltrans, SWRCBS, and local and regional governments. Subsidence and more specific recommendations regarding avoiding subsidence are included in the Water section of this document.

Improve the reliability of California's transportation system in the face of expected climate impacts

Action is needed to translate the findings of vulnerability studies described above into actions that improve the reliability of California's transportation system in the face of expected climate impacts. This might include:

(1) Continued integration of climate impact considerations and best available climate science in transportation planning, design, programming, construction, operations and maintenance and updating such efforts as the state of climate science evolves; and

(2) Implementing actions needed to ensure transportation fuel availability and functioning of fuel distribution infrastructure in light of expected climate impacts;

(3) Prioritizing improvements to address climate vulnerabilities in transportation systems, including prioritizing those projects that protect key evacuation routes and modes first; and

(4) For new construction and repairs, using state-of-art materials/infrastructure design to optimize transportation system resilience (against extreme heat, challenges of standing and moving water during extreme weather events including storms and floods) with continued research on materials and design to enhance resiliency of transportation systems.

Further enable incorporation of anticipated climate impacts into transportation plans

As noted above, pursuant to SB375 MPOs have been developing sustainable community strategies for incorporating regional greenhouse gas emission reduction targets in regional transportation plans. As also noted above, the 2013 document "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs" provides guidance to MPOs and RTPAs on possible steps to incorporate climate impacts into long-range transportation planning. As the 2013 guidance document notes, there is currently no requirement to incorporate climate impacts into regional transportation planning, and MPOs and RTPAs have varying capacity and resources to do so. The Strategic Growth Council currently administers a grant program for cities, counties, MPOs, regional transportation planning agencies, joint power authorities and councils of governments to assist with implementation of SB375; a certain amount of that grant funding is prioritized for projects in disadvantaged communities.[540] A similar grant program might help enable incorporation of climate impacts into sustainable community strategies and/or regional transportation plans.

Better understanding of expected climate impacts to inform transportation planning

(1) There is a continued need for <u>regional climate model downscaling</u>, particularly near major population centers, to provide more detailed information regarding anticipated, California-

specific climate impacts - so that such information can inform transportation planning. This type of work will be further described in the forthcoming California Climate Research Plan.

(2) There is also a need for better understanding of the specific vulnerabilities of transportation infrastructure (ports, roads, airports, transit systems) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As noted above, transportation infrastructure in California is managed by a variety of federal, state, local/regional, and private entities. These types of infrastructure vulnerabilities would likely need to be conducted by the entities most directly responsible for the particular infrastructure in question; enabling funding, staffing and/or other technical assistance for the vulnerability assessments might be necessary. For instance, for Caltrans to do a complete vulnerability assessment of the 50,000 lane miles, bridges and culverts under its jurisdiction would require approximately $5 million. The most appropriate form of assistance for a vulnerability assessment would be dependent on what type of entity is conducting the assessment (for instance, grant assistance might be appropriate for local/regional entities).

(3) There is a need for better understanding of specific vulnerabilities of fueling infrastructure: (refineries, pipelines, marine terminals, underground storage tanks, and fueling stations) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with transportation infrastructure, the entities most directly responsible for the fueling infrastructure in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary; and the appropriate form of assistance would vary according to the assessment.

(4) Better understanding of the specific vulnerabilities of energy systems supporting refineries, fueling stations, transit systems, and other important parts of California's transportation system to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with the above, the entities most directly responsible for the particular energy systems in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary. The CEC, ISO, and PUC would likely be the entities involved in this type of assessment. The work of these entities is further described in the Energy section of this document.

(5) In order to aid prioritization of needed changes in transportation planning and operations, the vulnerability assessments referenced above should include consideration of both the probability of impacts and the magnitude of potential damages, transportation disruptions, injuries and loss of life.

Information Sharing and Education

(1) While many agencies are beginning to incorporate climate impacts and considerations into planning and operations, information sharing and collaboration between agencies could expedite the learning process regarding best practices for transportation management in the era of climate change. The state could help convene an interagency task force on reducing risks to California transportation; such a task force should include federal, state, local/regional agencies and appropriate transportation, water, energy planning professionals. Caltrans might be an intuitive choice for leading such a convening effort.

(2) An interagency task force on reducing risks to California transportation might assist in the development of training tools and guidance for transportation professionals regarding incorporating climate impacts and considerations into transportation planning, design, programming, construction and operation and maintenance. The development of such tools and guidance may require funding and staff support.

Box 66

California Transportation

Several state entities play an important role with respect to transportation in California. The state also has important federal, local and private sector partners with respect to transportation. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks.

California Department of Transportation (Caltrans) is responsible for improving the mobility, safety, and environmental quality of the state's multi-modal transportation system. Caltrans operates, maintains, and develops the State Highway System; supports aviation activities by promoting safe and effective use of existing airports and heliports; provides leadership in the implementation of safe, effective public transportation; and implements statewide transportation policy through coordination at the local and regional levels and the development of transportation plans and projects.

California Energy Commission helps plan for and direct responses to energy emergencies.

California High-Speed Rail Authority (Authority) has a mission to plan, design, build, and operate a high-speed train system for California.

California Independent System Operator Corporation (CAISO) is a nonprofit public benefit corporation that manages the flow of electricity across the high-voltage, long-distance power lines that make up 80 percent of California's power grid.

California Public Utilities Commission (CPUC) has regulatory and safety oversight over railroads, light rail transit agencies, and rail crossings.

California State Water Resources Control Board (SWRCB) regulates petroleum underground storage tanks, water quality issues that result from use of the CalTrans road system, and water quality issues at ports and airports.

State of California Office of State Fire Marshal (SFM) regulates the safety of approximately 5,500 miles of intrastate hazardous liquid transportation pipelines and acts as an agent of the federal Office of Pipeline Safety with respect to the inspection of more than 2,000 miles of interstate pipelines. This office also has operational oversight regarding restoration of petroleum product pipeline service following temporary closures associated with pipeline failures or leaks.

California State Lands Commission (SLC) develops and oversees compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS). These standards apply to all existing and new marine oil terminals in California, and include criteria for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, fire, piping, mechanical and electrical systems. The purpose of these standards is to increases the integrity of existing facilities to better withstand earthquakes and tsunamis, thus reducing the risk of petroleum spills and temporary loss of the ability to receive and export transportation fuels at marine terminals.

Several federal agencies are important partners for California on transportation issues. The **Federal Transit Administration (FTA)** has primary federal responsibility for public transit systems. The **U.S. Department of Transportation Federal Aviation Administration (FAA)** has primarily regulatory authority over airports. The **U.S. Department of Transportation Federal Highway Administration (FHWA)** supports the State and local governments in the design, construction, and maintenance of the national highway system. The **U.S. Department of Transportation Maritime Administration** assists major ports in redevelopment plans, provides expertise on port financing and port infrastructure, and is the licensing agency for deep water LNG ports. The **Federal Energy Regulatory Commission (FERC)** has authority for oil pipelines as well as the operation and reliability of proposed and operating liquefied natural gas (LNG) terminals. The **Federal Maritime Commission (FMC)** is the federal agency responsible for regulating the U.S. international ocean transportation system.

Various local government agencies and private entities manage other transportation facilities. Local streets and roads are operated and maintained by cities and counties and many rail lines are privately owned. Ports may be operated by a state, a county, a municipality, a private corporation, or a combination. California has eleven publicly-owned, commercial ports.[541] Local authorities may also own and operate airports – for instance, the aviation unit of the Port of Oakland, which is an autonomous division of the City of Oakland, owns and operates the Oakland International Airport.[542]

WATER

INTRODUCTION

California's water resources support nearly 40 million people, many more millions of aquatic and terrestrial plants and animals including salmon and steelhead and California Redwoods and Sequoias, trillions of dollars of economic activity, millions of acres of the most productive farmland in the world, and a bountiful array of landscapes and ecosystems. But California's water supplies and water demands are not equally distributed throughout the state, and management and stewardship of water has been a constant source of tension throughout the history of California. Climate change adds new vulnerabilities and exacerbates historical challenges to California water management. Adapting California's water sector to the impacts of climate change will require a coordinated effort between federal, state, and local governments, businesses, and California's residents.

The water sector in California is influenced by a Mediterranean climate where water systems are designed to store water for dry months, provide winter and spring flood protection, and to address considerable year to year hydrologic variability. It is this very Mediterranean climate that enables the bountiful resources, diversity and economic vitality that is California. The major impacts of climate change on California's water sector may be changes in the timing, form, and amount of precipitation, changed runoff patterns, increases in the frequency and severity of extreme precipitation events (floods and droughts), and sea level rise.

Since the release of the 2009 California Climate Adaptation Strategy, significant progress has been made on improving water use efficiency, flood protection, developing scientific knowledge about climate risks to California's water supplies; however, more opportunities exist to enhance the resilience of the state's water supplies. These accomplishments and further needs are discussed in more detail below.

Management of California's water resources is complex and occurs at federal, state, regional and local levels. Some of the federal and state agencies involved in the management of water resources are listed at the end of this chapter in the Box 73*: California Water Management.*

Climate Risks to California's Water Resources

The major impacts of climate change on California's water sector may be changes in the timing, form, and amount of precipitation, changed runoff patterns, increases in the frequency and severity of extreme precipitation events (floods and droughts), and sea level rise. These impacts can negatively affect both water supplies and water quality.
Climate changes may also change water demand and alter other conditions (such as increasing wildfire risks) that impact the water sector as well. (For more information about climate and wildfire risks, please see the Forestry section of this document.)

Furthermore, climate changes that impact water supply, demand and quality occur against the background of other stressors on the California water system including continued population growth and urbanization. The “Climate Change: Stressing Our Water Systems” graphic below summarizes expected climate impacts on California’s water (see Box 69).

Changes in Precipitation and Runoff

Changes to precipitation and the timing and volume of runoff will challenge the operational flexibility of California’s multi-purpose water management systems.

Higher temperatures will mean that more precipitation falls as rain instead of snow, and the remaining snowpack melts and runs off earlier in the year.[543] Delays in snow accumulation and earlier snowmelt will have many related impacts including impacts on water supplies, natural ecosystems, and winter recreation.[544] (See **Box 70 Opinion: California's vanishing snowpack is another victim of climate change** By Forrest Shearer) While flows may be higher in winter, water levels in waterways and reservoirs may be lower in spring and summer; water supply for a variety of uses including hydropower and energy generation,[545] agriculture, recreation, and environmental uses will likely be reduced during the times of year when it is most needed.[546] For instance, hydropower generation may decline during summer months, at the same time that climate changes, such as increased temperatures and extreme heat waves, increase summer energy demand for air conditioning.[547] (For more information on climate impacts on the energy system, please see the Energy section of this document.)

California’s snowpack has historically stored about 15 million acre-feet of water and this amount of naturally occurring water storage has been an integral part of California’s water-supply systems. Snow has traditionally added about 35 percent to the reservoir capacity available to water managers in the state, carrying water over from California’s winter wet season to the summer dry season.[548] The water management community has invested in, and depends upon, a system based on historical conditions; modifying management, operations (see information below on system reoperation), and infrastructure will be necessary to attune the system to a changing climate.[549] By 2050, scientists project a loss of at least 25 percent of the Sierra snowpack.[550] Other forms of storage, whether surface storage or groundwater storage, can help save water when flows are high for use at times when flows are low. Above ground, or surface storage, can be in the form of large on-stream dams and reservoirs, large off-stream dams, or smaller on-stream and off-stream reservoirs. Groundwater storage consists of replenishing groundwater basins either directly through injection, or by allowing water to percolate into the ground naturally or from constructed spreading basins.[551] New storage capacity will be needed as Sierra snowpack declines.

California precipitation is variable not only between seasons (wet in winter and dry in summer), but also over the geographic range of the state. Many climate models predict that the disparity in precipitation between various parts of the state will be even greater in the future, with the southern part of California becoming drier.[552]

System reoperation means changing existing operation and management procedures for existing reservoirs and conveyance facilities to increase water related benefits from these facilities or to adapt to changing climate and hydrologic conditions. System reoperation may improve the efficiency of existing water uses (e.g., irrigation) or it may increase the emphasis of one use over another. Although reoperation is generally regarded as an alternative to construction of major new water facilities, physical modifications to existing facilities may be needed in some cases to expand the reoperation capability. Legal changes also may be needed. DWR has a System Reoperation Program.[553]

Box 67

California Department of Water Resources
Shasta Reservoir; March 13, 2009; showing low water levels

Increased Hydrologic Variability and Extreme Events

California has always experienced wide year-to-year and seasonal variability in precipitation. However, climate change is expected to increase that variability.

Flood

More than seven million Californians are currently exposed to flooding hazards within 500-year floodplains.[554] With climate change, extreme rainfall events are expected to increase in frequency and magnitude. A warmer atmosphere contains more water vapor and more moisture is available to form precipitation in extreme events and to provide additional energy to further intensify such events.[555] More frequent and more severe floods in California are projected.[556]

Flooding can lead to a variety of public health concerns, including water quality impacts, safety issues, property damage, mold in damp buildings, displacement and post-disaster mental health issues.[557]

Box 68

California Department of Water Resources
Flooding - Levee damage

<u>*Drought*</u>

Droughts are also expected to increase in frequency, duration, and intensity; and drought affects all sectors - impacting public health, biodiversity, agriculture, and the economy.[558] (See the Public Health, Biodiversity and Habitat, Agriculture, and Emergency Management sections of this document for more information.)

During droughts, groundwater use will likely intensify, potentially resulting in increased overdraft and subsidence (which can result in permanent loss of storage and damage to overlying infrastructure, including flood management and transportation facilities), and further stressing groundwater-dependent ecosystems. Agriculture relies extensively on the state's aquifers; groundwater is the only source of water for much of our most productive farmland, and agricultural water needs are likely to be heightened during prolonged hot and dry periods. Groundwater is also often the only source of water for small, rural water systems and households, which may lack the technical, managerial, and financial capacity to respond to drought conditions.

Drought can also impact water quality. Shrinking amounts of water can concentrate contaminants such as heavy metals, industrial chemicals and pesticides, and sediments and salts.[559]

Many of California's groundwater basins have been contaminated from industrial discharges, municipal wastes, and agriculture. Once contaminated, groundwater is difficult to clean up and may no longer be suitable for its intended use. To meet future demand, which is expected to increase, effective groundwater management will need to ensure that groundwater quality and quantity is maintained at sustainable levels that support the beneficial uses of water over the long-term.

To mitigate potential shortages during drought, a variety of measures may be utilized. State, regional and local agencies have increasingly been pursuing a strategy of making regions more self-reliant by developing new or underused water resources locally; improving water storage capacity may be another important strategy for preparing for drought risks. For instance, new or underused water resources may come from including: improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, conjunctive use (coordinated management of local surface and groundwater), desalination, and groundwater remediation. Temporary shortages during drought may also be addressed by firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements.[560]

<u>Sea Level Rise</u>

Sea level rise also poses a critical threat to the California water sector, particularly for water supplies exported from the Sacramento-San Joaquin Delta. Increased salinity intrusion into the Delta threatens these water supplies.[561] In addition, coastal groundwater aquifers are already vulnerable to salinization, which will be exacerbated by rising seas; new and innovative management techniques for protecting aquifers from salinity intrusion may be needed.[562]

As further discussed in the Oceans and Coastal Ecosystems and Resources chapter, wastewater treatment systems may also be threatened by sea level rise.

Changing Water Demand & Other Climate Stressors on California's Water Systems

<u>Changing water demand</u>

As climate is expected to impact precipitation and runoff, it is also anticipated to impact water demand. For example, as further discussed in the Agriculture section of this document, warmer temperatures are anticipated to cause a demand for more water for irrigation.[563]

<u>Potential for subsidence and reduced flows from intensified groundwater use</u>

Climate change may increase water demand and lead to intensified groundwater use. In California, water use already shifts drastically from surface water to groundwater during dry years, and as climate change is likely to increase the severity and duration of dry years, groundwater use is expected to intensify, potentially resulting in increased overdraft and subsidence (as further described below).

Many of California's groundwater basins are already in overdraft, with groundwater being used faster than it is being replenished and groundwater levels declining.[564] Overdraft can cause land subsidence (land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to movement of materials below the Earth's surface, such as the withdrawal of underground water[565]). The effects of subsidence may include strain on houses and other structures such as transportation infrastructure, increased exposure to flooding in lowland coastal areas, water well casing failures, and changes to the elevation and gradient of stream channels, drains, and other water transport structures.[566] Subsidence can also permanently reduce the capacity of aquifers to store water.[567]

Where groundwater withdrawals are hydraulically linked to such surface flows, intensified groundwater use can also lead to reduced surface flows, which may already be low due to climate-related changes in precipitation and runoff.[568]

<u>Wildfire and erosion impacting watersheds</u>
As discussed in the Forestry section of this document, climate change is also expected to cause more frequent and severe fires. Burned watersheds are prone to increased flooding and erosion, which can impair water-supply reservoirs (e.g. with high sediment loads reducing the storage capacity of reservoirs), water quality, and drinking-water treatment processes (greatly increasing water treatment costs).[569]

<u>Thermal changes affecting aquatic habitat</u>
Slow and low flows in waterways can lead to increased water temperatures that can negatively impact aquatic species; increased air temperatures can also increase water temperatures in the same area. Many aquatic species depend on certain temperature ranges for suitable habitat, and increases in water temperature can negatively impact such species.[570] For instance, the September 2002 Klamath fish kill was an unprecedented adult salmonid mortality event; the Klamath fish kill was caused by a number of factors including unusually warm water temperatures and low flows.[571] (For information regarding climate impacts to marine waters, please see the Oceans and Coast Ecosystems and Resources section of this document.) Climate impacts to aquatic species can have negative impacts on subsistence, recreational and commercial fishing. (See, for example, Box 7 Declining snowpack and the loss of a fly fishing dream in the Biodiversity and Habitat section of this document.)

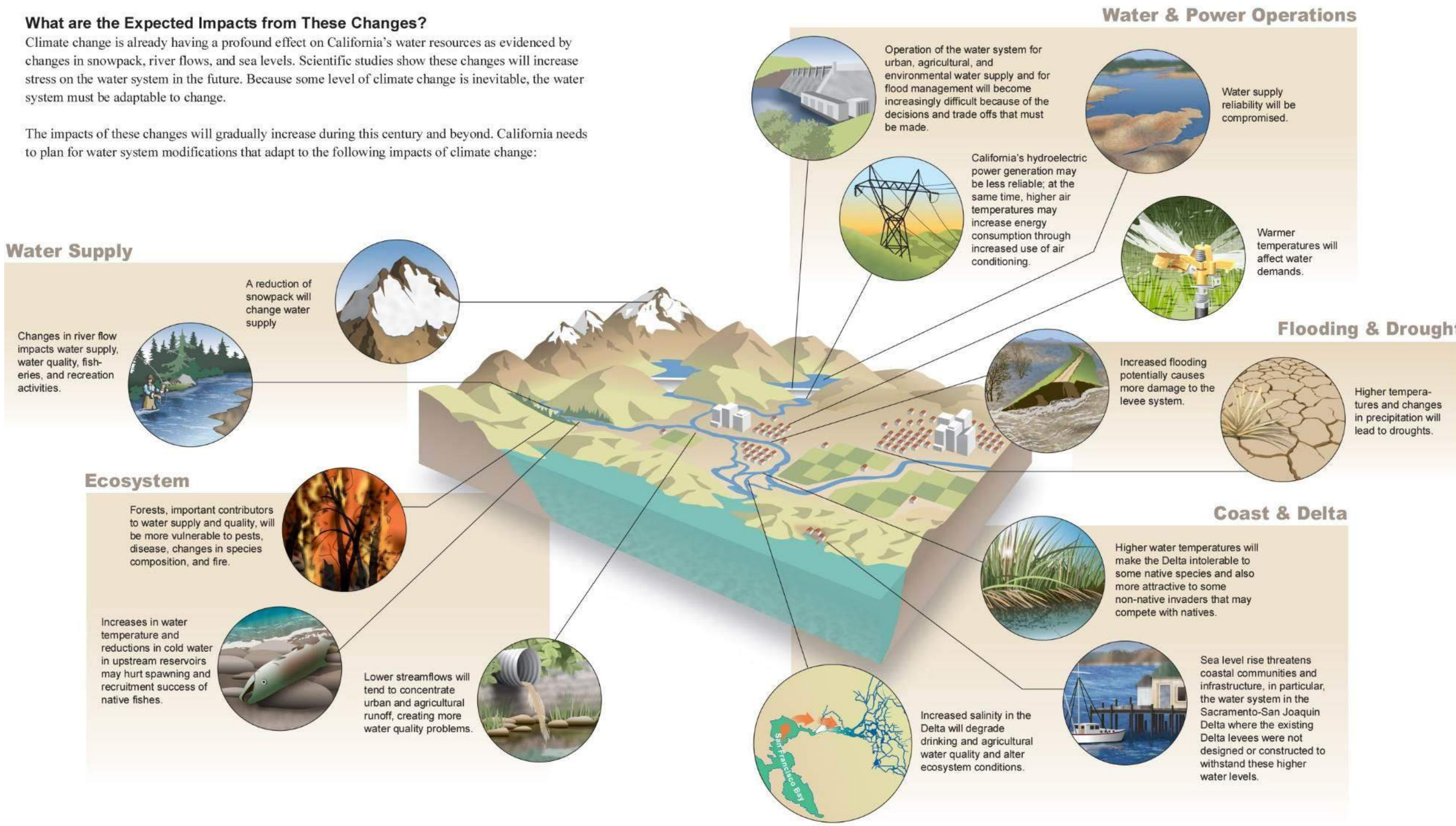
Box 69

Climate Change: Stressing Our Water Systems

What are the Expected Impacts from These Changes?

Climate change is already having a profound effect on California's water resources as evidenced by changes in snowpack, river flows, and sea levels. Scientific studies show these changes will increase stress on the water system in the future. Because some level of climate change is inevitable, the water system must be adaptable to change.

The impacts of these changes will gradually increase during this century and beyond. California needs to plan for water system modifications that adapt to the following impacts of climate change:



Box 70

Opinion: California's vanishing snowpack is another victim of climate change
By Forrest Shearer (October 2012) [Used with permission]


As a professional snowboarder lucky enough to ride mountains around the world, I have seen the impacts of climate change first-hand. I've seen once-famous slopes now with zero snow, ski resorts that have shut down, and glaciers that are disappearing.

In my native state of California, boarders and skiers are bracing for the effects of a warmer world. Scientists are predicting the Sierra snowpack will decline by 25 percent by 2050. We caught a preview this past ski season, when Lake Tahoe and Squaw Valley had to make their own snow well into February. It's no wonder the California Ski Industry Association is a big supporter of AB 32, the state's landmark clean energy and climate law.

But whether or not you've ever strapped on a board or some skis, all Californians should get behind the state's groundbreaking efforts to save energy and tackle climate change. Because sooner or later, our changing climate will affect all Californians.

Consider that declining mountain snowpack I mentioned. It's not just important for skiers and boarders and the businesses that rely on them. It also provides about one third of California's drinking water.

Or look at the record heat that's been roasting parts of California, along with much of the rest of the country. It's been epic; in fact, July was the hottest month on record for the continental United States, with drought covering almost two-thirds of the lower 48 and wildfires burning up two million acres.

Scientists tell us that extreme heat will become more and more common as the world warms. And we can expect more severe droughts, heavy rainfall events, and other extreme weather, as well as more wildfires.

Communities in vulnerable areas across the country are already feeling the burn of global warming. Through a program with the environmental nonprofit, Protect Our Winters, called "Hot Planet/Cool Athletes," I go to schools in mountain communities throughout the U.S. to talk about climate change.

Through these visits, I've seen that young people get it. Their future depends on a healthy environment, and they are committed to doing their part. At one school, a teacher talked about the school's recycling efforts, and said anyone who wanted to get involved should see a student who was in charge of the whole program. I was very impressed with that kid and it's my hope that today's young students become tomorrow's environmental leaders.

But we shouldn't put the burden on kids to protect the environment.

Adults have to take responsibility for the mess we've made and not leave it for future generations to clean up.

So far, California is doing pretty well. The first step in tackling climate change is burning less fossil fuel, and California leads the nation in energy efficiency. Then you develop alternative energy sources that are cleaner or that don't pollute at all. California leads the country in solar power, wind power, and electric vehicle deployment. And now with AB 32, we will show the nation how to create a successful market-based system for reducing emissions.

What Californians do is especially important, because what happens here will be imitated elsewhere. Californians are trendsetters, especially when it comes to influencing younger people. Surfing, skateboarding, and snowboarding started here, movies and television shows are made here, and environmental trends get started here - the rest of the country, and much of the world, ends up following our lead. Through AB 32 and other smart energy policies, California is blazing a trail to a sustainable clean energy future.

For some people, it's too much. They want us to slow down. But we can't stop now.

When you're tackling gnarly terrain on a snowboard, you can't hesitate. You have to know that you've trained, trust your instincts, and commit yourself fully. California has made a great start on a rad run. Let's stay committed.

Forrest Shearer grew up as a Southern California surfer and is now a professional snowboarder. His California-based sponsors include Patagonia, Clif Bar, Sanuk, and Jones Snowboards. He works with Protect our Winters, the Alliance for Climate Education, and the Action Sports Environmental Coalition.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

These activities highlight that climate change planning and preparedness have been areas of focus for the State’s water managers for decades and have only grown in importance and urgency in recent years.

Since as early as 1987, the California Department of Water Resources (DWR) has been conducting research on changing climate conditions and alerting the public to potential changes that could affect water supplies. The 2005 Update to the California Water Plan included a substantial discussion of potential impacts of climate change on the water sector, a first for a major state planning process.

Since the *2009 California Climate Adaptation Strategy* was released, significant progress has been made with respect to improving understanding of the climate risks to the state's water sector and preparing for those risks.

California Water Action Plan
In January 2014, the California Natural Resources Agency, the California Environmental Protection Agency, and the California Department of Food and Agriculture released the final California Water Action Plan, laying out California's water-related goals and vision for the next five years.[572] The plan will guide state efforts to enhance water supply reliability, restore damaged and destroyed ecosystems, and improve the resilience of our infrastructure.

Key actions identified in the Plan include:

- Make conservation a California way of life.
- Increase regional self-reliance and integrated water management across all levels of government.
- Achieve the co-equal goals for the Delta.
- Protect and restore important ecosystems.
- Manage and prepare for dry periods.
- Expand water storage capacity and improve groundwater management.
- Provide safe water for all communities.
- Increase flood protection.
- Increase operational and regulatory efficiency.
- Identify sustainable and integrated financing opportunities.

Water use efficiency, groundwater reporting, and recycled water
In November 2009, Governor Schwarzenegger signed SB7x7, or the Water Conservation Act of 2009, into law. SB7x7 requires a statewide 20 percent reduction in urban per capita water use by the year 2020 ("20x2020").[573] SB7x7 also directed DWR, in consultation with the California Agricultural Water Management Council, academic experts, and other stakeholders to develop and report to the Legislature a proposed methodology for agricultural irrigators, farmers and ranchers to use in quantifying the efficiency of agricultural water use and a plan of implementation that includes estimated implementation costs, roles and responsibilities, and types of data that would be needed to support the methodology. "A Proposed Method for Quantifying the Efficiency of Agricultural Water Use: A Report to the Legislature" was released in May 2012.[574]

In 2009, the Governor and Legislature also enacted SB 7x6, which requires the reporting of groundwater levels to DWR.[575]

In 2009, the Water Boards also approved the Recycled Water Policy, which promotes sustainable local water supplies that help adapt to climate change.[576] In 2010, the California

Public Utilities Commission (CPUC) instituted a rulemaking for development of a comprehensive policy framework for recycled water use by the larger investor owned utilities.[577]

In 2009, the Governor and the Legislature enacted SB 918 to amend the Water Code, and require, among other things, the adoption of uniform water recycling criteria for indirect potable water reuse for groundwater recharge and an investigation of the feasibility of developing uniform water recycling criteria for direct potable reuse.[578]

Preparing for climate change in the Delta

The Delta is an extremely important part of the state's water system, serving two-thirds of our state's populations and providing irrigation water for millions of acres of farmland. The region supports wetland and riparian habitats, as well as numerous fish and wildlife species. In recent years, important fish populations have declined dramatically, leading to historic restrictions on water supply deliveries. The current system also relies on water flowing through a network of fragile levees that are vulnerable to a variety of climate risks including floods and sea level rise, as well as other stressors such as seismic events.

There are currently three major planning activities underway to address the problems in the Delta: the State Water Resources Control Board's Bay-Delta Water Quality Control Plan update (Water Quality Control Plan), the Delta Stewardship Council's Delta Plan (Delta Plan), and the Bay-Delta Conservation Plan (BDCP).

The Water Quality Control Plan update will eventually determine the amount and timing of water entering, moving through, and exported from the Delta watershed. Many interests representing federal, state and local agencies, water users, non-governmental organizations, the scientific community and the public are participating in the current Water Quality Control Plan update, which is scheduled for completion in 2014.

The Delta Plan became effective with legally-enforceable regulations on September 1, 2013. The Delta Plan's provisions further the state's coequal goals for the Delta: improve statewide water supply reliability, and protect and restore a vibrant and healthy Delta ecosystem, all in a manner that preserves, protects and enhances the unique agricultural, cultural, natural resource and recreational characteristics of the Delta.[579]

BDCP is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin Delta ecosystem and securing California water supplies. The BDCP would secure California's water supply by building new water delivery infrastructure and operating the system to improve the ecological health of the Delta. The BDCP also would restore or protect approximately 145,000 acres of habitat to address the Delta's environmental challenges. The BDCP is made up of specific actions, referred to as Conservation Measures, to improve the Delta ecosystem. The BDCP includes 22 conservation measures aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework. As the Delta ecosystem improves in response to the implementation of the conservation measures, water operations would become more reliable, offering secure water supplies for 25 million Californians, an agricultural industry that feeds millions, and a thriving economy.[580] (Additional information on BDCP can be found in the Biodiversity and Habitat section of this document, in the Box 11 "Innovative land-use planning to balance multiple objectives".)

Supporting Local Water Management

For the last 11 years, DWR and the Water Boards have funded local and regional water planning through the Integrated Regional Water Management (IRWM) Program. In 2008, the Legislature formally added climate change adaptation as a required element of eligible plans. DWR updated the IRWM Guidelines to meet this requirement in 2010 and further refined the guidelines in 2012. In order to assist regional planners with meeting this new requirement, DWR placed full-time climate change specialists in each of its four regional offices to provide technical assistance and outreach to IRWM planning groups, water agencies, and local governments working on incorporating climate change mitigation and adaptation into their planning activities. DWR requires a climate change vulnerability assessment for every regional water management plan.[581]

In a related effort to provide additional technical guidance to IRWM groups, DWR partnered with the US Environmental Protection Agency, the US Army Corps of Engineers (USACE), and the Resources Legacy Fund to develop the *Climate Change Handbook for Regional Water Planning,* a comprehensive guide to assessing vulnerabilities and incorporating climate change into water management plans.[582]

Reducing Flood Risk

The state has taken several recent steps to improve land use decision-making and public safety in flood-prone areas:

- Assembly Bill 162, passed in 2007, requires cities and counties in the State to annually review the general plan land use element within "those areas covered by the plan that are subject to flooding identified by floodplain mapping prepared by the Federal Emergency Management Agency (FEMA) or the Department of Water Resources."[583]
- In 2010, DWR published "Implementing California Flood Legislation Into Local Land Use Planning: A Handbook for Local Communities", an award-winning guidance document to aid cities and counties in implementing the 2007 flood risk management legislation, specifically including considerations of climate change in land use planning decisions in floodplains.[584]
- In 2013, DWR and the U.S. Army Corps of Engineers (USACE) released *California's Flood Future: Recommendations for Managing California's Flood Risk*, a report that shows $580 billion in assets are exposed to flood risk throughout the state and 7 million Californians live in a floodplain. The report provides a comprehensive look at flooding, along with challenges and recommendations for improving flood management.[585]

- The Water Boards adopted some of the first permits in the nation to emphasize land use as a key provision in its stormwater permits that also provides flood management protection.[586]
- The California Building Code was updated to incorporate voluntary regulations to help flood-proof residential construction.[587]
- DWR updated the Urban Levee Design Criteria to incorporate advanced engineering approaches, including climate change considerations.[588]
- The 2012 Central Valley Flood Protection Plan provides a framework for modernizing flood management and investment in the Central Valley.[589]
- As further described in the Ocean and Coastal Ecosystems and Resources section of this document, construction of four coastal observatories in 2013 – in Eureka, Bodega Bay, Big Sur, and Santa Barbara – that will improve flood watch and flood warning information that can be provided to local emergency responders.

Mainstreaming Climate Considerations in Water Management

The state continues to improve the incorporation of climate change information in its water planning and management activities. For instance, in the *California Water Plan Update 2009,* the State's strategic plan for water resources, DWR included a robust analysis of 12 future climate change scenarios and outlined myriad Resource Management Strategies that can be used by State and regional water managers to improve water supply reliability and quality.[590] The *California Water Plan Update 2013* will include additional scenarios, tools, and analysis that provide state leaders and local decision makers with additional information about future changes in California's water resources.[591]

Education and outreach are important components of the DWR Climate Change Program. DWR convenes the Climate Change Technical Advisory Group (CCTAG) to advise agencies on the scientific aspects of climate change, its impacts on water resources, the use and creation of planning approaches and analytical tools, to inform the development of adaptation responses for California's water sector.[592] The DWR Climate Change Program offers two classes to DWR staff. They include Climate Literacy 101 for all staff and Climate Literacy 201 geared toward project managers and others who need to understand climate modeling and environmental documentation. The classes are so well-attended that six such classes were offered within the first year.[593] DWR has also established climate change exhibits at local science centers as well as online educational climate videos.[594]

Continued Research

Several major research initiatives were also initiated or completed since 2009. DWR served on the steering committee for the Third California Climate Change Assessment which was completed in 2012; and a significant portion of the Third California Climate Change Assessment was dedicated to water-focused research.[595] DWR also serves on the Steering Committee for the California Landscape Conservation Cooperative.[596]

As discussed in the Oceans and Coastal Ecosystems and Resources chapter, the National Research Council (NRC) completed a comprehensive study of sea level rise along the West Coast in 2012. The States of California, Oregon, Washington, and three federal agencies co-sponsored the NRC study, with DWR as the project manager.[597]

DWR has also initiated a study to develop tree-ring reconstructions of paleo-stream flows in the Sacramento, San Joaquin, and Klamath River Basins. This study will extend the hydrologic record beyond the relatively short modern observational period and will thus provide an improved picture of climate variability.

Box 71

Local Actions to Prepare for Climate Risks to Water – Los Angeles

Los Angeles is implementing a number of actions to prepare for climate risks to its water supply, including water conservation measures and locally-developed water supplies to reduce its dependence on imported water.

Under the City of Los Angeles Water Conservation Ordinance (Ordinance) restrictions on certain water uses apply at all times, to all customers.[598] Some of these prohibited uses include:

- Watering landscape between the hours of 9:00 a.m. and 4:00 p.m.
- Watering of any hard surfaces such as sidewalks, walkways, driveways or parking areas;
- Outdoor watering during periods of rain;
- Allowing runoff onto streets and gutters from excessive watering;
- Allowing leaks from any pipe or fixture to go unrepaired;
- Washing vehicles without using a hose with a self-closing water shut-off nozzle;
- Serving water to customers in restaurants unless specifically requested.

The Ordinance contains five water conservation “phases” which correspond to severity of water shortage, with each increase in phase containing more stringent conservation measures. Awareness and enforcement efforts are conducted by the LADWP Water Conservation Response Unit whose mission is to stop wasteful water practices. During times of severe drought, the Response Unit actively patrol Los Angeles communities to help inform customers of water waste they observe in progress and learn about through tips from neighbors and concerned citizens. First offenses are given verbal “warning” in the form of water conservation tips, water saving devices where possible and printed educational materials in order to raise customer awareness. Subsequent violations, however, can result in fines. Monetary citations, when given, range from $100 to $600 and are listed as specific charges on the LADWP utility bill. No monetary citation is given without prior warning.[599]

The Los Angeles Department of Water & Power (LADWP) has also embarked on a sustainability plan to increase its local water supply and decrease its reliance on imported water by making significant investments in conservation, stormwater capture, water recycling, and the remediation and cleanup of groundwater contamination in the San Fernando Basin (SFB)[600] As laid out in the 2010 Urban Water Management Plan (UWMP), ambitious long term goals for these local water supplies are projected through 2035.

On October 4, 2012, the Board of Water and Power Commissioners (Board) adopted the Board Resolution "LADWP Guiding Principles for the Development and Implementation of the Local Water Supply Program" which called for LADWP to generate a plan to accelerate local water supply development and remediate contamination in SFB beyond the goals set in the 2010 UWMP. As a result of this Board Resolution, LADWP began developing an initiative entitled "LA's Water Reliability 2025."

Preliminary findings of LA's Water Reliability 2025 show that LADWP can potentially meet its 2010 UWMP goals for local water resource development about a decade early by accelerating plans to implement specific stormwater capture, water conservation, recycled water projects and programs, and remediation of contamination in the SFB.

LADWP completed a study in June 2011 to analyze the operational and water supply impacts of potential shifts in the timing and quantity of runoff along the Los Angeles Aqueduct (LAA) system due to 21st Century climate change. Projected changes in climate expected to alter hydrologic patterns in the LAA's eastern Sierra Nevada Watershed include decreased precipitation, earlier snowmelt, increased ratios of rain to snow, increased variability of winter storm patterns, and increased evapotranspiration.

Changes in climate are also projected to increase the amount of rainfall and decrease the amount of snow that would occur in the Sacramento and San Joaquin rivers watersheds, thereby affecting State Water Project supplies from the Sacramento/San Joaquin River Delta. Local groundwater water supplies also expect considerable changes in recharge from precipitation as well. In addition to these water supply impacts, changes in local temperature and precipitation are anticipated to alter in-city water demand patterns.

LADWP is continuing to monitor developments in climate change science to better understand potential implications for the City's local and imported water supplies and in-city demands.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA WATER RESOURCES

Vigorously prepare California for flooding

Flooding currently presents a clear and present danger to public health and safety that will only worsen with climate change. As noted above, more than seven million Californians are currently exposed to flooding hazards within 500-year floodplains.[601] California remains underprepared for this current and growing threat, and the following actions are recommended:

- Protect taxpayer investments by requiring that DWR and SWRCB formally consider and account for climate risk in all water infrastructure planning, design, permitting, and funding, including loans and grants to local agencies;

- Expand the Western Observing and Forecasting System to allow for offshore observations that will provide greater forecast lead times for coastal communities;

- Conduct a vulnerability assessment of critical State-owned infrastructure located in the state's floodplains;

- Expand piloting and begin implementation of forecast-based operations to allow more flexibility to operate existing reservoirs for changing climate conditions;

- Given the concentration of State government facilities and functions in Sacramento, prepare a catastrophic disaster response and recovery plan for the Sacramento metropolitan area, in collaboration with local and regional governments and other partners;

- Continue work to implement critically needed repairs to California's levee system; and

- Reconnect rivers to their floodplains, rehabilitate upper watershed source areas, and provide more natural floodplain features and functions that slow, spread, capture, and infiltrate floodwaters throughout a watershed. Specifically,

  - improve stewardship of forests and headwaters to reduce the risks of catastrophic wildfire and downstream flooding impacts; and

  - expand existing and establish new flood bypasses.

Support regional groundwater management for drought resiliency

While California's largely decentralized regime for groundwater management presents significant challenges to adapting to climate change, it presents significant opportunities as well. For example, regionally managed groundwater recharge, storage, and conjunctive use (the coordinated management of surface and groundwater) can play a key role in compensating for the loss of natural water storage as the Sierra Nevada snowpack diminishes. Many local and regional groundwater management agencies also have the authority and capacity to: 1) establish thresholds for groundwater drawdown, quality, and subsidence; 2) monitor groundwater conditions; and 3) take actions to manage demand when needed to avert problems. State level support and oversight should be provided where needed to ensure the success of local and regional management efforts.

California must take steps now to ensure that its aquifers will help make its water systems climate resilient. Below are some recommended actions. Funding and staffing will be needed to implement many of these actions.

- Promote better understanding about California's groundwater, conjunctive use, and the potential risks associated with changing climatic conditions, including examples of groundwater crises already occurring in the state and projections on the condition of California's groundwater basins in 20 years, based on current groundwater management practices and climate projections.

- Strengthen and expand the California Statewide Groundwater Elevation Monitoring (CASGEM) Program established by SB 7x-6, to ensure continued groundwater level monitoring in areas where voluntary monitoring is not occurring, statewide prioritization of basins, and identifying basins subject to critical overdraft. Support a statewide evaluation of current groundwater conditions and management efforts, by analyzing CASGEM data and reviewing the content and implementation of groundwater management plans; from this assessment, develop guidelines to promote best practices for regional groundwater management.

- Develop and fund a state program for monitoring drought impacts on groundwater resources, including for remote sensing-based monitoring of land subsidence associated with groundwater extraction, as drought conditions cause water users whose surface supplies are curtailed to increase their groundwater use, depleting basin storage and sometimes creating impacts to others by inducing migration of poor-quality groundwater into pumping zones or accelerating land subsidence.

- Improve the State-level integration of existing groundwater data (quality and quantity) and information with surface water data and information.

- Promote groundwater recharge and storage by:

    - streamlining and aligning regulatory programs, as appropriate, to support increased conjunctive use and groundwater banking;

    - developing tools to help characterize and delineate groundwater recharge areas;

    - evaluating economic and water security benefits from more sustainable management practices;

    - developing estimates of storm water capture and groundwater recharge potential, and a tracking database to inform water resource planning and permitting decisions;

    - developing guidelines for coordinating land use planning and protection of groundwater recharge areas;

- incentivizing local and regional efforts to use low impact development techniques in new development and retrofits through State loans and grants;

- incentivizing reduced pumping in overdrafted groundwater basins and increasing groundwater recharge through State loans and grants;

- modernize the state's storm water regulatory program to incentivize storm water capture and infiltration, and protect the infiltrative capacity of hydrogeologically vulnerable areas;

- complete rulemaking for groundwater recharge with recycled water (indirect potable reuse);

- identify obstacles to increasing most efficient use of water by agriculture and develop programs, policies and practices to overcome these obstacles; and

- develop and adopt salt and nutrient management plans consistent with the State Water Boards recycled water policy.

- As part of IRWM plans, provide multi-agency support for local pilot projects that could become part of a system of regionally-based, strategic groundwater drought reserves; such pilot projects should be prioritized for high-use basins.

- Work with local and regional groundwater management agencies in impacted, vulnerable, and high-use basins to develop and refine groundwater thresholds for quality, level, and subsidence, conduct monitoring needed to determine if thresholds are being met, and take actions needed to sustainably manage groundwater.

Diversify Local Supplies and Increase Water Use Efficiency

Climate change is adding to other stressors to make water supplies from major sources like the Colorado River and the Sacramento-San Joaquin Delta less reliable. Increasing regional self-reliance and diversification of local water supplies will enable Californians to better respond to changing economic and climactic conditions while ensuring a reliable water supply for the diversity of the state's water needs. California's water agencies utilize a variety of water management measures to improve local water supply reliability. These measures include agricultural and urban water use efficiency, local storage, conjunctive use, increasing stormwater capture and infiltration, recycled water, and ocean and brackish water desalination. Since the early 2000s with the start of the Integrated Regional Water Management (IRWM) there has been increasing emphasis on regional collaboration in the implementation of water management measures. With the passage of SB7x7 in 2009, urban water suppliers are required to set and meet 2015 and 2020 water use targets and agricultural suppliers are required to adopt agricultural water management plans and report on the implementation of efficient water management practices. The Delta Stewardship Council's Delta Plan requires water suppliers to reduce reliance on water from the Delta.

- The State should continue to support regional water management planning and project implementation through additional funding for the IRWM. The IRWM Grant Program funds a wide variety of regional water management actions. The IRWM Program is intended to support flexible implementation of actions needed to address regional objectives and needs. As such, the IRWM funds water supply, water quality, flood management, and environmental protection and restoration.

- The State should develop a 2030 Statewide Urban Water Use Efficiency Plan with the goal of requiring urban water suppliers to continue the improvements in water use efficiency from the 20x2020 program. Accounting for population growth, continuing the current 20x2020 program will keep the total volume of urban water use in 2020 at the same volume as in the year 2000. The goal of the 2030 program is to replicate the 20x2020 success and keep the volume of 2030 urban water use the same as the 2020 level.

- Agricultural water suppliers with irrigated acreage equal or greater than 25,000 acres should begin utilizing the methodologies for quantifying agricultural water use efficiency in the "Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use" by 2020.[602] Quantifying water use efficiencies can provide valuable information to water suppliers and highlight efficiency improvements, and climate risks to California water will be increasing over time.

- Provide targeted funding for:
    - agricultural and urban water suppliers for projects that plan and implement sustainable water solutions serving disadvantaged communities
    - urban and agricultural water use efficiency research and development programs for development, testing and implementation of new technologies
    - the "Save Our Water" media campaign so it can achieve the same visibility and outreach as the California Public Utilities Commission's energy reduction campaigns.

- Set a statewide target of 1 million acre-feet (MAF) of recycled water use annually by 2020. DWR, with SWRCB, should prepare a comprehensive report of regional recycled water conditions to guide expanded use of recycled water including assessment of a 'fit for purpose' concept for urban, agricultural and environmental applications and a cost benefit analysis.

- State should promote the SWRCB's stormwater use target of 500,000 AF per year.

- Develop a coordinated streamlined permitting process for desalination projects that provides strong environmental protection.

- State entities, including SWRCB, DWR, CDPH, and CDFA, together with stakeholders should work to develop comprehensive data collection on water diversion, delivery, and use. This will assist in measuring program performance for this and other strategies.

Reduce Sacramento-San Joaquin Delta climate change vulnerability

As noted above, the Sacramento-San Joaquin Delta is vulnerable to climate risks such as flooding, sea level rise, and stress on aquatic habitat. Several planning efforts are underway to further the co-equal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

Reducing climate change vulnerability in the Delta will depend on completion and implementation of the Water Quality Control Plan, the Delta Plan and the BDCP. At the same time, as discussed elsewhere in this chapter, regions that depend upon water from the Delta will need to develop far more regional self-reliance, through a variety of measures, to ensure long-term water supply reliability.

Prepare California for hotter and dryer conditions and improve water storage capacity

While drought is a normal part of the water cycle in California, drought conditions are becoming more common and more severe. California's water infrastructure provides the ability to manage some degree of hydrologic uncertainty and variability through operational tools such as water transfers, reservoirs, and conjunctive surface water and groundwater use. However, it is not sufficient to address extreme or prolonged drought conditions.

As noted above, a variety of measures may be utilized to mitigate potential shortages during drought, including minimizing reliance on imported water, improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, desalination, groundwater remediation, conjunctive use, firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements. The state has made substantial investments, through grant programs, in helping local water agencies improve their water supply reliability and take other actions that reduce their vulnerability to droughts.

The state can further improve California's ability to deal with the risks of more frequent and severe drought conditions by:

Box 72

California Department of Water Resources
San Luis Reservoir; July 11, 2007

- Improving drought prediction at the one-month to two-year timescales critical for making operational decisions in managed water systems, and for helping those relying on unmanaged water supplies assess their risks, through investing in research and related hydroclimate monitoring to improve prediction. From an operational perspective, improving drought predictive capability is probably the single most important action the state could pursue.

- Reducing the drought vulnerability of small water systems, especially those in at-risk rural areas dependent on unreliable groundwater sources, through state financial assistance programs and through lowering the threshold for requiring public water systems to prepare Urban Water Management Plans (UWMPs) from 3,000 or more connections to 2,000 or more connections.

- Improving the understanding of wildfire risks to water infrastructure, and support actions to reduce those risks. The hotter, dryer climate conditions that result in drought, also create risks of more frequent and severe wildfires that can further impact water supplies that are already otherwise stressed by increased water demand and decreased flows. Wildfire is already a significant cause of system damage for small water systems in rural areas. The damages experienced by Denver Water facilities following Colorado's 2002 fire season[603] illustrate potential risks to large water system infrastructure in the Sierra Nevada. Wildfire risk planning should be included in large water agencies UWMPs.

- Improving flexibility in our water transfer systems. Streamlined water transfers in times of extreme drought will strengthen California's resilience to climate change.

- Improving water storage capacity, including supporting regional groundwater management as further discussed above.

Address water-related impacts of climate change on vulnerable and disadvantaged populations and cultural resources

Just as different regions of California will experience the impacts of climate change differently, so will the diverse populations of California. Indeed, some people—including those who are ill or unemployed, the very old and the very young—may be more sensitive or vulnerable than others, making them less capable of coping with climate change. For instance, the increased flood risk due to climate change may disproportionally impact poor communities, due to their location as well as their lack of mobility. Disadvantaged communities already grappling with drinking water quality and supply problems are unlikely to have the capacity to deal with the additional challenges—deeper and longer droughts, deteriorating water quality—that climate change may bring to their water resources. Climate change may also negatively impact water resources that are important for tribal subsistence and cultural purposes.

Climate impacts are experienced locally, in communities. Targeted assistance in the form of outreach, information, funding, investments and community engagement will improve the likelihood that communities will support, implement, and benefit from adaptation strategies that can improve community resilience.[604] For these reasons, water planners and their partners must ensure equitable access to information and resources and explicitly recognize, target, and prioritize efforts to ensure that the most vulnerable Californians are prepared for climate risks to water; for instance, by establishing stable long-term funding sources for the provision of safe drinking water to small disadvantaged communities. A Tribal Advisory Committee helped to develop the content in the California Water Plan 2013 Update, and continued engagement with tribal nations will continue to be important when managing water resources in the era of climate change.

Continue to mainstream climate considerations into water management

As noted above, DWR has made great progress in mainstreaming climate considerations into its many operations. It began climate research as early as 1987, has integrated climate considerations into the California Water Plan since 2005, convenes a Climate Change Technical Advisory Group, and offers climate literacy classes for its staff.

Further actions can help mainstream climate considerations in all the state's water management activities. For instance, in order to reduce institutional barriers to preparing for climate risks, the Water Boards will use relevant, peer-reviewed climate science to identify climate adaptation criteria and processes for incorporating climate change considerations into all Water Boards' programs, such as water quality permits or guidelines for infrastructure loans and grants. The State Water Board and DWR should develop funding criteria to discourage construction of new water infrastructure in high-risk areas. In coastal groundwater basins, which are vulnerable to increased salt water intrusion as a result of sea level rise, the Water

Boards will support and encourage measures such as recycled water injection and groundwater storage during wet years to make coastal aquifers more resilient to climate change impacts.

Utilize low impact development and other methods in State and regional stormwater permits to restore the natural hydrograph

The Water Boards are encouraging permitees to use a watershed approach to “slow the flow” of water, using urban runoff best management practices to achieve multiple benefits, such as reduced pollution, water supply augmentation, flood protection and habitat enhancement. Municipal stormwater permitees are required to exercise their land use authority to implement development programs that require installation of stormwater controls at new developments and significant redevelopment projects. The permits adopted require the use of Low Impact Development techniques but also recognize that alternative or regional projects can be beneficial. These techniques range from onsite tree planting to installation of porous pavement to designing recharge wetlands and must be monitored to measure their effect on water quality. In collaboration with other State, regional and local agencies, the Water Boards will identify data needs to enhance planning decisions associated with preparing for climate risks and incorporate that data gathering in their permitting authority.

Urban trees can help filter and remove pollutants from stormwater, and also reduce stormwater runoff. Continued and expanded support for urban forestry and urban greening will be important not only for water-related benefits, but to reduce heat island impacts and reduce energy demand as California experiences climate impacts. For more information on urban forestry and heat island effects, please see the Forestry and Public Health sections of this document.

Require closer collaboration and coordination of land use and water planning activities to ensure that each reinforces sustainable development that is resilient to climate changes

Despite state laws requiring demonstration of “adequate water supplies” for development and extensive requirements for both land use and water resource planning, these processes continue to lack integration allowing land use decisions to be made that may conflict with water resource plans or imperil sustainable management of water resources. Currently, General Plan Guidelines lack the specificity to ensure that water supply and water quality issues created by new development are adequately analyzed and addressed; in an era when climate risks present escalating challenges to water resources, new development must be carefully integrated with sustainable water management efforts. The Governor’s Office of Planning and Research will engage local land use authorities and water agencies and amend the General Plan Guidelines to promote local land use decisions that are consistent with local sustainable water management.

Closer integration of Urban and Agriculture Water Management Plans and Integrated Regional Water Management Plans into General Plans and local climate action plans and/or resilience plans, through better coordination and harmonized planning requirements, will help establish consistent sustainability goals across these planning processes. Water sustainability should also be given consideration for addition to the requirements of Sustainable Communities Strategies that are required for each of the state's Metropolitan Planning Organizations (MPOs). Increased coordination between land use and water planners may also reveal opportunities for improvements in stormwater management and the use of recycled water, both important strategies for improving resilience.

Protect and restore water resources for important ecosystems

As noted above and in the Biodiversity and Habitat section of this document, climate change presents a variety of escalating risks to important ecosystems in California. In order to reduce these risks, the state should continue its efforts to restore key wetlands and to ensure adequate water quality and supply for important ecosystems. Collaboration between state entities working on water issues and ecosystem management issues will also continue to be important.

Better understand climate risks to California water and develop tools to support efforts to prepare for climate risks

Additional information and tools are needed to adequately prepare for climate risks to the California water sector.

For instance, more research is needed regarding:

- the relationship between snow pack, rainfall, and groundwater recharge and quality;
- land-cover and ecosystem responses to changing precipitation and runoff conditions;
- how water quality in rivers, lakes and aquifers will be affected by changes in precipitation, timing of flow, and temperature;
- how water flow management can help support climate-stressed aquatic species; and
- the role of extreme precipitation events and implications for within-year variability on our water supply.

It will also be important to continue and enhance monitoring of changing water conditions. Monitoring allows tracking of changes in snow-covered and rain-dominated portions of key watersheds, and direct observation of climate changes can help refine climate projections and models.

It will no longer be adequate to manage California water resources based on historical trends, and decisions support tools for water managers that reflect climate projections are needed to help guide water management and planning decisions.

Box 73

California Water Management

Management of California’s water resources are complex and occur at federal, state, regional and local levels. Some of the entities involved in the management of California water resources are listed below. At the local level, cities, counties, local and regional water utilities, wastewater agencies, irrigation districts, reclamation and levee maintenance districts and flood control agencies along with others too numerous to list here provide water quality, water supply, flood control, and ecosystem management.

California Department of Water Resources (DWR) Protects, conserves, develops, and manages much of California's water supply including the State Water Project which provides water for 25 million residents, farms, and businesses. DWR also develops strategic goals, and near-term and long-term actions to conserve, manage, develop, and sustain California's watersheds, water resources, and management systems. DWR works to prevent and respond to floods, droughts, and catastrophic events that would threaten public safety, water resources and management systems, the environment, and property. DWR prepares the California Water Plan, which is updated every five years through a collaborative process, to present the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios. DWR also provides local assistance, in the form of technical advice and grants, to regional water management groups.

State Water Resources Control Board and Regional Water Quality Control Boards (Water Boards) Regulates the quality of both surface and groundwater, allocates surface waters to support beneficial uses and provides low-interest loans and grants for wastewater and drinking water treatment as well as stormwater and recycled water management.

California Water Commission Advises the Director of the Department of Water Resources on matters within the Department's jurisdiction, approves rules and regulations, and monitors and reports on the construction of the State Water Project.

Central Valley Flood Protection Board Plans flood controls along the Sacramento and San Joaquin rivers and their tributaries in cooperation with the US Army Corps of Engineers.

Colorado River Board Protects California’s rights and interests in the resources provided by the Colorado River.

Delta Conservancy Leads efforts that advance environmental protection in the Delta and the economic well-being of Delta residents. The Conservancy's goal is to implement projects that will result in integrated environmental, economic and social benefits.

Delta Stewardship Council The Delta Stewardship Council was created by the Sacramento-San Joaquin Delta Reform Act of 2009 to develop a comprehensive management plan for the Delta

(Delta Plan) that furthers the co-equal goals of providing a more reliable water supply and restoring the Delta ecosystem.

California Department of Public Health (CDPH) Regulates public water systems; oversees water recycling projects; permits water treatment devices; certifies drinking water treatment and distribution operators; supports and promotes water system security; provides support for small water systems and for improving technical, managerial, and financial capacity; oversees the Drinking Water Treatment and Research Fund for MTBE and other oxygenates; and provides funding opportunities for water system improvements, including funding under Proposition 84, Proposition 50, and the Safe Drinking Water State Revolving Fund.

California Public Utilities Commission (CPUC) Regulates privately owned water and other utility companies.

California Department of Fish and Wildlife (DFW) Regulates and conserves the state's wildlife and is a trustee for fish and wildlife resources (FGC § 1802). It is the State's primary department for managing the native fish, wildlife, plant species, and natural communities for their intrinsic and ecological value. It serves a regulatory role by enforcing the California Endangered Species Act and Fish and Game Code 1600, Streambed Alteration Agreements.

Governor's Office of Emergency Services (OES) OES is responsible for overseeing and coordinating emergency preparedness, response, recovery, and homeland security activities in the state including those related to flooding and other water related disasters.

California Department of Conservation (DOC) Provides services and information that promote environmental health, economic vitality, informed land-use decisions, and sound management of California's natural resources. This department also manages a state watershed program.

California Department of Food and Agriculture (CDFA) Serves the citizens of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Forestry and Fire Protection (CAL FIRE) Manages and protects California's natural resources. Provides fire protection and stewardship of more than 31 million acres of California's privately owned wildlands which provide important watershed source areas.

California Department of Parks and Recreation (State Parks) Manages more than 270 park units, which protect and preserve culturally and environmentally sensitive structures and habitats, threatened plant and animal species, ancient Native American sites, and historic structures and artifacts. Responsible for almost one-third of California's scenic coastline and manages many of the state's coastal wetlands, estuaries, beaches, and dune systems.

California Department of Pesticide Regulation Regulates pesticide sales and use and plays a significant role in monitoring for the presence of pesticides and in preventing further contamination of the water resource.

California Department of Toxic Substances Control (DTSC) Provides technical oversight for the characterization and remediation of soil and water contamination.

Delta Protection Commission Responsible for preparation of a regional plan for the "heart" of the Delta. The DPC ensures orderly, balanced conservation and development of Delta land resources and improved flood protection by adaptively protecting, maintaining, and where possible, enhancing and restoring the overall quality of the Delta environment including agriculture, wildlife habitat, and recreational activities.

Sierra Nevada Conservancy (SNC) Initiates, encourages, and supports efforts that improve the environmental, economic, and social well-being of the Sierra Nevada region, its communities, and the citizens of California. The region, which comprises all or part of 22 counties and more than 25 million acres, is California's principal watershed, supplying 65 percent of the developed water supply.

State Lands Commission (SLC) Manages public trust lands of the State (the beds of all naturally navigable rivers, lakes, and streams, as well as the State's tide and submerged lands along California's more than 1,100 miles of coastline). The public trust doctrine is applied to ensure that the public trust lands are used for water-related purposes, including the protection of the environment, public recreation, and economic benefit to the citizens of California.

Federal Agencies

US Army Corps of Engineers (USACE) Oversees management of flood protection infrastructure and facilities throughout the state and provides dredging services for waterways that serve as transportation and shipping routes. The USACE also regulates any construction or dredging within "navigable waterways of the United States" through Section 10 of the Rivers and Harbors Act.

US Bureau of Reclamation (USBR) Operates the Central Valley Project (CVP), the largest water project in California; and regulates diversions from the Colorado River.

US Department of Agriculture (USDA) Manages forests, watersheds, and other natural resources though the US Forest Service and US Natural Resource Conservation Service.

US Environmental Protection Agency (US EPA) Protects human health, safeguarding the natural environment.

US Fish and Wildlife Service (USFS) Conserves, protects, and enhances fish, wildlife, and plants and their habitats.

<u>US Geological Survey (USGS)</u> Provides water measurement and water quality research.

APPENDIX A: COMPENDIUM OF RECOMMENDED ACTIONS

The Safeguarding California Plan is not meant to replace the 2009 CAS, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward.

The 2009 CAS was built on several guiding principles. Many of these principles are still relevant and are carried forward as updated here:

- Use the best available science to identify risks and adaptation strategies;
- Understand that an effective strategy for preparing for climate risks should evolve as new information is available;
- Involve all relevant stakeholders;
- Establish and maintain strong partnerships across all levels of government, tribes, businesses, landowners, and non-governmental organizations;
- Give priority to strategies that also achieve benefits other than climate risk reduction benefits, including additional benefits to public health, the economy, environmental justice, and conservation of natural resources; and
- Ensure that strategies to reduce climate risk are coordinated, to the extent possible, with the state's efforts to reduce GHG emissions and other local, national and international efforts.

The Safeguarding California Plan is designed as policy guidance for state decision makers. Climate risks often present cross-sectoral challenges, and may require cross-sectoral solutions. As a result, the Safeguarding California Plan identifies cross-sectoral linkages throughout. Each sector chapter features its own recommendations; cross-sectoral strategies are presented in the Introduction.

The various actions recommended in this Safeguarding California Plan are compiled here for ease of reference. Full text and citations supporting these recommendations may be found in the Introduction and respective sector chapters of this document; any discrepancies between the text in this Appendix A and the text in the body of this Safeguarding California Plan should be resolved by referring to the text in the body of the Safeguarding California plan.

- **CROSS-SECTOR STRATEGIES**

Establish a mandate and guidelines for all state agencies to consider climate risks in their policies, planning efforts, and investments

● Require that climate risk considerations be incorporated into state infrastructure planning; and

● Provide guidelines for state agencies to incorporate climate risk considerations into all policies, plans, and investments:

- Encourage Iterative Approaches
- Protect California's Most Vulnerable Populations
- Achieve Multiple Benefits from Efforts to Reduce Climate Risks and Prioritize Green Infrastructure Solutions
- Integrate Efforts to Reduce Climate Risk with Efforts to Reduce the Emissions that Cause Climate Change to the Fullest Extent Possible
- Develop Metrics and Indicators to Track Progress on Efforts to Reduce Climate Risk

Provide data, tools, and guidance to support efforts to reduce climate risks

- Additional research to fill informational gaps about California's climate vulnerabilities and additional research on the scope, timing, cost and feasibility of management options to address climate change;
- Tools and guidance to support efforts to plan for climate risks at the state, local, and regional level; and
- Supporting monitoring to gather direct observations of the changing climate.

Build the capacity to plan for and implement actions to reduce climate risk through collaboration, education, outreach and funding.

●Foster collaboration and innovation across state agencies and across levels of government

●Develop a comprehensive climate education and outreach strategy

●Provide significant and sustainable funding for investments that reduce climate risks, human loss and disaster spending

ACTIONS NEEDED TO SAFEGUARD AGRICULTURE

Developing and promoting adoption of management strategies that reduce climate risks to agriculture

Actions to develop and promote adoption of management strategies with multiple benefits that reduce climate risks to agriculture will be important, these may include:

- Developing new and adapting existing best management practices that reduce climate risks, including, for example, soil conservation practices and practices that support pollinator health;
- Developing incentive programs for sustainable, science-based practices that create resilience to climate impacts, including pilot-projects to demonstrate proof-of-concept;
- As further discussed in the Water section of this document, management strategies that reduce climate risks to water are needed including, but not limited to, enhanced flood management, water use efficiency, and regional groundwater management for drought resiliency;

- Reducing the rate of farmland conversion to buffer against climate risks to food production by supporting smart growth and reducing urban sprawl, and supporting farmland conservation;
- While continuing breeding research as discussed above, also supporting efforts to systematically collect and preserve agricultural genetic material in recognition of the risk of agricultural biodiversity loss from climate change;
- Investing in and improving agricultural equipment to be adaptable between crops to facilitate shifting crop patterns and to optimize capital investments in the face of changing climate conditions; and
- Working with industry to develop new technologies for field-level monitoring of climate impacts, including, for example pests.

Understanding and responding to evolving trends that relate to agriculture

<u>Changing climate risks and emergency management</u>
CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As noted in the Emergency Management section of this document, climate change is likely to require improvements emergency preparedness and response capacity. As discussed above, climate change has implications for infectious diseases and food and animal safety. It will be important to ensure that CDFA has adequate support and capacity to respond quickly to emergencies related to food and feed safety and agricultural diseases and pests.

<u>Supporting new revenue streams for agriculture that support positive climate action</u>
Climate change threatens the California agricultural sector with economic losses, and the ability to develop new revenue streams may help provide added fiscal resilience for California farmers and ranchers. Activities that generate new revenue streams may themselves help foster positive action on reducing the emissions that cause climate change, and help to build resilience against climate risks. For instance, as discussed above, the development of anaerobic digesters and co-digestion of agricultural by-products can provide flexible, renewable energy and help with waste diversion goals. Developing incentives for agricultural ecosystem services, such as beneficial soil practices (for example, cover crops, tillage practices, and the use of compost), can provide greenhouse gas and water quality benefits, and such practices can also foster greater resilience in the face of climate impacts (for instance by improving soil moisture during hotter, drier conditions).

<u>Cross-sectoral climate impacts</u>
Climate risks to other sectors are important to agriculture. Climate risks to water and management strategies to address those risks are obviously important to agriculture. Impacts in other sectors are also important, for instance, impacts to the energy system can disrupt agricultural production, impacts in the transportation sector can have critical implications for agricultural goods movement, and climate impacts to biodiversity and habitat may have impacts on species that are beneficial to agricultural production.

Furthermore, impacts to the agricultural sector can have important implications for other sectors. For instance, increasing temperatures, may require increased energy or water consumption for agriculture (for instance, to enhance or provide livestock cooling systems). As discussed in this chapter, declining agriculture productivity or price increases related to climate impacts may also have impacts on public health. Cross-sectoral collaboration and engagement will be increasingly important in the era of climate change.

Support risk sharing mechanisms that protect food security and California's agricultural sector

As discussed in the Emergency Management section of this document, insurance and disaster relief are important risk sharing mechanisms that can help foster resilience, especially when combined with other efforts to reduce climate risks. However, federal program spending on the types of crops grown in California remains a small fraction of that spent on crops, like corn, wheat, soy, and cotton, which are predominantly grown in other parts of the nation. Climate risks to California's crops and livestock not only threaten California's agricultural sector and economy, climate impacts may cause price increases in healthy foods, like fruits, nuts, and vegetables, that are important for food security in California, the nation, and the world.

California should continue to support national policy reforms that would provide crop insurance and disaster assistance safety net programs to all commodities, and ensure that California farmers and ranchers have access to these types of important risk sharing mechanisms.

Improving Understanding of Climate Impacts on Agriculture

Research, Modeling and Monitoring

Some important work has been completed with respect to research and modeling projected climate impacts to agriculture, but more remains to be done. Needed actions include, but are not limited to:

- Studies of infrastructure and capital associated with relocating crops or shifting between crops; and economic studies of crop relocation or crop shifting, including comparative cost studies of moving or losing certain crops;
- Studies that evaluate the climate benefits of organic materials as soil amendments, such as compost, biochar, and digestate;
- Research supporting the beneficial use of agricultural by-products for renewable energy and organic fertilizers;
- Studies to quantify carbon sequestration and water saving potential of compost use in agricultural setting such as irrigated croplands and rangelands;
- Cumulative impact studies: As discussed in this chapter, agriculture faces multiple changing climate variables and multiple climate risks, and these threats occur against the backdrop of other stressors such as farmland conversion. More research

is needed to understand the compound and cumulative impacts of these risks, to develop more accurate projections to inform risk management strategies;

- Plant and animal breeding research, including research on pest and disease resistance, drought resistance, heat and chill resilience, and stress tolerance;
- Research on changing water needs for agriculture in times of more sustained higher temperatures and extreme heat events;
- Research on climate impacts on vector-borne diseases in animals, along with action to preserve and enhance monitoring, testing and reporting capacity for such diseases, especially in light of reductions in federal funding from the Centers for Disease Control and Prevention for such activities;
- Research on climate change risks to food safety;
- Research on temperature changes and other climate stresses on livestock;
- Further research on temperature changes and other climate stresses on crops;
- Further studies on barriers to efforts to prepare for climate risks and ensure the long-term sustainability of California agriculture, including possible strategies for overcoming such barriers;
- Creating an online "research needs" forum where agricultural stakeholders, including farmers, ranchers and industry groups, can share their needs, observations, and ideas directly with scientific researchers; and promoting cooperative research that involves farmers and ranchers in the research process, including "on-farm" research projects;
- Studies of the economic and social risks of negative climate impacts on California agriculture;
- More crop-specific and location-specific studies of climate risks, and modeling projections of productivity effects and impacts to help facilitate the development of specific, actionable management activities to reduce climate risks (e.g. strategies for salt water intrusion for agriculture located in areas susceptible to such risks)
- Further research on climate impacts on weeds and invasive plant species, insect pests, and pathogens affecting crops;
- Further research on climate impacts on pollinators, including native pollinator species;
- Studies of the ability of California's beneficial species to control new or worsening invasive species problems; and
- Studies of the effectiveness of different cropping practices, e.g. organic, crop rotation, fertilization, for addressing climate risks to agriculture.

<u>Visualization Tools</u>
Climate research and data will need to be translated into tools that can be used by agricultural producers involved with on-the-ground management of agricultural resources. Tools may include:

- An early effort at mapping California agricultural vulnerability was developed as part of the Third Climate Change Assessment but the mapping effort needs to be refined

to consider additional variables and more fully assess the vulnerabilities to California's water resources and livestock systems in a spatially explicit manner, and to modify the mapping to accommodate future projections of climate, land use, and socio-economic variables;
- Vulnerability maps showing projected climate risks to California agriculture, should be integrated in state visualization tools such as Cal-Adapt and the California Geoportal;
- Climate risk visualization tools tailored more specifically to agricultural producers should be developed, supported, maintained, and publicized.

Outreach and Education

It will be important to disseminate information regarding the results of continuing research on climate risks to agriculture, the development of best management practices for dealing with such risks, and any expanded business, funding, or risk sharing opportunities that can enhance resilience. This information must be shared with farmers and ranchers, decision makers, and other partners in a format that is easily accessible and readily usable in order to promote timely action to protect agricultural resources from climate risks.

Efforts to foster this type of outreach and educational might include:

- Working collaboratively with partners (such as USDA Climate Hubs, USDA Natural Resources Conservation Service, University of California Cooperative Extension, Resource Conservation Districts, and the California Agricultural Commissioners and Sealers Association) to provide information on climate risks as well as financial and technical assistance to farmers and ranchers interested in adopting practices that create resilience against climate risk;
- Establishing an international exchange program to facilitate the learning and adoption of new tools and techniques to create resilience in farming and ranching in the face of climate risks;
- Developing a comprehensive list of adaptation strategies that have worked throughout the world to reduce climate risks to agriculture, and promote such strategies in California if relevant and useful;
- Hosting a recurring conference focused on preparing for climate risks to agriculture for farmers, ranchers, researchers, government agencies, and other partners;
- Continuing integration of agricultural climate risk considerations into broader state efforts to prepare for climate risks;
- Recognizing and publicizing the efforts of innovative farmers and ranchers who are proactive in preparing for climate risks and adopting practices that foster resilience; and
- Providing online materials, in addition to the visualization tools discussed above, regarding climate risks to agriculture (such as changing water availability, extreme

weather events, loss of winter chill and other temperature changes, possible shifts in pests and disease, possible shifts in pollinator lifecycles, etc.).

ACTIONS NEEDED TO SAFEGUARD BIODIVERSITY AND HABITATS

Develop management practices to help safeguard species and ecosystems from climate risks

1) Improve habitat connectivity and protect climate refugia

Promoting habitat connectivity and protection of refugia will aid in species migration and movement and propagate ecological processes across the landscape. We must utilize existing programs such as NCCP and planning documents such as the State Wildlife Action Plan to continue improving connectivity between existing terrestrial, aquatic, and marine conservation areas in addition to creating new conservation areas where applicable. Priorities for creating, maintaining or restoring conservation areas should include landscape features that will ease the transition to future climatic conditions for species supported by the habitat (e.g., low fragmentation, climatic and elevational gradients, groundwater resources, etc.). Coordination should be promoted among state, federal, and private landholders to encourage consistency across management approaches to maximize biodiversity and promote large-scale connectivity.

2) Implement adaptive management studies to refine approaches for conserving biodiversity, especially for species and communities vulnerable to climate change

As mentioned in the 2009 CAS, the original CA State Wildlife Action Plan (2005) articulated an approach for designing monitoring programs to support adaptive management, which is still relevant today. Actual case studies that implement adaptive management are needed to further understanding of the relative merits of alternative management strategies for conserving biodiversity in the face of rapidly changing climate conditions. NCCP plans already incorporate adaptive management and may provide opportunities to study and refine approaches for managing biodiversity in the era of climate change. Vulnerability studies should help inform where adaptive management studies should be focused and which species and natural communities should be included in such studies.

Enhance biodiversity monitoring in California to detect climate impacts and inform responses

There continue to be gaps in the monitoring of resource conditions that can support effective management decisions in the era of climate change. A comprehensive, statewide approach to biodiversity monitoring is needed to help develop baseline ecological information and to detect changes in terrestrial and aquatic species and habitat patterns on the landscape. Monitoring and observing changing conditions is critical to refining climate impact and species/habitat response models and to informing the development of forward-looking conservation strategies and management actions that account for changing conditions.

The CDFW Species and Natural Communities Monitoring and Assessment Program, or simply Resource Assessment Program (RAP), was designed to help inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities in California. As such, RAP provides a basic infrastructure for addressing biodiversity inventory and monitoring needs in the state. With additional support, this program could be expanded to meet the need for comprehensive, state-wide biodiversity monitoring to support forward-looking management actions that are responsive to a changing climate. Climate considerations should be integrated into monitoring strategy design and the development of monitoring priorities; and strategic monitoring priorities may be informed by other state efforts including CDFW's State Wildlife Action Plan, DWR's California Water Plan, CalFire's Forest and Rangeland Assessment Program, State Water Resource Control Board's (SWRCB) Basin Plan, and the type of statewide climate vulnerability assessment discussed above.

Support Environmental Stewardship Across Sectors

1) Promote Nature-Based Solutions for Adapting to Climate Risks

Nature-based solutions can be a cost-effective means for addressing climate risks, and also provide additional benefits including benefits for habitat and biodiversity. The State should encourage and support the consideration of nature-based approaches for preparing for climate risks where such approaches are available. In order to support informed decision making, funding is needed for studies that help quantify the benefits of ecosystem services that reduce climate risks.

2) Create, maintain and support tools that help resource managers determine when and where to focus conservation activities that will protect biodiversity in the face of climate risks

Improved modeling of the impacts of climate change on wildlife, fish, and plants will be necessary at a scope and scale appropriate for management application. Associated predictive and planning tools are also necessary to ensure that resource management actions are informed by best available science, and such tools require maintenance over time and support to encourage user adoption. As noted above, CDFW developed the Areas of Conservation Emphasis (ACE) Mapping and Modeling Tool to provide a spatial model that can be used to identify areas of biological or conservation interest to guide conservation priorities. Tools such as ACE should continue to be maintained and updated with new biological data developed over time, in order to support biodiversity conservation planning and management decisions within CDFW and other state agencies. Determining what biodiversity-related information and tools would be useful to other agencies in their climate change planning efforts will also be necessary to manage the needs of wildlife, habitats, and humans in tandem.

Improve Understanding of Climate Risks to Biodiversity and Habitats

As further described below, continued research is essential to improve understanding of climate risks to biodiversity and habitats in order to inform management responses that might reduce risks to biodiversity and promote resilience. One overarching need is to improve baseline information; there are still significant data gaps with respect to California's biological resources. Baseline information provides a reference point against which future changes in biodiversity can be assessed. Continued and enhanced predictive modeling combined with monitoring of certain species will be also be needed to guide resource management decisions. Further information is also needed regarding the interactions between plants, animals and their environment, especially as the timing of life cycle events shift in response to climate change. Finally, there is a need to continue vulnerability studies and the identification of critical connections and corridors.

In addition to informational needs around biological resources, it would be useful to consolidate and analyze non-habitat baseline information such as current land uses and land use policies throughout the state, as well as whether municipalities and permitting agencies have incorporated climate change impacts into their land use planning (i.e. General Plans, Local Coastal Programs). This information will be an important part of determining the best opportunities for habitat restoration and land acquisition as part of a larger effort to create a well-connected system of conservation areas, minimize the impacts of climate change to the greatest extent possible, and plan appropriate strategies for long term conservation and management actions.

It is important for the state to coordinate with other research efforts, including the efforts of federal, academic and regional collaboratives, in order to benefit from collaborative work and optimize resources. As noted in the introduction to this document, there is also a need to ensure consistency in data sets and tools developed and utilized by different state entities.

Research needs related to climate impacts and risks to biodiversity and habitat are described below. Additional information on these types of needs may be found in the August 2011 CDFW Climate Change Research Considerations document, the February 2012 CDFW Climate Change Research Needs document, the California Climate Research Plan, and the forthcoming 2015 update to the State Wildlife Action Plan.

1) <u>Completing habitat and vegetation mapping</u>
   High-resolution, state-wide vegetation mapping following the National Vegetation Standard is needed to identify movement of vegetative communities, detect changes in their composition, and identify any new assemblages created throughout time. This information may provide insight into how species will move in accordance with changes in the location of their required habitat. Vegetation mapping can also be directly tied to the California Wildlife Habitat Relationships system, for example, to identify which species will likely be impacted most by these environmental changes. Additional funding and resources are needed to sustain existing efforts related to vegetation mapping, for example through the CDFW Vegetation Mapping and Classification Program.

2) <u>Refining regional connectivity analyses</u>

The California Essential Habitat Connectivity Project was a state-wide effort to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife. Finer-scale, regional corridor modeling and connectivity analyses are needed to help prioritize land acquisition and protection. Corridor prioritization exercises, for example those currently taking place in the Northern Sierra Nevada Foothills and Desert regions of California, should be replicated in other parts of the state. Work to identify critical habitat linkages has also been undertaken along the north-central coast of California led by the Science and Collaboration for Connected Wildlands in conjunction with many other agencies and organizations.

3) Additional climate vulnerability analyses

As described below, more research is needed to understand species and habitat vulnerability to climate change. Vulnerability studies will need to be refined and updated periodically to ensure that best available science informs management decisions. Training and tools may need to be developed to help translate vulnerability findings into management actions. Additional funding and resources may be needed to support vulnerability studies over time.

- A comprehensive, statewide climate change vulnerability analysis at the habitat scale is needed to better understand climate risks to California's biodiversity. Vulnerability information at this scale will support ecosystem-based conservation planning and management efforts, and can also be used to increase our broader, ecoregional understanding of the vulnerabilities of biodiversity to climate change. Existing and future species and taxa-specific vulnerability assessments can also be compared against habitat assessment results to gain further insight into climate risks and inform development of strategies that can help protect biodiversity resources.
- As mentioned earlier in this chapter, a subset of rare plants in the state have already been analyzed for climate vulnerability, however, follow-up coverage of additional rare plant species is needed. Species most likely to be at risk from climatic changes, such as those found in higher elevations, ephemeral systems, vernal pools, etc., should be high priorities for examination.
- A state-wide vulnerability assessment of mammal species of special concern is also necessary.
- A state-wide vulnerability assessment is needed for invertebrates. Examining certain invertebrates will contribute to our knowledge of how some pollinators will be impacted by climate change, with implications for agriculture and other ecosystem services. These species are already being impacted by changes in phenology that have been linked to climate change, and more information is needed on species future vulnerability.
- Marine and aquatic habitat climate vulnerability assessments are also needed. For more information on climate and marine habitat, please see the Oceans and Coastal Ecosystems and Resources section of this document.

4) Understanding extreme events and disturbance regimes

Research is needed regarding the risks posed by extreme events or disturbances (e.g. fire, flooding, drought, insect outbreaks, invasive species, etc.) to ecosystem function, resilience, and services. This will provide additional insight into how some existing stressors or processes may be exacerbated by climate change.

5) Identifying opportunities to address the emissions that contribute to climate change

Carbon storage can be one of the benefits provided by healthy ecosystems. Additional research is needed to quantify baseline carbon information associated with natural systems, and to identify and prioritize conservation and restoration opportunities with carbon sequestration benefits. Pilot projects can help refine understanding of the greenhouse gas storage capacity associated with natural systems.

Information Sharing and Education

1) Create and maintain partnerships that support biodiversity conservation in a changing climate

Collaborating with other agencies and partners supports not only the transfer of data and information, but ensures that conservation priorities with respect to climate change are clearly communicated within the broader conservation community. Communication is imperative to identifying and promoting common goals, and to support adaptation planning and implementation to conserve biodiversity. Collaboration will also promote complementary actions across jurisdictions on adjacent landscapes, which is vital to achieving our objectives related to habitat connectivity. State agencies should continue to pursue national, regional, and local coordination and promote initiatives to conserve biodiversity beyond the borders of California such as through the Western Governors' Association, West Coast Governors Alliance on Ocean Health, Association of Fish and Wildlife Agencies, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management, and the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Continued engagement with partners in the CDFW Climate Change Stakeholder Group will also be important and should be supported.

2) Promote public education and outreach on climate change impacts to biodiversity

Increasing communication with the public and partners on climate change impacts to biodiversity will raise awareness of this important issue and help create support for state actions that promote biodiversity conservation. State agencies should develop a collaborative messaging campaign centered on California's climate activities to safeguard natural resources, while highlighting the importance of nature-based action.

Many state agencies have staff that interface regularly with the public through education or outreach programs, which provide opportunities to engage the public on this topic. Agencies should work with partners to develop information to be used for public interpretation and classroom education related to biodiversity conservation in the face of climate change. Opportunities may be available at visitor centers in hatcheries, State Parks, wildlife areas, or other facilities run by the state. Helping to educate the public on climate change issues may have the additional benefit of promoting public involvement in data collection activities across many locations with limited costs through citizen science.

3) Provide support for the continuation of the CDFW Climate College and educational outreach efforts and link those efforts to broader state climate literacy programs

As noted in the Introduction to this document, it is necessary to build internal capacity for state entities to operationalize climate risk considerations into their activities. The CDFW Climate College provides a useful template for a departmental climate literacy program. The CDFW Climate College and related educational efforts should continue to be supported, and those efforts should be linked to any broader state climate literacy efforts.

ACTIONS NEEDED FOR IMPROVED EMERGENCY MANAGEMENT IN THE FACE OF CLIMATE IMPACTS

Improve Integration of Climate Impacts and Projections into All Phases of Emergency Management

Promote the implementation of the Climate Adaptation Planning Guide (APG) and Inclusion of Climate Risk Reduction in Hazard Mitigation Planning Efforts

The State will continue to promote APG implementation and principles of sustainability, resilience and hazard mitigation through collaboration with key public and private sector organizations through mechanisms including:

- Local hazard mitigation plans encouraged under federal law;
- Emergency operations plans required under federal law;
- Local general plan safety elements required by California law;
- Encouraging LHMP adoption into Local Government General Plan Safety Element;
- Sustainable Communities Strategies of metropolitan planning organizations;
- Local Coastal Programs under the California Coastal Act;
- Strategic Fire Plan for California;
- The Central Valley Flood Protection Plan;
- California Water Plan and other flood planning documents; and
- The Energy Assurance Plan.

These mechanisms relating to transportation planning, fire, flood, energy and coastal planning are discussed in their respective sections in this document.

Hazard mitigation efforts should consider the vulnerability of these community resources to climate risks:

- Essential Facilities – hospitals, medical facilities, police and fire stations, waste management facilities, emergency operations centers, shelters, schools, etc.
- Transportation Systems – airways, bridges, tunnels, roads, railways, waterways, etc.
- Lifeline Utility Systems - potable water, wastewater, landfills, oil, natural gas, electric power, communication systems.
- High Potential Loss Facilities - nuclear power plants, dams, military installations, etc.
- Hazardous Material Facilities
- Facilities Supporting Vulnerable populations
- Economic elements - major employers, financial centers, etc.
- Areas of special consideration – high-density residential or commercial development resulting in high death tolls/injury if damaged.
- Historic, cultural, and natural resources areas

<u>Continue to support the integration of climate risks in state and local government emergency planning efforts and enhance capacity to respond and recover from climate risk</u>
Emergency management grants, planning assistance and guidance, mutual aid agreements and post-disaster recovery and hazard mitigation, all play key roles in effective emergency management efforts. As California agencies plan for climate change, there may be opportunities for joint projects, information sharing, and shared funding opportunities with local and regional partners as well as with other States. Preparing for climate risks may also offer additional benefits for overall resilience in emergency situations; for example, increasing energy and water security to prepare for climate risks will help California better prepare and respond to earthquakes and terrorist attacks and will help to ensure first responders, the military and other emergency services can continue to operate during emergencies and disasters.

Support Risk Sharing Mechanisms

As noted above, public and private insurance and disaster relief provide important risk sharing mechanisms. Efforts to reduce climate risks through hazard mitigation activities, including but not limited to fire hazard reduction, minimizing new development in areas most vulnerable to hazards, and improved flood management, will be important to managing risks and supporting sustainable insurance and disaster programs. Specific recommendations regarding National Crop Insurance and the National Flood Insurance Program may be found in the Agriculture and Oceans and Coastal Resources sections of this document respectively.

Better Understanding of Climate Impacts on All Phases of Emergency Management

<u>Assess adequacy of surge and response capacity in light of climate projections for more frequent and more severe weather events</u>
Climate change is projected to increase the frequency and severity of natural disasters related to flooding, fire, drought, extreme heat, and storms (especially coupled when coupled with sea-level rise). This may require preparing for additional emergency surge capacity across the various emergency functions identified in the State Emergency Plan and for additional

emergency response capacity. The State should assess the adequacy of its current emergency surge and response capacities. Funding for this type of assessment may be needed.

Research and monitoring
As discussed in this document, the State has already invested significant resources to conduct and support initial climate vulnerability and cost assessments in a variety of sectors. As noted in the various sections of this document, additional research is still needed to continue to expand and refine information about the climate vulnerabilities of California's populations, infrastructure, property, food and agriculture, and biodiversity. Monitoring and research related to extreme weather events including flood, drought, heat, fire, and related losses will be especially important for emergency management and public safety. Coordination between sectors will help to maximize research and monitoring funding, information sharing, and will help facilitate well-integrated actions to build safe and healthy communities.

Climate Risk Communication and Education

Integrate climate projections into the MyHazards and MyPlan tools, and continue to update and maintain the MyHazards and MyPlan tools
As noted above, the MyHazards and MyPlan tools provide important information for individuals and local and regional governments to plan for hazards. As the climate changes, it will be important to integrate future climate projections into the tools. The Cal-Adapt tool, discussed in the Introduction to this document, is a climate projection visualization tool, and might be used to help integrate climate projections into My Hazards and My Plan. The tools will need to continue to be updated and maintained as new information and risk management strategies are developed.

Increase outreach efforts to prepare for extreme events
Increasing outreach efforts can help households and business better understand and prepare for climate risks and extreme events such as fires, floods, storms, drought and extreme heat. Funding may be needed for such outreach efforts, but prospective emergency planning can help lower emergency response risks and costs. The state should support outreach to encourage emergency preparedness actions including the development of evacuation plans and preparedness kits. These outreach efforts should tailored to be culturally and linguistically relevant for California's diverse populations.

Training for first responders and other emergency managers on climate risks

First responders and other emergency managers play a key role in emergency management; and first responders are directly at risks from increasingly frequent and severe risks such as fire and floods. As noted in the Introduction to this document, state agencies and departments should be provided with the resources to enable climate training for staff. Climate training for emergency managers is critically important for both public health and safety and for the safety of first responders.

ACTIONS NEEDED FOR SUFFICIENT, RELIABLE AND SAFE ENERGY

The state will need to continue enhancing California's energy adaptation efforts and ensure that California has a sufficient, reliable, and safe energy infrastructure to meet current and future energy demand as well as the state's clean energy goals. In implementing any of the adaptation strategies, consideration will also be given to other socio-economic and environmental objectives, such as habitat protection, ecosystem services, environmental justice, public health, and economic feasibility. Further collaborative work that is needed includes the following:

Protect existing energy facilities and consumers from impacts of climate change

- Conduct vulnerability and adaptation studies for the energy sector in coordination with private entities managing energy resources with the goal of generating actionable research products; make research results available with a geographical context via Cal-Adapt.
- Support the energy component of local cross-sector adaptation efforts, such as expanding the CaLEAP (California Local Energy Assurance Planning) website.
- Promote use of sustainable woody biomass materials for power generation to reduce fire risks to transmission lines and hydropower watersheds consistent with the 2012 Bioenergy Action Plan.
- Install smart grid and microgrid technologies to better protect reliable operation of the grid during extreme climate-related events.
- Evaluate the cost effectiveness of potential measures to maintain the efficiency of thermal plants during heat waves or other extreme climate-related events.
- Evaluate hydropower adaptation options to accommodate reduced or increased runoff and storage and evaluate operational changes or investment options (e.g., more pumped storage) to maintain the value of California hydropower resources even with climate change.
- Continue development of the Integrated Forecast and Reservoir Management (INFORM) project in coordination with private entities and DWR to demonstrate its ability as a modern decision support system for management of major water reservoirs to both private entities and DWR.
- Investigate strategic use of high temperature, low sag conductors for transmission lines where climate change impacts make conventional conductors vulnerable.
- Explore the use of seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation for the forthcoming summer season (*Summer Electricity Supply and Demand Outlook* – a CEC annual publication).

Diversify energy supply to reduce vulnerability to extreme weather-related events and climate change

- Diversify the energy supply portfolio as needed by: (1) enhancing the local utility distribution grids with smart grid features and expanding distributed generation; (2) exploring and developing energy storage technology applications; (3) evaluating state properties and buildings (and other government properties) for distributed and centralized power generation options; (4) encouraging in-state and out-of-state transmission system expansion and upgrades to reduce vulnerability to extreme events and long-term changes; and (5) expanding transmission access to renewable resource areas in preferred geographic locations consistent with the Renewable Energy Strategic Plan developed as part of the 2012 IEPR Update proceeding.
- Explore post-2020 greenhouse gas emissions targets for the energy sector (including transportation, electricity generation, and the rest of the energy system) that are compatible with the 2050 goal of reducing GHG emissions by 80 percent from 1990 levels.
- Improve our understanding of the environmental and public health implications of potential energy scenarios for California to avoid unintended consequences, such as negative impacts to wildlife, habitats, air quality, and water quality.
- Adopt environmentally benign and cost-effective options to maintain the efficiency of thermal power plants during heat waves. Improve environmentally acceptable and cost effective approaches for dealing with the efficiency of thermal power plants on extreme hot days.
- Improve our understanding of how climate change impacts the estimation of energy demand and assessments of energy supply (e.g., availability of hydropower in the summer).

<u>Promote energy demand side measures that facilitate climate adaptation</u>

- Investigate all available measures that will allow the delivery of high quality energy services at the lowest costs and with the minimum amount of energy feasible, such as deep energy efficiency retrofit programs with an integrated regulatory paradigm across water, electricity, and natural gas, green buildings, cool roofs, cool pavement, cool vehicles, urban greening, demand-side management and automated demand response, smart grid, permanent load shifting (from peak to off-peak), energy conserving land use practices, and zero net energy homes.
- Promote the expanded use of smart energy meter data to provide residential and commercial customers better access to their energy use profiles and allow them to take advantage of improved energy management systems that promote higher energy efficiency and better overall energy management. Suitable protections and policies should be put in place to protect vulnerable and low-income households from cost impacts, including time-of-use pricing, in order to ensure, among other things, access to air conditioning for heat emergencies.

- Broaden the use of automated demand response capabilities and systems to make it easier for future residential, commercial, and industrial end users to participate in demand response programs and tariffs.
  - Retrofit existing buildings through the Energy Commission's AB 758 program.
  - Implement Executive Order B-18-12 that directs state agencies to take immediate steps to green the state's buildings, reduce greenhouse gas emissions, and improve energy efficiency.
  - Explore the feasibility of considering climate change in cost-benefit analyses of energy efficiency standards for buildings (Title 24) and appliances (Title 20), such as increased ambient temperatures in the 16 climatic zones used to set building standards rather than the current practice of using historical climate data.

<u>Enhance energy-related climate change research</u>

- Coordinate climate change research with all the state agencies supporting or using climate change science via the Climate Action Team (CAT) Research Working Group. The Energy Commission will continue to provide leadership to the CAT Research Working Group. This group will also assist with the coordination of research activities with federal agencies.
- Continue to support and enhance the State Climate Change Research Catalog, which will provide basic information about past and current climate change research projects that have been or are supported by the State.
- Specify energy-related research in the California Climate Research Plan (the Research Plan) being developed by the CAT Research Working Group. This plan will represent a unifying vision on how the different state agencies intend to support climate research, forming a well-coordinated and integrated overall research program for California. Likely energy-related topics will be to:
  - Continue climate monitoring, analysis, and modeling for development of down-scaled climate change scenarios for California to support improved vulnerability assessments for energy and other sectors, better energy forecasts, and adaptation planning by local governments and private entities.
  - Improve vulnerability assessment methods for existing energy infrastructure and update assessments to inform more targeted adaptation options in the short- and medium-term based on the revised climate change scenarios.
  - Continue development and testing of supply and demand forecasting methods, such as seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation and new hydroelectric supply forecasting methods.
  - Continue the legacy of research, development, and demonstration for successful adaptation that also reduce GHG emissions, strengthen the green economy and maintain California's leadership in energy technology innovation, including transportation. Examples include energy storage, renewable energy efficiency, microgrid resilience, and efficiency improvements for buildings and vehicles, and low carbon transportation fuels. The discussion in the Research Plan will be fully

compatible with efforts in this area in the Energy Commission and the CPUC via the Electric Program Investment Charge (EPIC) and research supported by the Air Resources Board and others on this topic. The strength of the Research Plan will be in its capability to show how the different programs support each other.

- Identify and find solutions to regulatory, legal, institutional, and socio-economic barriers that can hamper the implementation of promising adaptation measures.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA FORESTS

Improve Forest Management Practices and the Capacity of the Forest Sector to Withstand and Recover from Climate Impacts In Order to Protect the Value and Continued Productivity of Forest Resources

(1) Continue and Enhance Coordinated Efforts to Reduce Wildfire Risks and Promote Fire Safe Communities

As called for in the 2010 Strategic Fire Plan, the State continues to reduce wildfire risks and promote fire safe communities in a number of ways including:

a) By identifying, mapping, evaluating, and monitoring fire hazard threats under current and projected climate conditions;
b) Helping to articulate and promote the use of land use planning to help reduce fire risk;
c) Assisting in the development of local county and regional plans that address fire protection and landowner objectives and responsibilities;
d) Increasing awareness regarding wildfire risks and safety precautions (such as using fire resistant building materials and clearing vegetation and other fire hazards near buildings) in individuals and communities;
e) Working with federal and local partners to integrate fire management practices with community and landowner priorities;
f) Calibrating the level of resources devoted to protecting assets from wildfire risk according to community values identified in planning efforts; and
e) Addressing post-fire recovery actions to restore natural resources, minimize flooding, address impacts of silt, sand, gravel from denuded slopes on water quality (so called "sedimentation").

The State must continue to refine understanding of how climate impacts will change wildfire risk. As that understanding develops, education efforts to communities and individuals must reflect the best available science regarding anticipated climate impacts and the state of wildfire risk in California. A cost-benefit analysis should be performed to estimate the probability and magnitude of loss of property, injury and loss of life to wildfire, as well as the necessary investments and actions to reduce wildfire risk in the face of expected climate impacts. This type of analysis might be done as part of updates to the Strategic Fire Plan. Funding to support this type of expanded climate and cost analysis may be necessary, and collaboration with partners and stakeholders would be necessary.

Wood waste from needed fire hazard reduction efforts might be used for biomass energy. The Electric Program Investment Charge (EPIC), which is further described in the Energy section of this document, might help provide funding to support utilization of biomass generated from forest fire hazard reduction efforts, perhaps focusing on development of small distributed power/heating facilities that could utilize existing sawmill infrastructure as well as the workforce in rural communities. Any such funding would have to be consistent with the current EPIC investment plan.

(2) Provide Funding to Support, Maintain and Expand Seed Banks and Revive State Tree Nurseries

As noted above, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been diminishing, with the suspension of nursery services. In order to ensure the ability to undertake restoration work following fires, to maintain the genetic diversity of California forests, and to protect tree species, including iconic species like the giant - continuing support for the State Nursery Program is critical. Seed processing and storage does not take the place of nursery production of seedlings (small immature plants); the availability of seedlings is particularly important for reforestation efforts following a fire.

With adequate funding, the State Nursery Program could:

- Maintain or expand seed banks to preserve genetic material from representative California tree species;
- Continue to promote the use of genetically appropriate native species in reforestation efforts; and
- Continue or expand work with the Natural Resources Conservation Service, Resource Conservation Districts, the US Forest Service, and private reforestation nurseries to increase the availability of reforestation seedlings available to small landowners.

(3) Assess and Implement Cost-Effective Forest Watershed Protection and Restoration

Forests provide a broad range of ecosystem services, including flood protection, improving the quantity and quality of water supplies for downstream communities, shading and energy savings, and improvements to air quality. Investments in forest protection and restoration can be a cost-effective way of protecting communities from the impacts of climate change such as more extreme weather and changing water availability.

The State should help incentivize best management practices for land management for better upper watershed protection, and encourage further cost-benefit analyses; while such cost-benefit analyses would require funding and staffing support, implementation of cost-effective ecosystem investment programs could be self-sustaining.

The Department of Water Resources and CAL FIRE might work together to identify potential areas for collaboration, such as further cost-benefit analyses and integrated regional water management plans.

(4) Improve Understanding of Trade-offs Between Different Management Responses to Expected Forest Climate Impacts
As described in more detail in the Biodiversity and Habitat section of this document, the rapidly shifting impacts and conditions associated with climate change are fundamentally altering long-standing paradigms for natural resource management. Species are not only changing in response to climate change, but geographic locations of suitable habitat are also changing as temperatures and precipitation patterns change. Natural resource management efforts must now occur in the context of these multiple shifting variables; various types of natural management approaches in response to unfolding climate changes are further described in the Biodiversity and Habitat section of this document. Continued research into the relative strengths and weaknesses of possible forest management approaches is needed and will help inform forest land owners, managers and regulators on how to best protect forest health and productivity in the face of climate impacts.

Certain public lands, such as National Forest System Experimental Forests and CAL FIRE Demonstration State Forests, are particularly suitable for near-term and longer-term research into the efficacy of various forest management approaches in the face of climate change. These experimental and demonstration forests function as living laboratories for forest scientists. Enabling funding is needed to support necessary research into forest management options to protect forest health and resilience in the face of climate risks.

Iterative refinements to chosen management strategies will be necessary as both climate science continues to improve and knowledge about natural resource management in the face of climate change also improves (this type of iterative refinement is sometimes referred to as “adaptive management”).

Statewide Assessment of Potential Cost Savings from Urban Forestry Investments

As noted above, urban forests provide myriad benefits, including cooling benefits that can reduce urban temperatures, public health impacts from climate change, and energy needs. Although research has been done on the quantification of potential benefits at the residential, project and city level, a thorough statewide assessment of potential opportunities, has yet to be done. A thorough assessment should include an evaluation of potential benefits as well as the cost of achieving such benefits. While the assessment would require funding, it could identify opportunities for urban forestry investments that might generate significant energy and cost savings for the State and California communities. A 2003 study by the USFS, Pacific Southwest Research Station, suggested that there were significant, cost-effective urban forest investment opportunities. According to the 2003 study, planting 50 million trees in California to shade east and west facing walls could reduce peak energy demand by 4.5% over 15 years, for a savings of $7.6 billion (with projected cost of 50 million trees estimated to be $2.5 billion). The

California Energy Commission is well positioned to lead this type of statewide assessment, in coordination with CAL FIRE, the California Department of Public Health and the California Environmental Protection Agency. Funding for a CEC assessment of this sort might come from the EPIC program, but would have to be consistent with the current EPIC investment plan. Any cost-justified recommendations suggested by the assessment would require funding support for implementation. CAL FIRE might help implement the urban forestry investments through its Urban and Community Forestry Program. CAL FIRE might also develop additional tools to help local and regional governments utilize urban forestry data for making planning decisions.

Improve Understanding of Forest Climate Impacts to Support Improved Forest Management Responses

(1) Improve Monitoring
Both the Forest Carbon Inventory and FRAP rely on data generated by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA), which is the nation's on-going forest census program. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. FIA data necessarily has error estimates as results are extrapolated from sampled forest plots and measurements are only taken at periodic intervals; however, greater accuracy can be obtained by increasing the number of sampled forest plots (this is called "densification" of survey plots) and/or by measuring more frequently. State support for densification and increased frequency of FIA measurements of California forests would allow for better forest management that is more responsive to changing climate impacts. For instance, better data would allow for improved mapping of pest outbreaks, spread of invasive species, and tree mortality – which has implications for wildfire risks and forest management interventions. As noted below, improved monitoring will also aid in evaluating different management options that might be used to address expected climate impacts. Current estimates of carbon stocks on forest lands are highly variable and additional monitoring and research to refine methods are needed.

(2) Better Modeling of Vulnerabilities and Climate Impact Trends
Some research has been done to understand how expected climate impacts (changing temperatures, changing water availability, more frequent and severe wildfire, changes in pests and invasive species) will affect the geographic shifts of tree species in California, but more of this type of trend analysis is needed. This analysis will have important ramifications not only for California's commercial tree species, but also for California's biodiversity and habitat more generally. Better understanding of climate impacts and geographic shifts in tree species will help inform and improve forest management options. Having a better understanding of the potential cost ramifications of expected forest climate impacts (i.e. impacts to forest health and forest productivity, loss of property/injury and other health impacts/and loss of life from wildfire risks, impacts to water supplies, etc.) and better cost-benefit analysis of investments to make the forest sector more resilient against the impacts of climate change would also be helpful for prioritizing forest sector climate strategies.

As FRAP (the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program) already produces periodic assessments of the state's forest and rangeland resources and carbon stocks, FRAP could be enabled to undertake necessary forest climate vulnerability (including relevant economic analyses) and trend analysis to support improved California forest management. Additional funding or staffing may be necessary to enable this type of work.

(3) Identify Priority Landscapes and Support Actions to Increase Forest Resilience
As climate changes rapidly over the coming decades, species (including trees) will be stressed and forced to adapt to new conditions. Some areas of the state may be able to serve as safe havens, or areas of refuge (also called "refugia") for climate stressed species. For instance, as the Southern Sierra Nevadas – Blue Oak Climate Scenarios map in **Box 39** illustrates, the mid-elevation areas of the Southern Sierra may be such an area of refuge for tree species that are unable to survive in higher temperature conditions that will start to occur in the lower elevation areas of the State.

CAL FIRE, through FRAP and in coordination with partners, should continue to identify potential niches in existing landscapes that may provide refugia for plants and wildlife in light of expected climate impacts. Listed species habitat requirements and diverse gene pool preservation needs to be considered to allow for species to respond to climate change. As noted in the Biodiversity and Habitat section of this document, preserving the biodiversity and limiting habitat fragmentation has important economic, public health and social dimensions. Additional funding or staffing may be necessary to enable this additional work to identify priority landscapes for protection.

Information Sharing and Education

As noted throughout this section, California has many key partners and stakeholders with respect to its forest resources. These partners and stakeholders include: the USFS, USDA Natural Resources Conservation Service, Resource Conservation Districts, local governments, industrial and non-industrial timberland owners, numerous nongovernmental organizations, and residents who enjoy and use California forests and forest resources. Information sharing and coordination with partners and stakeholders will continue to be important in order to monitor and protect forest resources in the face of growing climate threats such as fire, increased temperature, pests and invasive species, and changing water availability. Coordination may take the form of collaboration on research and management strategies, including fire risk reduction plans. Given the substantial federal ownership and management of California forest lands, coordination with federal partners, including USFS, will continue to be particularly important as climate impacts escalate.

Interagency collaboration on forests will also continue to be important, and should be reflected in the State's many on-going climates and energy related policy efforts and programs with a forestry nexus; these include the:

- California Forest and Rangelands Strategy Report and Assessment (CAL FIRE),
- Bioenergy Action Plan (California Energy Commission),
- Assembly Bill 32 Scoping Plan and Forest Carbon Inventory (California Air Resources Board),
- California Wildlife Action Plan (California Department of Fish and Wildlife),
- State Water Plan (Department of Water Resources),
- Public health and air quality programs which may be impacted by particulate matter from wildfires, and
- California Climate Research Plan and 4th Climate Assessment.

In order to assist incorporation of expected climate impacts into forest management decisions, education must be made available to forest land managers. With enabling funding, CAL FIRE and/or the University of California Cooperative Extension program could offer this type of technical, education assistance to forest managers.

ACTIONS NEEDED FOR SAFEGUARDING OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

Improve Management Practices for Coastal and Ocean Ecosystems and Resources and Increase Capacity to Withstand and Recover from Climate Impacts

(1) Hazard Avoidance for New Development

In order to minimize the adverse effects of sea-level rise and storms, it is important to carefully consider decisions regarding areas vulnerable to flooding, inundation and erosion. The state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea-level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need (*e.g.* coastal-dependent marine terminals or marinas that must necessarily be sited in areas at risk). If the state is building or planning to build, lease, or permit structures that will require additional new expenditures for sea-level rise protection during the expected life of the new structures, the state should ensure that the project proponent:

a) Minimizes risks through siting, design and engineering;
b) Ensures viable funding sources for building, monitoring and maintaining the new sea- level rise protections;
c) Ensures that any new protections must consider how risk changes over time, ensures that actions to reduce risk in the short-term do not increase risk in the long-term; and ensures that any new protections are capable of being augmented over time;
d) Designs protection in a manner that maximizes conservation of natural resources and public access.

As discussed in the Emergency Management section of this document, it is important to note that actions to reduce risk in the near term (such as developing protections for near-term sea-level rise) may encourage development patterns that actually increase risk in the longer term. Development must be carefully considered in light of local vulnerabilities, principles laid out in this section, and any recommendations resulting from the State Coastal Leadership Group described below.

(2) Encourage Innovative Design of New Structures/Infrastructure in Areas Vulnerable to Sea-level Rise

Where there is a compelling need for structures and infrastructure in areas susceptible to sea-level rise, storm surge and erosion, best available material science and structural design should be utilized to minimize pooling water on roadways, ensure maximum durability and public safety, and otherwise incorporate expected impacts into building plans. The State should propagate relevant design standards for engineering and construction in areas susceptible to sea-level rise, storm surge and erosion and priority should be given to development of green or nature-based infrastructure when appropriate. Efforts in other states affected by hurricanes (Florida, Georgia, Louisiana, etc.) should be studied to illuminate the potential impacts of severe storms in California.

(3) Enhance Integration of Climate Risk Considerations, Including Extreme Weather Events and Sea-Level Rise, into Emergency Management Activities

For a discussion of the integration of climate risks considerations into emergency management activities, please see the Emergency Management section of this document.

(4) State Coastal Leadership Group

Although there is a lot of work in California to address sea-level rise, coastal storms and erosion, the urgency of the situation requires more active management and coordination to understand what is working on local, regional and state levels that can be expanded and to leverage resources and better integrate work in an on-going manner. The OPC will lead an inclusive, collaborative, science-based process to inventory existing actions to reduce risks from sea-level rise, storms and erosion and to collaborate with others to improve the capacity of entities at multiple scales to more effectively act to reduce these risks. OPC will work with the California Coastal Zone Management Agencies (Coastal Commission, BCDC and Coastal Conservancy), the state coastal land owners (State Lands Commission, Department of Parks and Recreation) and other state entities and with consultation with local land use planning authorities, tribes, federal partners, and other stakeholders.

This process will involve activities such as:

- Conducting a science needs assessment in partnership with the CA Ocean Science Trust and the OPC's Science Advisory Team to identify key information needs and the opportunities for existing and new science to inform management and reduce risks.
- Engaging state partners to assess progress and future plans and leverage resources.
- Engaging non-state entities working on many scales to learn what is working, what could be expanded and what else needs to be done.
- Collaborating with FEMA, NOAA, USGS and the Army Corps of Engineers and

state agencies such as the Coastal Conservancy, Coastal Commission, BCDC and the Department of Water Resources on improving mapping of areas at risk of flooding due to sea-level rise, storms and shoreline change.

- Bring resources and expertise to assist the State Lands Commission, Coastal Commission and others address the issue of changing boundaries between public trust lands and private lands.
- Providing resources on funding sources and mechanisms for supporting actions to understand and reduce risks on many scales.
- Describing a range of tools that can be utilized to reduce risk while maximizing conservation of natural resources and public access, consistent with the public trust doctrine.
- Supporting state agencies to have the capacity to take effective action.
- Improving coordination and sharing of information needed to leverage resources and improve consistency and effectiveness.

The OPC will consider how to support innovative practices including managed retreat and use of natural processes and habitats to reduce risk from flooding, inundation and erosion; and will also address expected impacts to public access and use of beaches, trails and recreational areas along the coast.

(5) <u>Support Pilot Projects for Innovative Shoreline Management Techniques</u>
Particularly during the State Coastal Leadership Group, the state should continue to support local and regional governments and other entities implementing innovative shoreline management projects. Pilot project may provide valuable insights into best practices for managing shorelines in the era of rising sea levels and storm surges.

(6) <u>Continue to Study and Support Investment in Cost-Effective Green Infrastructure to Reduce Flood Risk and Stormwater Runoff and to Maximize Associated Co-Benefits</u>
As noted above, there can be significant cost savings and co-benefits associated with the use of green infrastructure, such as wetland restoration and urban forestry, to improve water quality and flood protection. Co-benefits may include greenhouse gas reductions that can reduce the pace and scale of climate impacts, habitat for wildlife, and improved air quality. For example, wetlands have the potential to reduce subsidence in the Delta, thus reducing pressure on levees which in turn reduces risk of levee failure and flooding. *See DWR's Twitchell Island Project in the* <u>Biodiversity and Habitat</u> *section for more information.*

(7) <u>Addressing Climate Impacts in Local Coastal Programs and General Plan Guidelines</u>
Under existing law, Local Coastal Programs (LCPs) and General Plans are key tools for addressing sea-level rise, storms and shoreline change. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. Continued investments to update LCPs is necessary since most LCPs currently do not include plans for reducing risk from sea-level rise. In addition, the Governor's Office of Planning and Research (OPR) will also be providing a 2013 update to its General Plan Guidelines (GPG 2013). The GPG

2013 will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.

(8) Support and Continue Progress Toward a More Integrated Ecosystem Approach to Management of Ocean Resources

Ocean acidification, changing ocean temperatures, rising sea levels, changes in oxygen levels, changes in ocean circulation, more extreme weather events, and cumulative and synergistic impacts, are rapidly changing marine habitats. Species ranges, species interaction, reproductive success, and many other variables are shifting. There is need to move away from a focus of only looking to management approaches that focus on single-species management. A more integrated approach might include the tenets of ecosystem management, a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural needs of current and future generations. While recognizing the importance of a more integrated approach, it is important to recognize that managers will continue to work within the confines of existing regulatory requirements, laws, and responsibilities as they relate to single species. A more integrated approach will be better suited to highly dynamic changing variables. For instance, the Pacific Fishery Management Council is developing an ecosystem-based approach to managing fish stocks in the offshore waters of Washington, Oregon, and California. Ecosystem-based management as defined by the Council "recognizes the physical, biological, economic, and social interactions among the affected components of the ecosystem and attempts to manage fisheries to achieve a stipulated spectrum of societal goals, some of which may be in competition." The Pacific Fishery Management Council is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976. In addition, the Delta Reform Act of 2009 adopted an ecosystem approach to restoring the Delta, along with the co-equal goal of improving statewide water supply reliability.

(9) Continued Development of State Sediment Master Plan and Sediment Management Activities

The Coastal Sediment Management Working Group (CSMW) is a collaborative taskforce of state, federal, and local/regional entities, chaired by the U.S. Army Corp of Engineers South Pacific Division and the California Natural Resources Agency. The CSMW is developing a comprehensive state Sediment Master Plan ("SMP") for the conservation, restoration, and preservation of valuable sediment resources along the coast of California. Sediment includes materials such as gravel, sand, silt and clay formed by natural erosion such as precipitation, wind, and stream flows. Humans have substantially altered natural sediment transport processes within California's coastal watersheds, reducing storm protection, habitat and recreation along the coast. The goal of the SMP is to reduce shoreline erosion and coastal storm damages, provide for environmental restoration and protection, increase natural sediment supply to the coast, restore and preserve beaches, maintain or improve coastal access, improve water quality along coastal beaches, and optimize the beneficial use of material dredged or excavated from ports, harbors, wetlands, and other sediment sources. For instance, the types of hybrid levees discussed in this Safeguarding California Plan would utilize dredged sediment from nearby flood control channels for marsh restoration. That dredged sediment is currently disposed of in landfills. Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) Program is implemented by state, federal and local partners, including the Bay Delta Conservation and Development Commission (BCDC). BCDC is working, in part with the CSMW, to prepare sediment management plans that integrate the successful Long Term Management Strategy for dredging with flood control planning, wetlands restoration and other aspects affecting sediment processes throughout the San Francisco Bay system.

(10) Water Management Responsive to Saltwater Intrusion Issues
For information about saltwater intrusion and water management activities, please see the recommendations for continuing to mainstream climate considerations into water management in the Water section of this document.

Better Understanding of Evolving Trends that May Impact Ocean and Coastal Ecosystems and Resources

(1) Better understand the impacts and opportunities associated with offshore renewable energy development
Renewable energy development helps to reduce greenhouse gas emissions from fossil fuel use and can help reduce the pace and scale of climate impacts on ocean and coastal ecosystems and resources. M arine renewable energy has the potential to play a role in meeting California's renewable portfolio standards and energy demand; however, marine renewable energy development can also have some negative impacts on coast and ocean ecosystems and resources including noise and light pollution and impacts on avian and other flying species. In response, the California Marine Renewable Energy Working Group; is an interagency group chaired by the California Ocean Protection Council was formed with the following goals:

- Address uncertainties in regulatory processes for marine renewable energy projects in California;
- Address the information needs of state agencies and stakeholders to inform potential impacts and user conflicts with marine renewable energy projects; and
- Facilitate the development of agreements and joint state-federal committees to improve coordination of state and federal permitting processes.

As noted above, it will be important to understand the benefits and impacts of ocean renewable energy development in the larger context of other expected climate impacts and traditional stressors on ocean and coastal ecosystems and resources.

(2) Support Reform of Federal Flood Insurance Program
As noted above, there were $68 billion of California assets insured under the Federal Flood Insurance program as of August 2012. However, continuing issues with respect to the financial integrity of NFIP may pose serious threats to the economic well-being and health of Californians. The State should support appropriate continuing reform of NFIP and implementation of the 2012 Biggert-Waters Flood Insurance Reform Act while engaging in risk communication efforts and other efforts described in this chapter.

Better Understanding of Climate Impacts on Ocean and Coastal Ecosystems and Resources

(1) Further Vulnerability Assessments and Cost Analyses
Additional vulnerability assessments and cost analyses are needed to fully assess California's risks to climate impacts and appropriate responses to reduce those risks. Every community potentially impacted by sea-level rise will need to prepare vulnerability and cost assessments that include but are not limited to consideration of recreational and environmental losses to the evaluation of cumulative and synergistic impacts, the importance of hazard avoidance, and the importance of adequately accounting for the environmental and recreational costs and benefits of strategies. Appropriate resources are needed for local governments and communities to not only prepare vulnerability assessments and cost analyses but also for the training and tools to apply the results to adaptation planning and implementation. Specifically, local vulnerability assessments are needed at scales that enable and inform planning and project implementation. The State has already invested significant resources to conduct and support vulnerability and cost assessments across sectors and a sampling of additional needs are listed below. An Adaptation Planning Guide for local and regional governments has also been developed.

a) Water Supply, Wastewater and Stormwater: An assessment of the state's wastewater and stormwater facilities is needed to identify vulnerabilities of aging infrastructure and system capacities in light of more extreme weather events and sea-level rise projections in the NRC report and as incorporated into the OPC's guidance to state agencies on planning for sea-level rise. Any such assessment should include cost analysis of system upgrades and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
b) Hazardous Waste Sites and Facilities: An assessment is needed for toxic release vulnerabilities from the state's hazardous waste facilities and hazardous waste sites in light of more extreme weather events and sea-level rise projections in the NRC report. The assessment should include recommendations for addressing vulnerabilities, including cost analysis of recommendations and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
c) Underground Storage Tanks (USTs): An assessment is also needed to address toxic release vulnerabilities from the state's USTs, not just in coastal areas, but also in inland areas susceptible to flooding. This need is further described in the Water section of this document.
d) Energy and Transportation Infrastructure: Additional needs with respect to vulnerability studies for energy and transportation infrastructure are described in the Energy and Transportation sections of this report.
e) Cumulative and Synergistic Impacts: As noted above, ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on ocean and coastal habitats and resources such as pollution and overfishing. Development of ocean renewable energy projects, and other offshore energy development, may also present new stressors on ocean and coastal habitats and resources.

The cumulative impact, and any synergistic dynamics among the stressors, is not well understood, and the potential implications for commercial fish and shellfish species and human health are also not fully understood. A more robust scientific understanding of cumulative and synergistic impacts, accompanied by a science-informed trade-off analysis framework, is critical to supporting innovative management techniques that are responsive to the new, and rapidly changing, marine conditions. Further, there is a need for OPC to continue supporting data layers within the California Geoportal to underpin decisions that will be made by permitting agencies. Funding support to enable studies of such cumulative and synergistic impacts is needed.

f) Economic Costs to Californians As noted above, there have been some studies to date of the economic impacts of sea-level rise to some California communities, and there has been some study of potential impacts from more extreme weather events. However, more information about the cost of expected climate impacts is needed to inform and evaluate management options. Needed economic cost studies include resource economics studies that study the value of services provided by ocean and coastal investments (e.g. improved water quality, enhanced soil stability, recreation and tourism opportunities, benefits from intact ecosystems, etc.). Funding support to enable such studies is needed.

g) Marine Species and Ecosystems See Biodiversity and Habitat section of this document for information regarding the need for a comprehensive, state-wide vulnerability assessment for marine species and ecosystems in California.

(2) Continued Modeling Scientific models are tools used to generate predictions and explanations. Models must be built, tested for accuracy, and revised. Models add greatly to our understanding of the possible outcomes from and consequences of changes to a system.

Along the coast, the main drivers of change will be changing water conditions (water level, waves, storms, extreme events, acidification, or temperature), and changes to the shoreline (sediment supplies, addition or removal of structures, development patterns). Models may be used to predict changes in the California shoreline, expected storm surges, pollution inputs, estuarine and near shore impacts, and sediment movement in coastal areas in the era of climate change. Modeling is important to examining the full extent of consequences associated with various sea-level rise projections along with storm wave conditions and the dynamics at coastal inlets. Continued development and refinement of models for climate impacts on California's ocean and coastal ecosystems and resources will be important. Funding to support such work will be needed.

(3) Continued Support and Investment in Monitoring Efforts

Monitoring changes to biological, chemical and physical processes is critical to continue advancing knowledge of climate impacts on coastal and marine ecosystems and resources and to support informed management responses that incorporate the best-available science on changing ocean and coastal conditions. Partnerships to enable funding and staffing of these efforts will be important. The Ocean Protection Council (OPC), in partnership with the Ocean Science Trust and the OPC's Science Advisory Team, will lead a process to identify priority monitoring needs to improve management of ocean and coastal resources under a changing climate. This process will address topics such as:

a) Ongoing monitoring and assessment of coastal inundation damages, for purposes of statewide flood planning;
b) Monitoring of offshore meteorological parameters and wave heights to obtain data for storm surge modeling and meteorological forecasting; and
c) Estuarine monitoring for changes to wetlands, sediment, changes in salinity, etc.

Information Sharing and Education

(1) Invest in Risk Communication Efforts, Emphasizing Disclosure of Risks that Have Not or Cannot Be Addressed in an Economically Feasible Manner
The State should invest in efforts to raise public awareness and understanding of sea-level rise and accompanying risks of flooding, erosion, infrastructure and property damage, and permanent submersion of coastal lands, salt water intrusion, toxic releases and other public health impacts. The state should also invest in efforts to raise awareness of the limitations of flood insurance and disaster relief, and the costs associated with response and recovery efforts associated with various anticipated sea-level rise impacts. Finally, the state should invest in efforts to raise awareness regarding options to protect new and existing structures and infrastructure from sea-level rise; awareness raising efforts should include discussion of any relevant benefits from employing green infrastructure, cost estimates, awareness and support for protecting vulnerable communities, and funding sources for protective measures. For example, California State Parks are one important venue to communicate risk and disseminate information. There are 114 coastal units in the State Park System – encompassing some 340 miles of the coast, and including coastal portions of State Parks, State Recreation Areas, Natural Reserves, and State Beaches. In 2011, 34 million visitors attended coastal parks. Each of those visitors presents an opportunity to communicate about climate change.

(2) Improve Maps and Tools and Provide Training to Incorporate Best-Available Climate Science into Planning and Operation and Management Decisions for Assets at Risk from Sea-level Rise
As sea-level rise projections and storm surge projections continue to be refined, maps and tools reflecting those projections must be developed and updated to support flood management planning, hazard planning, capital investment and development decisions. Training in the use of these maps and tools must also be provided so that best available knowledge about expected impacts can be fully integrated into routine governmental decision making, for instance for land use planning, transportation planning and operation and management, and the siting and operation and management of energy infrastructure.

(3) Sustainability Modeling Tools for Fishery Managers
Utilizing data collected from monitoring efforts, and best available understanding of cumulative and synergistic impacts from climate and other stressors, sustainability modeling tools should be developed to assist fishery managers. These tools should be consistent, to the

extent it serves the State, with relevant ecosystem-based management approaches propagated by the Pacific Fisheries Management Council as described above. California's network of MPA's provide scientist with an unprecedented opportunity to utilize and create tools to assess trends in oceanographic conditions that fishery scientists and managers may then use to determine the effects of these changing conditions on fisheries.

(4) Public Health Risk Communication Efforts
As noted above, climate impacts to ocean and coastal ecosystems and resources have numerous public health implications. Flooding, permanent inundation, and more extreme weather events may cause: toxic exposures from USTs and hazardous waste sites and facilities, increased pollution from stormwater and wastewater systems, contamination of fish and shellfish, and serious property damage including damage to transportation and energy systems and critical infrastructure including hospital facilities. In-situ instrumentation will help provide better data to inform needed beach closures to limit health risk exposures and consumption advisories. CDPH and SWRCB already have programs in place that could be used for these continuing public health risk communication efforts.

ACTIONS NEEDED FOR IMPROVED READINESS FOR CLIMATE-RELATED PUBLIC HEALTH RISKS

Improve Capacity of Communities to Prepare, Respond and Recover from Climate-Related Health Risks

Planning for Climate Change and Water-Related Public Health Risks
Climate change will present new challenges to providing safe drinking water. Any new state plans for drinking water or infrastructure investments to provide safe drinking water should consider climate risk implications.

The state's Drinking Water Program, which was transferred from CDPH to the State Water Resources Control Board on July, 1, 2014, has participated with US EPA, other states and representatives of several of California's water utilities on the USEPA National Drinking Water Advisory Council Climate Ready Utility Workgroup. The workgroup developed findings and recommendations relating to the development of a program enabling water and wastewater utilities to prepare long-range plans that account for climate change impacts. The findings and recommendations were published (Climate Ready Water Utilities, December 2010) and placed on the US EPA website.

The state's Drinking Water Program will continue to work with public water systems in the State to evaluate and permit innovative new sources of drinking water such as desalinization plants.

California should also begin to examine and identify the vulnerability of its public water systems to climate risks such as salt water intrusion, sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses will be needed. These analyses should be coordinated with other state agencies, water agencies and local agencies. Other priorities include advancing the science and policy needed to expand the role of recycled water as a drinking water supply. This work involves developing regulations to guide the use of recycled water for recharging groundwater and surface water reservoirs subsequently used as drinking water sources ("indirect potable reuse") and, and eventually directly as a water source for drinking water systems ("direct potable reuse"). Emergency regulations regarding the use of recycled water for groundwater recharge were completed and became effective June 18, 2014.

Evaluate Health Care Infrastructure Resilience

The Public Health workgroup of the Climate Action should convene a discussion with state agencies (including CDPH's Emergency Preparedness Office, the Office of Statewide Health Planning and Development and Emergency Medical Services Authority), healthcare industry partners and other stakeholders to discuss measures to improve resilience of the health care sector to climate impacts, and how such efforts can be coordinated with related federal efforts. Any assessment should also consider health care "surge capacity"—the ability to provide care to large numbers of patients in the immediate aftermath of an extreme event (heat wave, flood, storm, etc.) and the resilience of the health care workforce.

California should also begin to examine the vulnerability study of its health care infrastructure to climate risks such as sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses, and the implementation of any recommendations for reducing vulnerabilities, will be needed. A 2009 study funded by the Public Interest Energy Program at the California Energy Commission, indicated that a 55-inch sea level rise increase (which is within the range of sea level rise projections for San Francisco in 2100), would increase the number of health care facilities along San Francisco Bay that are at risk of a 100-year flood from 15 to 42. (For more information on risks associated with sea level rise in California, please see the Oceans and Coastal Ecosystems and Resources section of this document.)

Support Implementation of Recommendations in the 2013 State of California Extreme Heat Guidance Document

The State of California has developed *Preparing California for Extreme Heat: Guidance and Recommendations*. The State should support implementation of its recommendations. As the document notes, the implementation of some recommendations will require additional resources.

Support Development of Public Health Planning Tools for Local Communities

Enhanced climate and health-sensitive warning systems are needed. For instance, the California Environmental Health Tracking Program, which is a collaboration of the California Department of Public Health and the Public Health Institute, funded by the CDC, has conducted a study to determine if heat alerts accurately predicted times when people suffered the most heat illness. The methodologies that the National Weather Service (NWS) uses to issue heat alerts and warnings for local areas do not incorporate explicit health criteria. Working with the CDC, NOAA and the NWS, state and local health scientists can provide their expertise to enhance the sensitivity of NWS heat products so that California's population and health systems can be better warned and prepared to take countermeasures during heat emergencies.

Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice. Such surveillance can serve as an early warning system for impending public health emergencies; can document the impact of an intervention, or track progress towards specified goals; and can monitor and clarify the epidemiology of health problems, to allow priorities to be set and to inform public health policy and strategies.

Surveillance depends on the most accurate and latest data available. California's local health jurisdictions, CDPH, and the CDC employ a variety of public domain and commercial surveillance systems to capture syndromic and ongoing surveillance data. These systems vary from a simple system collecting data from a single source, to electronic systems that receive data from many sources in multiple formats, to complex surveys. When considering or employing a health surveillance system, jurisdictions should use the CDC's *Guidelines for Evaluating Surveillance Systems* to address the need for a) the integration of surveillance and health information systems, b) the establishment of data standards, c) the electronic exchange of health data, and d) changes in the objectives of public health surveillance to facilitate the response of public health to emerging health threats (e.g., new diseases).

Tools that provide public health data and information to public health officials will be an important part of efforts to detect, track, prepare, and respond to climate-related health risks. California should collaborate with federal and local partners to support development and enhancement of such tools.

Better Understanding of Evolving Trends that May Impact Public Health in the Era of Climate Change

<u>Healthy Energy Efficient Buildings</u>

Constructing and upgrading buildings to be more energy efficient can provide tremendous benefits including lower utility costs, greater energy security, improved air quality, reducing emissions that cause climate change, and the creation of green jobs. However, if construction or upgrades are performed improperly, health risks may arise. For instance, if proper ventilation is not part of design, then indoor air quality may be compromised and can be exacerbated by changing climate conditions. US EPA released a 2011 document entitled "Guidelines to Ensure Healthy Indoor Air during Home Energy Upgrades". The Guidelines provide a step-by-step process for conducting assessments to evaluate indoor air conditions and the potential for risks that may arise during residential energy upgrades.

California includes in its 2008 and newly adopted 2013 Energy Efficiency Standards for New Residential and Nonresidential Buildings ventilation requirements that meet or exceed current minimum state and national ventilation requirements. These requirements are consistent with best practices for the design of ventilation systems for newly constructed buildings, as well as, the additions and alterations of existing buildings. In June of 2013, the California Energy Commission (CEC) also published the draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings (the "Action Plan") in order to meet the intent and requirements of legislation that requires the CEC develop a comprehensive program to achieve greater energy efficiency in the state's existing buildings. The programs and standards that are developed according to the final Action Plan may include strategies to meet or exceed national and state requirements for whole house and multi-family ventilation including: heating, ventilation and air conditioning (HVAC) systems and equipment; combustion safety; contaminant distribution and source ventilation that are identified in the EPA Protocols for Home Energy Upgrades. The Action Plan also establishes building industry outreach and education goals for job training that includes health and safety considerations. Support for implementation and compliance with the state's energy efficiency standards and the Action Plan will be important to realizing all the benefits of energy efficient buildings.

Low Allergen or Nonallergenic Urban Greening to the Extent Feasible
As noted above, there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, but models indicated that pollen will likely increase in many parts of the United States and there may be shifts in the seasonal timing of allergen production and other changes to air-borne allergens. In order not to exacerbate public health issues associated with air-borne allergens, urban greening programs should consider low allergen or nonallergenic species to the extent that such species are otherwise regionally suitable.

Better Understanding of Climate Impacts on Public Health

Further Development and Support of Local Vulnerability Assessments
As noted above, some initial local vulnerability assessments, for communities, have been developed for selected communities, like Fresno, Los Angeles and San Francisco. However, all California communities face climate risks to public health, and there is still a need for further development and support of local vulnerability assessments for climate-change health risks (such as risks relating to heat, air quality, fire, flooding, and water availability and quality). Conducting geographically-specific vulnerability assessments and the identification of vulnerable populations can help guide efforts to design and implement strategies to address local risks and needs of high risk groups. The February 2012 ASTHO Climate Change Population Vulnerability Screening Tool discussed above should be revised to include improved data and additional stakeholder input; and vulnerability analyses for additional communities should be undertaken. CDPH's four year CDC BRACE grant will expand this planning for ten additional counties; however, funding to expand and support these efforts so that local public health partners can be actively involved may be necessary.

Increase Capacity to Monitor Climate-Related Deaths and Illnesses
Continued actions to improve disease reporting and surveillance will aid efforts to understand and respond to emerging climate risks to public health. These actions may include: coordinating with federal and regional rapid surveillance efforts; upgrading the California Death Registration System to provide for continuous monitoring of abnormal death patterns, including heat-related death; and improving surveillance programs for infectious diseases including vector-borne, water-borne and food-borne diseases.

Social Vulnerability Mapping for Climate Change

Multiple screening tools for social vulnerability now exist, such tools reflect a variety of conceptual frameworks, methodologies, and data. These tools have varying strengths, weaknesses, assumptions and limitations. CDPH should convene a meeting with various state entities and other partners who have developed such social vulnerability tools in order to identify gaps that may be filled by collaborative research and to examine best practices for developing social vulnerability assessments for Cal-Adapt.

Regional Studies of Aeroallergens

Significant gaps still exist with respect to California's ability to monitor potential shifts in air-borne allergens. Funding to enhance allergen monitoring, identification and forecasting would support efforts to better understand how allergens are shifting in response to climate change, and would help support the development of policies to help reduce these health risks for Californians in light of these changing conditions.

Information Sharing and Education

Capacity Building to Raise Awareness and Foster Action to Address Climate Risks to Public Health

Outreach efforts are important to ensure that public health and medical professionals are prepared and educated on climate risks. Health professionals are uniquely positioned to help raise community awareness about risks to public health from a changing climate and a health framing may help more members of the public to consider climate risks and actions. In addition to capacity building efforts described in the Introduction to this document, a grant program for local health departments and professional medical and nursing associations could be established to support the development of courses on climate and California health risks for the staff and constituents of such organizations. Funding and adequate staffing to support such a grant program would be required. Any such capacity building courses for local public health, medical and nursing professionals should include information about the health impacts of climate change, as well as information related to the prevention and management of climate-related illnesses (e.g., heat illness) and promoting resilience.

Public Education on How to Reduce and Prepare for Climate Health Risks

The Public Health workgroup of the Climate Action Team together with other relevant state entities, should develop culturally and linguistically relevant educational materials for diverse populations (e.g., vulnerable communities, school-age children, businesses, and labor) using best practices in climate change education. Materials should promote an understanding of various health risks associated with California's changing climate, including, but not limited to, risks associated with extreme weather, heat waves, heat and outdoor labor, air quality, aeroallergens, wildfire, floods and sea level rise, and drinking water, and describe strategies and actions that foster preparedness.

Public education campaigns should be designed to disseminate this information. The campaign should not only utilize existing resources to disseminate information (e.g., the bepreparedcalifornia.ca.gov website and public health advisories), but should also involve collaboration with partners and innovative modes for disseminating information. Additional funding and staffing will be needed for this effort.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO THE TRANSPORTATION SECTOR

Better understanding of evolving trends that may impact transportation systems

In addition to changing climate conditions, transportation continues to evolve in California. Preparing for climate impacts on California's transportation system must be considered in conjunction with the evolving landscape of California's transportation sector. For instance, there might be a need to:

(1)Better understand the impact and opportunities associated with vehicle electrification and other advanced clean cars on timing and demand for energy supplies (at the same time that climate impacts are occurring and causing changes to energy demand) and better understand the reliability of energy supplies for all vehicles in the face of expected climate impacts. The California Energy Commission already does some of this type of work, for instance in its Energy Demand Forecast, and could further this type of analysis in collaboration with other agencies.

(2) Better understanding of likelihood of land subsidence events that may compromise transportation systems and steps that can be taken to avoid such subsidence if possible. This type of enhanced knowledge will likely take collaboration between a number of entities including the California Department of Water Resources (DWR), Caltrans, SWRCBS, and local and regional governments. Subsidence and more specific recommendations regarding avoiding subsidence are included in the Water section of this document.

Improve the reliability of California's transportation system in the face of expected climate impacts

Action is needed to translate the findings of vulnerability studies described above into actions that improve the reliability of California's transportation system in the face of expected climate impacts. This might include:

(1) Continued integration of climate impact considerations and best available climate science in transportation planning, design, programming, construction, operations and maintenance and updating such efforts as the state of climate science evolves; and

(2) Implementing actions needed to ensure transportation fuel availability and functioning of fuel distribution infrastructure in light of expected climate impacts;

(3) Prioritizing improvements to address climate vulnerabilities in transportation systems, including prioritizing those projects that protect key evacuation routes and modes first; and

(4) For new construction and repairs, using state-of-art materials/infrastructure design to optimize transportation system resilience (against extreme heat, challenges of standing and moving water during extreme weather events including storms and floods) with continued research on materials and design to enhance resiliency of transportation systems.

Further enable incorporation of anticipated climate impacts into transportation plans

As noted above, pursuant to SB375 MPOs have been developing sustainable community strategies for incorporating regional greenhouse gas emission reduction targets in regional transportation plans. As also noted above, the 2013 document "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs" provides guidance to MPOs and RTPAs on possible steps to incorporate climate impacts into long-range transportation planning. As the 2013 guidance document notes, there is currently no requirement to incorporate climate impacts into regional transportation planning, and MPOs and RTPAs have varying capacity and resources to do so. The Strategic Growth Council currently administers a grant program for cities, counties, MPOs, regional transportation planning agencies, joint power authorities and councils of governments to assist with implementation of SB375; a certain amount of that grant funding is prioritized for projects in disadvantaged communities. A similar grant program might help enable incorporation of climate impacts into sustainable community strategies and/or regional transportation plans.

Better understanding of expected climate impacts to inform transportation planning

(1) There is a continued need for regional climate model downscaling, particularly near major population centers, to provide more detailed information regarding anticipated, California-specific climate impacts - so that such information can inform transportation planning. This type of work will be further described in the forthcoming California Climate Research Plan.

(2) There is also a need for better understanding of the specific vulnerabilities of transportation infrastructure (ports, roads, airports, transit systems) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As noted above, transportation infrastructure in California is managed by a variety of federal, state, local/regional, and private entities. These types of infrastructure vulnerabilities would likely need to be conducted by the entities most directly responsible for the particular infrastructure in question; enabling funding, staffing and/or other technical assistance for the vulnerability assessments might be necessary. For instance, for Caltrans to do a complete vulnerability assessment of the 50,000 lane miles, bridges and culverts under its jurisdiction would require approximately $5 million. The most appropriate form of assistance for a vulnerability assessment would be dependent on what type of entity is conducting the assessment (for instance, grant assistance might be appropriate for local/regional entities).

(3) There is a need for better understanding of specific vulnerabilities of fueling infrastructure: (refineries, pipelines, marine terminals, underground storage tanks, and fueling stations) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with transportation infrastructure, the entities most directly responsible for the fueling infrastructure in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary; and the appropriate form of assistance would vary according to the assessment.

(4) Better understanding of the specific vulnerabilities of energy systems supporting refineries, fueling stations, transit systems, and other important parts of California's transportation system to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with the above, the entities most directly responsible for the particular energy systems in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary. The CEC, ISO, and PUC would likely be the entities involved in this type of assessment. The work of these entities is further described in the Energy section of this document.

(5) In order to aid prioritization of needed changes in transportation planning and operations, the vulnerability assessments referenced above should include consideration of both the probability of impacts and the magnitude of potential damages, transportation disruptions, injuries and loss of life.

Information Sharing and Education

(1) While many agencies are beginning to incorporate climate impacts and considerations into planning and operations, information sharing and collaboration between agencies could expedite the learning process regarding best practices for transportation management in the era of climate change. The state could help convene an interagency task force on reducing risks to California transportation; such a task force should include federal, state, local/regional agencies and appropriate transportation, water, energy planning professionals. Caltrans might be an intuitive choice for leading such a convening effort.

(2) An interagency task force on reducing risks to California transportation might assist in the development of training tools and guidance for transportation professionals regarding incorporating climate impacts and considerations into transportation planning, design, programming, construction and operation and maintenance. The development of such tools and guidance may require funding and staff support.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA WATER RESOURCES

Vigorously prepare California for flooding

Flooding currently presents a clear and present danger to public health and safety that will only worsen with climate change. As noted above, more than seven million Californians are currently exposed to flooding hazards within 500-year floodplains. California remains underprepared for this current and growing threat, and the following actions are recommended:

- Protect taxpayer investments by requiring that DWR and SWRCB formally consider and account for climate risk in all water infrastructure planning, design, permitting, and funding, including loans and grants to local agencies;
- Expand the Western Observing and Forecasting System to allow for offshore observations that will provide greater forecast lead times for coastal communities;
- Conduct a vulnerability assessment of critical State-owned infrastructure located in the state's floodplains;
- Expand piloting and begin implementation of forecast-based operations to allow more flexibility to operate existing reservoirs for changing climate conditions;
- Given the concentration of State government facilities and functions in Sacramento, prepare a catastrophic disaster response and recovery plan for the Sacramento metropolitan area, in collaboration with local and regional governments and other partners;
- Continue work to implement critically needed repairs to California's levee system; and
- Reconnect rivers to their floodplains, rehabilitate upper watershed source areas, and provide more natural floodplain features and functions that slow, spread, capture, and infiltrate floodwaters throughout a watershed. Specifically,
    - improve stewardship of forests and headwaters to reduce the risks of catastrophic wildfire and downstream flooding impacts; and
    - expand existing and establish new flood bypasses.

Support regional groundwater management for drought resiliency

While California's largely decentralized regime for groundwater management presents significant challenges to adapting to climate change, it presents significant opportunities as well. For example, regionally managed groundwater recharge, storage, and conjunctive use (the coordinated management of surface and groundwater) can play a key role in compensating for the loss of natural water storage as the Sierra Nevada snowpack diminishes. Many local and regional groundwater management agencies also have the authority and capacity to: 1) establish thresholds for groundwater drawdown, quality, and subsidence; 2) monitor groundwater conditions; and 3) take actions to manage demand when needed to avert problems. State level support and oversight should be provided where needed to ensure the success of local and regional management efforts.

California must take steps now to ensure that its aquifers will help make its water systems climate resilient. Below are some recommended actions. Funding and staffing will be needed to implement many of these actions.

- Promote better understanding about California's groundwater, conjunctive use, and the potential risks associated with changing climatic conditions, including examples of groundwater crises already occurring in the state and projections on the condition of California's groundwater basins in 20 years, based on current groundwater management practices and climate projections.

- Strengthen and expand the California Statewide Groundwater Elevation Monitoring (CASGEM) Program established by SB 7x-6, to ensure continued groundwater level monitoring in areas where voluntary monitoring is not occurring, statewide prioritization of basins, and identifying basins subject to critical overdraft. Support a statewide evaluation of current groundwater conditions and management efforts, by analyzing CASGEM data and reviewing the content and implementation of groundwater management plans; from this assessment, develop guidelines to promote best practices for regional groundwater management.

- Develop and fund a state program for monitoring drought impacts on groundwater resources, including for remote sensing-based monitoring of land subsidence associated with groundwater extraction, as drought conditions cause water users whose surface supplies are curtailed to increase their groundwater use, depleting basin storage and sometimes creating impacts to others by inducing migration of poor-quality groundwater into pumping zones or accelerating land subsidence.

- Improve the State-level integration of existing groundwater data (quality and quantity) and information with surface water data and information.

- Promote groundwater recharge and storage by:

  - streamlining and aligning regulatory programs, as appropriate, to support increased conjunctive use and groundwater banking;

  - developing tools to help characterize and delineate groundwater recharge areas;

- evaluating economic and water security benefits from more sustainable management practices;

- developing estimates of storm water capture and groundwater recharge potential, and a tracking database to inform water resource planning and permitting decisions;

- developing guidelines for coordinating land use planning and protection of groundwater recharge areas;

- incentivizing local and regional efforts to use low impact development techniques in new development and retrofits through State loans and grants;

- incentivizing reduced pumping in overdrafted groundwater basins and increasing groundwater recharge through State loans and grants;

- modernize the state's storm water regulatory program to incentivize storm water capture and infiltration, and protect the infiltrative capacity of hydrogeologically vulnerable areas;

- complete rulemaking for groundwater recharge with recycled water (indirect potable reuse);

- identify obstacles to increasing most efficient use of water by agriculture and develop programs, policies and practices to overcome these obstacles; and

- develop and adopt salt and nutrient management plans consistent with the State Water Boards recycled water policy.

- As part of IRWM plans, provide multi-agency support for local pilot projects that could become part of a system of regionally-based, strategic groundwater drought reserves; such pilot projects should be prioritized for high-use basins.

- Work with local and regional groundwater management agencies in impacted, vulnerable, and high-use basins to develop and refine groundwater thresholds for quality, level, and subsidence, conduct monitoring needed to determine if thresholds are being met, and take actions needed to sustainably manage groundwater.

Diversify Local Supplies and Increase Water Use Efficiency

Climate change is adding to other stressors to make water supplies from major sources like the Colorado River and the Sacramento-San Joaquin Delta less reliable. Increasing regional self-reliance and diversification of local water supplies will enable Californians to better respond to changing economic and climactic conditions while ensuring a reliable water supply for the diversity of the state's water needs. California's water agencies utilize a variety of water management measures to improve local water supply reliability. These measures include agricultural and urban water use efficiency, local storage, conjunctive use, increasing stormwater capture and infiltration, recycled water, and ocean and brackish water desalination. Since the early 2000s with the start of the Integrated Regional Water Management (IRWM) there has been increasing emphasis on regional collaboration in the implementation of water management measures. With the passage of SB7x7 in 2009, urban water suppliers are required to set and meet 2015 and 2020 water use targets and agricultural suppliers are required to adopt agricultural water management plans and report on the implementation of efficient water management practices. The Delta Stewardship Council's Delta Plan requires water suppliers to reduce reliance on water from the Delta.

- The State should continue to support regional water management planning and project implementation through additional funding for the IRWM. The IRWM Grant Program funds a wide variety of regional water management actions. The IRWM Program is intended to support flexible implementation of actions needed to address regional objectives and needs. As such, the IRWM funds water supply, water quality, flood management, and environmental protection and restoration.

- The State should develop a 2030 Statewide Urban Water Use Efficiency Plan with the goal of requiring urban water suppliers to continue the improvements in water use efficiency from the 20x2020 program. Accounting for population growth, continuing the current 20x2020 program will keep the total volume of urban water use in 2020 at the same volume as in the year 2000. The goal of the 2030 program is to replicate the 20x2020 success and keep the volume of 2030 urban water use the same as the 2020 level.

- Agricultural water suppliers with irrigated acreage equal or greater than 25,000 acres should begin utilizing the methodologies for quantifying agricultural water use efficiency in the "Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use" by 2020. Quantifying water use efficiencies can provide valuable information to water suppliers and highlight efficiency improvements, and climate risks to California water will be increasing over time.

- Provide targeted funding for:
    - agricultural and urban water suppliers for projects that plan and implement sustainable water solutions serving disadvantaged communities
    - urban and agricultural water use efficiency research and development programs for development, testing and implementation of new technologies
    - the "Save Our Water" media campaign so it can achieve the same visibility and outreach as the California Public Utilities Commission's energy reduction campaigns.

- Set a statewide target of 1 million acre-feet (MAF) of recycled water use annually by 2020. DWR, with SWRCB, should prepare a comprehensive report of regional recycled water conditions to guide expanded use of recycled water including assessment of a 'fit for purpose' concept for urban, agricultural and environmental applications and a cost benefit analysis.

- State should promote the SWRCB's stormwater use target of 500,000 AF per year.

- Develop a coordinated streamlined permitting process for desalination projects that provides strong environmental protection.

- State entities, including SWRCB, DWR, CDPH, and CDFA, together with stakeholders should work to develop comprehensive data collection on water diversion, delivery, and use. This will assist in measuring program performance for this and other strategies.

Reduce Sacramento-San Joaquin Delta climate change vulnerability

As noted above, the Sacramento-San Joaquin Delta is vulnerable to climate risks such as flooding, sea level rise, and stress on aquatic habitat. Several planning efforts are underway to further the co-equal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

Reducing climate change vulnerability in the Delta will depend on completion and implementation of the Water Quality Control Plan, the Delta Plan and the BDCP. At the same time, as discussed elsewhere in this chapter, regions that depend upon water from the Delta will need to develop far more regional self-reliance, through a variety of measures, to ensure long-term water supply reliability.

Prepare California for hotter and dryer conditions and improve water storage capacity

While drought is a normal part of the water cycle in California, drought conditions are becoming more common and more severe. California's water infrastructure provides the ability to manage some degree of hydrologic uncertainty and variability through operational tools such as water transfers, reservoirs, and conjunctive surface water and groundwater use. However, it is not sufficient to address extreme or prolonged drought conditions.

As noted above, a variety of measures may be utilized to mitigate potential shortages during drought, including minimizing reliance on imported water, improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, desalination, groundwater remediation, conjunctive use, firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements. The state has made substantial investments, through grant programs, in helping local water agencies improve their water supply reliability and take other actions that reduce their vulnerability to droughts.

The state can further improve California's ability to deal with the risks of more frequent and severe drought conditions by:

- Improving drought prediction at the one-month to two-year timescales critical for making operational decisions in managed water systems, and for helping those relying on unmanaged water supplies assess their risks, through investing in research and related hydroclimate monitoring to improve prediction. From an operational perspective, improving drought predictive capability is probably the single most important action the state could pursue.

- Reducing the drought vulnerability of small water systems, especially those in at-risk rural areas dependent on unreliable groundwater sources, through state financial assistance programs and through lowering the threshold for requiring public water systems to prepare Urban Water Management Plans (UWMPs) from 3,000 or more connections to 2,000 or more connections.

- Improving the understanding of wildfire risks to water infrastructure, and support actions to reduce those risks. The hotter, dryer climate conditions that result in drought, also create risks of more frequent and severe wildfires that can further impact water supplies that are already otherwise stressed by increased water demand and decreased flows. Wildfire is already a significant cause of system damage for small water systems in rural areas. The damages experienced by Denver Water facilities following Colorado's 2002 fire season illustrate potential risks to large water system infrastructure in the Sierra Nevada. Wildfire risk planning should be included in large water agencies UWMPs.

- Improving flexibility in our water transfer systems. Streamlined water transfers in times of extreme drought will strengthen California's resilience to climate change.

- Improving water storage capacity, including supporting regional groundwater management as further discussed above.

Address water-related impacts of climate change on vulnerable and disadvantaged populations and cultural resources

Just as different regions of California will experience the impacts of climate change differently, so will the diverse populations of California. Indeed, some people—including those who are ill or unemployed, the very old and the very young—may be more sensitive or vulnerable than others, making them less capable of coping with climate change. For instance, the increased flood risk due to climate change may disproportionally impact poor communities, due to their location as well as their lack of mobility. Disadvantaged communities already grappling with drinking water quality and supply problems are unlikely to have the capacity to deal with the additional challenges—deeper and longer droughts, deteriorating water quality—that climate change may bring to their water resources. Climate change may also negatively impact water resources that are important for tribal subsistence and cultural purposes.

Climate impacts are experienced locally, in communities. Targeted assistance in the form of outreach, information, funding, investments and community engagement will improve the likelihood that communities will support, implement, and benefit from adaptation strategies that can improve community resilience. For these reasons, water planners and their partners must ensure equitable access to information and resources and explicitly recognize, target, and prioritize efforts to ensure that the most vulnerable Californians are prepared for climate risks to water; for instance, by establishing stable long-term funding sources for the provision of safe drinking water to small disadvantaged communities. A Tribal Advisory Committee helped to develop the content in the California Water Plan 2013 Update, and continued engagement with tribal nations will continue to be important when managing water resources in the era of climate change.

Continue to mainstream climate considerations into water management

As noted above, DWR has made great progress in mainstreaming climate considerations into its many operations. It began climate research as early as 1987, has integrated climate considerations into the California Water Plan since 2005, convenes a Climate Change Technical Advisory Group, and offers climate literacy classes for its staff.

Further actions can help mainstream climate considerations in all the state's water management activities. For instance, in order to reduce institutional barriers to preparing for climate risks, the Water Boards will use relevant, peer-reviewed climate science to identify climate adaptation criteria and processes for incorporating climate change considerations into all Water Boards' programs, such as water quality permits or guidelines for infrastructure loans and grants. The State Water Board and DWR should develop funding criteria to discourage construction of new water infrastructure in high-risk areas. In coastal groundwater basins, which are vulnerable to increased salt water intrusion as a result of sea level rise, the Water Boards will support and encourage measures such as recycled water injection and groundwater storage during wet years to make coastal aquifers more resilient to climate change impacts.

Utilize low impact development and other methods in State and regional stormwater permits to restore the natural hydrograph

The Water Boards are encouraging permitees to use a watershed approach to "slow the flow" of water, using urban runoff best management practices to achieve multiple benefits, such as reduced pollution, water supply augmentation, flood protection and habitat enhancement. Municipal stormwater permitees are required to exercise their land use authority to implement development programs that require installation of stormwater controls at new developments and significant redevelopment projects. The permits adopted require the use of Low Impact Development techniques but also recognize that alternative or regional projects can be beneficial. These techniques range from onsite tree planting to installation of porous pavement to designing recharge wetlands and must be monitored to measure their effect on water quality. In collaboration with other State, regional and local agencies, the Water Boards will identify data needs to enhance planning decisions associated with preparing for climate risks and incorporate that data gathering in their permitting authority.

Urban trees can help filter and remove pollutants from stormwater, and also reduce stormwater runoff. Continued and expanded support for urban forestry and urban greening will be important not only for water-related benefits, but to reduce heat island impacts and reduce energy demand as California experiences climate impacts. For more information on urban forestry and heat island effects, please see the Forestry and Public Health sections of this document.

Require closer collaboration and coordination of land use and water planning activities to ensure that each reinforces sustainable development that is resilient to climate changes

Despite state laws requiring demonstration of “adequate water supplies” for development and extensive requirements for both land use and water resource planning, these processes continue to lack integration allowing land use decisions to be made that may conflict with water resource plans or imperil sustainable management of water resources. Currently, General Plan Guidelines lack the specificity to ensure that water supply and water quality issues created by new development are adequately analyzed and addressed; in an era when climate risks present escalating challenges to water resources, new development must be carefully integrated with sustainable water management efforts. The Governor’s Office of Planning and Research will engage local land use authorities and water agencies and amend the General Plan Guidelines to promote local land use decisions that are consistent with local sustainable water management.

Closer integration of Urban and Agriculture Water Management Plans and Integrated Regional Water Management Plans into General Plans and local climate action plans and/or resilience plans, through better coordination and harmonized planning requirements, will help establish consistent sustainability goals across these planning processes. Water sustainability should also be given consideration for addition to the requirements of Sustainable Communities Strategies that are required for each of the state’s Metropolitan Planning Organizations (MPOs). Increased coordination between land use and water planners may also reveal opportunities for improvements in stormwater management and the use of recycled water, both important strategies for improving resilience.

Protect and restore water resources for important ecosystems

As noted above and in the Biodiversity and Habitat section of this document, climate change presents a variety of escalating risks to important ecosystems in California. In order to reduce these risks, the state should continue its efforts to restore key wetlands and to ensure adequate water quality and supply for important ecosystems. Collaboration between state entities working on water issues and ecosystem management issues will also continue to be important.

Better understand climate risks to California water and develop tools to support efforts to prepare for climate risks

Additional information and tools are needed to adequately prepare for climate risks to the California water sector.

For instance, more research is needed regarding:

- the relationship between snow pack, rainfall, and groundwater recharge and quality;
- land-cover and ecosystem responses to changing precipitation and runoff conditions;
- how water quality in rivers, lakes and aquifers will be affected by changes in precipitation, timing of flow, and temperature;
- how water flow management can help support climate-stressed aquatic species; and
- the role of extreme precipitation events and implications for within-year variability on our water supply.

It will also be important to continue and enhance monitoring of changing water conditions. Monitoring allows tracking of changes in snow-covered and rain-dominated portions of key watersheds, and direct observation of climate changes can help refine climate projections and models.

It will no longer be adequate to manage California water resources based on historical trends, and decisions support tools for water managers that reflect climate projections are needed to help guide water management and planning decisions.

APPENDIX B: ACKNOWLEDGMENTS

The Safeguarding California Plan was prepared by the California Natural Resources Agency. Deputy Secretary for Climate Change and Energy Ann Chan led the overall plan development. This document was made possible by the hard work of numerous contributors. Below is a list of State agencies, organizations, individuals and events that have provided input into the Safeguarding California Plan. Valuable tribal and stakeholder input also shaped the final document.

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- Bay Conservation and Development Commission
- California Air Resources Board
- California Coastal Commission
- California Department of Conservation
- California Department of Fish and Wildlife
- California Department of Food and Agriculture
- California Department of Forestry and Fire Protection
- California Department of Insurance
- California Department of Parks and Recreation
- California Department of Public Health
- California Department of Transportation
- California Department of Water Resources
- California Energy Commission
- California Environmental Protection Agency
- California Fish and Game Commission
- California Health and Human Services Agency
- California Independent System Operator
- California Labor and Workforce Development Agency

- California Ocean Science Trust
- California Public Utilities Commission
- California State Coastal Commission
- California State Coastal Conservancy
- California State Lands Commission
- Delta Conservancy
- Delta Protection Commission
- Delta Stewardship Council
- Department of Toxic Substances Control
- Governor’s Office of Planning and Research
- Governor’s Office of Emergency Services
- Ocean Protection Council
- State Water Resources Control Board

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- Cody Hooven, Senior Environmental Specialist, Port of San Diego
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Guest Speakers at Public Workshops and Listening Sessions:

- Gary Griggs, University of California Santa Cruz
- Kathleen Sloan, Yurok Tribe Environment Program
- Ken Topping, FAICP, California Polytechnic State University-San Luis Obispo
- Angelo J. Bellomo, County of Los Angeles Department of Public Health.
- Michael F. Wehner, Lawrence Berkeley National Laboratory
- Mike Chrisman-Former Secretary of the California Natural Resources Agency and former Director of the Southwestern Partnership Office of the National Fish and Wildlife Foundation
- Maximilian Auffhammer, University of California, Berkeley
- Jayant Sathaye, Lawrence Berkeley National Laboratory and University of California, Berkeley
- David Sapsis, California Department of Forestry and Fire Protection (presenting materials from Malcom North, United State Forest Service, Pacific Southwest Research Station and Department of Plant Sciences, University of California, Davis)

Public Workshops and Listening Sessions

- July 12, 2013: Advance Tribal Outreach & Listening Sessions-Sacramento, CA
- July 18, 2013: Advance Tribal Outreach & Listening Sessions-Sacramento, CA
- September 30, 2013: California Natural Resources Agency- Sacramento, CA
- October 2, 2013: Yurok Tribal Office- Klamath, CA
- October 8, 2013: Ronald Regan State Building-Los Angeles, CA
- October 10, 2013: University of California, Merced-Merced, CA
- October 11, 2013: Truckee Town Hall-Truckee, CA
- January 22, 2014: California Energy Commission, Sacramento, CA
- January 27, 2014: Milton Marks Conference Center, San Francisco State Building, San Francisco, CA

APPENDIX C: GOVERNOR'S EXECUTIVE ORDER

EXECUTIVE ORDER S-13-08--by the Governor of the State of California

WHEREAS climate change in California during the next century is expected to shift precipitation patterns, accelerate sea level rise and increase temperatures, thereby posing a serious threat to California's economy, to the health and welfare of its population and to its natural resources; and

WHEREAS California is a leader in mitigating and reducing its greenhouse gas emissions with the 2006 Global Warming Solutions Act (Assembly Bill 32), the Low Carbon Fuel Standard (Executive Order S-01-07), the 2008 Senate Bill 375 and the Renewable Portfolio Standard; and

WHEREAS these efforts, coupled with others around the world, will slow, but not stop all long-term climate impacts to California; and

WHEREAS California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science; and

WHEREAS there is a need for statewide consistency in planning for sea level rise; and

WHEREAS California's water supply and coastal resources, including valuable natural habitat areas, are particularly vulnerable to sea level rise over the next century and could suffer devastating consequences if adaptive measures are not taken; and

WHEREAS the country's longest continuously operating gauge of sea level, at Fort Point in San Francisco Bay, recorded a seven-inch rise in sea level over the 20th century thereby demonstrating the vulnerability of infrastructure and resources within the Bay; and

WHEREAS global sea level rise for the next century is projected to rise faster than historical levels with the Intergovernmental Panel on Climate Change predicting that global sea levels will rise by between seven to 23 inches this century and some experts predicting even higher rises; and

WHEREAS while climate models predicting global sea level rise are generally understood and improving, less information is available for sea level rise projections specific to California that accounts for California's topography, coastal erosion rates, varying land subsidence levels and tidal variations; and

WHEREAS billions of dollars in state funding for infrastructure and resource management projects are currently being encumbered in areas that are potentially vulnerable to future sea level rise; and

WHEREAS safety, maintenance and operational efforts on existing infrastructure projects are critical to public safety and the economy of the state; and

WHEREAS the longer that California delays planning and adapting to sea level rise the more expensive and difficult adaptation will be; and

WHEREAS the California Resources Agency is a member of the California Climate Action Team and is leading efforts to develop and implement policy solutions related to climate change adaptation regarding current and projected effects of climate change; and

WHEREAS the Department of Water Resources (DWR) is responsible for managing the state's water resources to benefit the people of California, and to protect, restore and enhance the natural and human environments; and

WHEREAS California's coastal management agencies such as the California Coastal Commission, the California Ocean Protection Council (OPC) and California State Parks are charged with managing and protecting the ocean and coastal resources of the state; and

WHEREAS the California Energy Commission's (CEC) Public Interest Energy Research Program has funded research on climate change since 2001 including funding the development of preliminary sea level rise projections for the San Francisco Bay area by the Scripps Institution of Oceanography/University of California at San Diego.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power vested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. The California Resources Agency, in cooperation with DWR, CEC, California's coastal management agencies, and the OPC, shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate, within 60 days after the signing of this Order, an independent sea level rise science and policy committee made up of state, national and international experts.

2. By March 31, 2009, the OPC, DWR and the CEC, in coordination with other state agencies, shall hold a public workshop to gather policy-relevant information specific to California for use in preparing the Sea Level Rise Assessment Report and to raise state awareness of sea level rise impacts.

3. The California Resources Agency shall request that the final Sea Level Rise Assessment Report be completed as soon as possible but no later than December 1, 2010. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise

projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California.

4. The OPC shall work with DWR, the CEC, California's coastal management agencies and the State Water Resources Control Board to conduct a review of the NAS assessment every two years or as necessary.

5. I direct that, prior to release of the final Sea Level Rise Assessment Report from the NAS, all state agencies within my administration that are planning construction projects in areas vulnerable to future sea level rise shall, for the purposes of planning, consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. However, all projects that have filed a Notice of Preparation, and/or are programmed for construction funding the next five years, or are routine maintenance projects as of the date of this Order may, but are not required to, account for these planning guidelines. Sea level rise estimates should also be used in conjunction with appropriate local information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

6. The Business, Transportation, and Housing Agency shall work with the California Resources Agency and the Governor's Office of Planning and Research (OPR) to prepare a report within 90 days of release of this Order to assess vulnerability of transportation systems to sea level rise that will include provisions for investment critical to safety, maintenance and operational improvements of the system and economy of the state.

7. By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by CEC's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts.

8. By May 30, 2009, OPR, in cooperation with the California Resources Agency, shall provide state land-use planning guidance related to sea level rise and other climate change impacts.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 14th day of November 2008.

ARNOLD SCHWARZENEGGER
Governor of California

APPENDIX D: GLOSSARY

This glossary provides definitions for terms commonly used in discussing climate risks.

Carbon Sequestration This refers to the capture of CO2 from the atmosphere and its long term storage in oceans (oceanic carbon sequestration), in biomass and soils (terrestrial carbon sequestration) or in underground reservoirs (geologic carbon sequestration).[605]

Climate Climate in a narrow sense is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.[606]

Climate Adaptation Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.[607]

Climate Mitigation A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.[608]

Ecosystem Services Ecosystem services are commonly defined as the benefits people obtain from ecosystems. Ecosystem services include basic services - provisioning services like the delivery of food, fresh water, wood and fiber, and medicine - and services that are less tangible and harder to measure but equally critical: regulating services like carbon sequestration, erosion control, and pollination; cultural services like recreation, ecotourism, and educational and spiritual values; and supporting services like nutrient cycling, soil formation, and primary productivity.[609]

Exposure the nature and degree to which natural or social systems are subjected to climate variations.[610]

Extreme weather event: In most cases, extreme weather events are defined as lying in the outermost ("most unusual") ten percent of a place's history. Analyses are available at the national and regional levels.[611]

Downscaling Downscaling is a method for obtaining high-resolution climate or climate change information from relatively coarse-resolution global climate models[612]

Global Warming Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. Also see Climate Change.[613]

Greenhouse Gas Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrochlorofluorocarbons (HCFCs), ozone (O3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).[614]

Hazard Mitigation Hazard Mitigation is sustained action taken to reduce or eliminate long-term risk to people and their property from hazards and their effects.[615]

Mainstreaming: A process of integrating climate change concerns in development efforts and other policy processes.[616]

Maladaptation Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead.[617]

Phenology: The timing of natural events, such as flower blooms and animal migration, which is influenced by changes in climate. Phenology is the study of such important seasonal events. Phenological events are influenced by a combination of climate factors, including light, temperature, rainfall, and humidity.[618]

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.[619]

Storm surge Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides.[620]

Vulnerability the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate.[621]

APPENDIX E: REFERENCES

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[2] 2009 California Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008, page 7.
[3] http://climatechange.ca.gov/climate_action_team/reports/climate_assessments.html
[4] http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience/taskforce
[5] *See e.g.* http://indiancountrytodaymedianetwork.com/2013/10/15/8-tribes-are-way-ahead-climate-adaptation-curve-151763
[6] *See e.g.* California Department of Fish and Wildlife Climate College: https://www.dfg.ca.gov/Climate_and_Energy/Climate_Change/Climate_College/ AND California Department of Water Resources climate literacy program: http://www.water.ca.gov/pubs/dwrnews/dwr_magazine_fall_2012/dwr_magazine_fall_2012.pdf
[7] *See e.g.* The Risky Business initiative: http://riskybusiness.org/
[8] *See e.g.* The "Climate Change and Insurance" discussion in the Emergency Management section of this *Safeguarding California Plan.*
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[180] See the "**Climate Risk Communication and Education"** section of this chapter.

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[182] For more information, please see the Ocean and Coastal Ecosystem and Resources section of this document.

[183] For more information, please see the Ocean and Coastal Ecosystem and Resources section of this document.

[184] For more information, please see the Water section and the Ocean and Coastal Ecosystem and Resources section of this document.

[185] As described elsewhere in this document, climate risk communication and education can help shape choices that reduce climate risks by reducing exposure and vulnerability.

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[190] For more information, please see the Public Health section of this document.

[191] For more information, please see the Transportation section of this document.

[192] See e.g. discussion of use of state-of-art materials in the Transportation section of this document
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[253] http://www.munichreamerica.com/site/mram/get/documents_E1449378742/mram/assetpool.mr_america/PDFs/3_Publications/ks_severe_weather_na_exec_summary.pdf
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[262] *See* Effectiveness of weather derivatives as cross-hedging instrument against climate change : The cases of reservoir water allocation management in Guanajuato, Mexico and Lambayeque, Peru / Miriam Juárez- Torres, Leonardo Sánchez-Aragón, Inter-American Development Bank, 2012. *See also* http://www.oxfamamerica.org/issues/private-sector-engagement/weather-insurance
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[273] http://www.cdph.ca.gov/programs/CCDPHP/Documents/Preparing_California_for_Extreme_Heat.pdf

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[276] http://insurance.lbl.gov/availability-affordability.html

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[284] http://www.calema.ca.gov/Pages/default.aspx

[285] http://www.fire.ca.gov/

[286] http://www.hcd.ca.gov/

[287] http://www.cdfa.ca.gov/ahfss/animal_health/Emergency_Management.html

[288] http://www.insurance.ca.gov/

[289] http://www.dot.ca.gov/

[290] http://water.ca.gov/

[291] http://www.conservation.ca.gov/CGS/Pages/Index.aspx

[292] 2009 State of California Emergency Plan, Section 13.1. http://www.calema.ca.gov/PlanningandPreparedness/Pages/State-Emergency-Plan.aspx

[293] http://www.seismic.ca.gov/

[294] http://opr.ca.gov/docs/GPG_2013_One_Pager.pdf

[295] http://www.calema.ca.gov/RegionalOperations/Pages/Business-and-Utility-Operations.aspx

[296] This figure includes transportation; electric power; and commercial, residential, industrial, and agricultural fuels; and is based on California's GHG Inventory for 2011, accessible at: http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_00-11_2013-08-01.pdf

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[303] www.energy.ca.gov/title24/2013standards/rulemaking/documents/2013_Building_Energy_Efficiency_Standards_FAQ.pdf

[304] http://www.caleap.org/

[305] http://www.energy.ca.gov/title24/

[306] http://www.energy.ca.gov/appliances/

[307] http://www.cpuc.ca.gov/PUC/energy/Renewables/overview.htm

[308] http://www.cpuc.ca.gov/puc/energy/solar/aboutsolar.htm

[309] http://www.cpuc.ca.gov/PUC/energy/DistGen/netmetering.htm

[310] http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/

[311] http://www.drecp.org/

[312] http://www.energy.ca.gov/research/renewable/community.html

[313] http://www.energy.ca.gov/2013_energypolicy/

[314] http://www.cpuc.ca.gov/PUC/energy/Demand+Response/

[315] http://www.caiso.com/1893/1893e350393b0.html

[316] http://www.cpuc.ca.gov/NR/rdonlyres/E2A36B6A-977E-4130-A83F-61E66C5FD059/0/CPUCBriefingPaperonLongTermResourceAdequacyBriefingPaperFebrua.pdf

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318 http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_2501-2550/ab_2514_bill_20100929_chaptered.pdf

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321 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/CERTS_Article_May2011.pdf

322 http://www.opc.ca.gov/2012/06/prestigious-independent-study-underscores-need-to-address-impacts-of-sea-level-rise/

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324 http://www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm

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326 For more information about New York City Department of Environmental Protection's Long-Term Watershed Protection Program and its work with the U.S. Environmental Protection Agency, State of New York, and other partners on watershed protection, please see: http://www.nyc.gov/html/dep/html/watershed_protection/working_with_partners.shtml

327 U.S. Environmental Protection Agency, Region 2, New York City Watershed. http://www.epa.gov/region2/water/nycshed/

328 http://www.dec.ny.gov/lands/58524.html

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330 How New York City Kept Its Drinking Water Pure — In Spite of Hurricane Sandy, Albert Appleton and Daniel Moss, Huffington Post, November 5, 2012, http://www.huffingtonpost.com/daniel-moss/new-york-drinking-water_b_2064588.html

331 "From Forests to Faucets: U.S. Forest Service and Denver Water Watershed Management Partnership" by Denver Water. http://www.denverwater.org/supplyplanning/watersupply/partnershipUSFS/

332 (extracted from Region 5 Forest Service website, http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5352584)

333 Battles, et al. (2008) - under the highest temperature scenarios

334 http://www.arb.ca.gov/cc/inventory/pubs/battles%20final%20report%2030jan14.pdf

335 Department of Forestry and Fire Protection. 2010. California's Forests and Rangelands: 2010 Assessment. Fire and Resource Assessment Program, Sacramento. http://www.frap.cdf.ca.gov/assessment2010/document.html

336 Goines, B. and M. Nechodom. 2009. National Forest Carbon Inventory Scenarios for the Pacific Southwest Region (California), Report to Regional Forester and PSW Station Director, CA: Albany: U.S. Department of Agriculture, Forest Service Region 5 Climate Change Interdisciplinary Team.

337 The Calculator utilizes some estimates based on regional averages rather than project specific measurements. [For instance, total above-ground and below-ground (i.e. roots) live carbon pools are estimated based on timber-utilized portions of the tree. Soil emissions are also estimated by applying a factor based on soil disturbance. Both calculations are estimates based on average regional factors rather than project specific measurements.)

338 http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf668.pdf

339 14 CCR §§ 895, 1051.3, 1051.4, 1051.5, 1051.6 and 1051.7

340 http://www.fs.fed.us/rmrs/experimental-forests/

341 http://www.fire.ca.gov/resource_mgt/resource_mgt_stateforests.php

342 McPherson, E. Gregory, and Simpson, James R., Potential Energy Savings in Buildings by an Urban Tree Planting Program in California, USDA Forest Service, Pacific Southwest Research Station, Urban Forestry and Urban Greening. http://www.fs.fed.us/ccrc/topics/urban-forests/docs/calif_energy-savings.pdf

343 http://www.fia.fs.fed.us/

344 In 2011, the USFS issued a guidance document entitled, "Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options". The USFS also provide important climate-related research.

345 As noted in the introduction to this document, the Safeguarding California Plan is not meant to replace the 2009

California Climate Adaptation Strategy, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward

[346] U.S. Census Bureau. 2011. Census 2010. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml; NOAA State of the Coast National Coastal Population Report: Population Trends from 1970 to 2020.

[347] See OPC-led process for Coordinated Action Informed by Science Needs Assessment on page 173.

[348] As noted in this section, oceans are a part of the global water system; the separate discussion of water management and oceans management in this document reflects administrative constructs that often separate oceans and water management. As climate change radically changes the earth's environment, a more holistic approach to resource management may be necessary to adequate address emerging climate threats.

[349] Sea ice melt contributes a small, but not insignificant amount, to sea level rise. An ice cube melting in a glass of drinking water doesn't change the level of liquid in the glass because the ice cube displaces its own weight in the water, and the melting process simply replaces the water which was previously displaced by the ice. However, freshwater contained in sea ice, is less dense than sea water, so although the amount of sea water displaced by the iceberg is equal to its weight, the melted fresh water will take up a slightly larger volume than the displaced salt water. *See*, Shepherd, A.*,* D. Wingham*,* D. Wallis*,* K. Giles*,* S. Laxon*, and* A. V. Sundal *(*2010*),* recent loss of floating ice and the consequent sea level contribution*,* Geophys. Res. Lett.*,* 37*, L13503,* is estimating that 1.6% of current sea level rise is caused by sea ice loss.

[350] *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*, National Research Council (NRC), 2012. Energy Commission's Public Interest Energy Research (PIER) Program, OPC, and the California Environmental Protection Agency (CalEPA) funded a 2009 study on sea level rise by researchers from Scripps Institution of Oceanography, the University of California San Diego, the California Department of Boating and Waterways, the U.S. Geological Survey, and the Hydrologic Research Center. The 2009 study projected California sea levels would rise approximately 16 inches by 2050 and 55 inches by 2100. As climate science continues to evolve, projections will continue to be refined and improved.

[351] Sea level rise projections in the 2012 report were expressed in metric units (i.e. 12-61 cm projected sea level rise by 2050 and 42-167 cm by 2100); for readability, this report expresses the projections in English units rounded to the nearest whole number. Due to plate tectonics, the land elevation of the northernmost portion of California's coast is actually rising about 1.5-3.0 mm per year. As a result, sea level rise projections for that area of the State differ. For the California coast north of Cape Mendocino, projections are that, relative to 2000, sea level change will range from -3 cm (i.e. approximately a 1 inch fall in sea level) to +48 cm (i.e. approximately 19 inch rise in sea level) by 2050, and +10 cm (i.e. approximately a 4 inch rise in sea level) to +143 cm (i.e. approximately 56 inch rise in sea level) by 2100. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, National Research Council, 2012, pp. 3-4.*

[352] For more information on climate impacts and California agriculture, please see the Agriculture section of this document.

[353] The map in Box 45 shows areas vulnerable to approximately 16 inch sea level rise and areas vulnerable (in pink) to a 55 inch sea level rise (in red). Prior to the 2012 NRC study referenced in Footnote 5, the California

[354] http://www.coastal.ca.gov/climate/erosion.html *See also* Pendleton, L., King, P., Mohn, C., Webster, D.G., Vaughn, R. and Adams, P., Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches, April 2009, CEC-500-2009-033-D. http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-D.PDF noting that sea-level rise will not impact all beaches equally.

[355] http://www.coastal.ca.gov/climate/access.html

[356] The Impacts of Sea Level Rise on the California Coast, Paper from the California Climate Center, Prepared by: *Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute, August 2009, pp. 2-3.* California Energy Commission. Publication number: CEC-500-2009-024-F http://www.energy.ca.gov/2009publications/CEC-500-2009-024/CEC-500-2009-024-F.PDF

[357] *See* Pendleton, L., King, P., Mohn, C., Webster, D.G., Vaughn, R. and Adams, P., Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches, April 2009, CEC-500-2009-033-D. http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-D.PDF *See also* King, Philip G., McGregor, Aaron R., and Whittet, Justin D., The Economic Cost of Sea-Level Rise to California Beach Communities,

A Paper from The California Department of Boating and Waterways and San Francisco State University, September 2011. http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

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[414] http://opr.ca.gov/docs/GPG_2013_One_Pager.pdf

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develop a set of innovative approaches for bringing environmental benefits and cost-savings to flood protection infrastructure along the San Francisco Bay shoreline. http://www.sfestuary.org/our- projects/watershed-management/floodcontrol/

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[427] More information on climate impacts and transportation and energy systems may be found in the Transportation and Energy sections of this document.

[428] As noted below, sea level risk will significantly increase the risk of toxic releases associated with flooding and inundation of hazardous waste facilities and sites.

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[432] In additional to local, regional, state and federal regulation, international regulation is also relevant to ocean and coastal management. The United States has not ratified the 1982 United Nations Convention on the Law of the Sea, which has two implementation agreements (the Part XI Deep-Sea Mining Agreement and the Fish Stocks Agreement). However, the United States is a member of the International Maritime Organization (IMO), established by the United Nations in 1948, "to promote safe, secure, environmentally sound, efficient and sustainable shipping through cooperation." (IMO Resolution A.1011(26))

[433] In addition to innovative shoreline management efforts and LCPs described below, a number of California communities have begun the process of studying and preparing for climate impacts to coastal and ocean resources. These efforts include, but are not limited to: the San Diego Foundation Climate Initiative http://www.sdfoundation.org/CivicLeadership/Programs/Environment/Climate.aspx, the 2011 City of Santa Cruz Climate Change Vulnerability Assessment http://www.cityofsantacruz.com/Modules/ShowDocument.aspx?documentid=21198,and the work of the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) - which is a California Joint Powers agency established in 1992 to address coastal erosion, beach nourishment and clean oceans within the Central California Coast from Point Conception to Point Mugu. The agencies making up BEACON are Santa Barbara and Ventura Counties and the cities of Port Hueneme, Oxnard, San Buenaventura, Carpinteria and Santa Barbara. http://www.beacon.ca.gov/

[434] http://www.cdph.ca.gov/programs/Documents/BurdenReportOnline%2004-04-13.pdf Health is not distributed equally across our population and communities.

[435]California Health and Safety. Code, Division 1, Part 1, Section 152 http://www.leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=00001-01000&file=152

[436] Recognizing the impact that non-health policies have on health, as well as the complex relationship between sustainability and health, the State of California created a Health in All Policies Task Force in 2010. Created by Executive Order S-04-10 created and placed the Task Force under the auspices of the Strategic Growth Council (SGC), where it is charged with identifying "priority programs, policies, and strategies to improve the health of Californians while advancing the goals of improving air and water quality, protecting natural resources and agricultural lands, increasing the availability of affordable housing, improving infrastructure systems, promoting

public health, planning sustainable communities, and meeting the climate change goals". http://www.sgc.ca.gov/hiap/about.html

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[447] *See* Californian's Without Safe Water, California Water Plan, 2005 Update http://www.waterplan.water.ca.gov/docs/cwpu2005/vol4/vol4-waterquality-californianswithoutsafewater.pdf A 2013 update is currently being developed.

[448] http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf

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EXECUTIVE ORDER S-13-08

WHEREAS climate change in California during the next century is expected to shift precipitation patterns, accelerate sea level rise and increase temperatures, thereby posing a serious threat to California's economy, to the health and welfare of its population and to its natural resources; and

WHEREAS California is a leader in mitigating and reducing its greenhouse gas emissions with the 2006 Global Warming Solutions Act (Assembly Bill 32), the Low Carbon Fuel Standard (Executive Order S-01-07), the 2008 Senate Bill 375 and the Renewable Portfolio Standard; and

WHEREAS these efforts, coupled with others around the world, will slow, but not stop all long-term climate impacts to California; and

WHEREAS California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science; and

WHEREAS there is a need for statewide consistency in planning for sea level rise; and

WHEREAS California's water supply and coastal resources, including valuable natural habitat areas, are particularly vulnerable to sea level rise over the next century and could suffer devastating consequences if adaptive measures are not taken; and

WHEREAS the country's longest continuously operating gauge of sea level, at Fort Point in San Francisco Bay, recorded a seven-inch rise in sea level over the 20th century thereby demonstrating the vulnerability of infrastructure and resources within the Bay; and

WHEREAS global sea level rise for the next century is projected to rise faster than historical levels with the Intergovernmental Panel on Climate Change predicting that global sea levels will rise by between seven to 23 inches this century and some experts predicting even higher rises; and

WHEREAS while climate models predicting global sea level rise are generally understood and improving, less information is available for sea level rise projections specific to California that accounts for California's topography, coastal erosion rates, varying land subsidence levels and tidal variations; and

WHEREAS billions of dollars in state funding for infrastructure and resource management projects are currently being encumbered in areas that are potentially vulnerable to future sea level rise; and

WHEREAS safety, maintenance and operational efforts on existing infrastructure projects are critical to public safety and the economy of the state; and

WHEREAS the longer that California delays planning and adapting to sea level rise the more expensive and difficult adaptation will be; and

WHEREAS the California Resources Agency is a member of the California Climate Action Team and is leading efforts to develop and implement policy solutions related to climate change adaptation regarding current and projected effects of climate change; and

WHEREAS the Department of Water Resources (DWR) is responsible for managing the state's water resources to benefit the people of California, and to protect, restore and enhance the natural and human environments; and

WHEREAS California's coastal management agencies such as the California Coastal Commission, the California Ocean Protection Council (OPC) and California State Parks are charged with managing and protecting the ocean and coastal resources of the state; and

WHEREAS the California Energy Commission's (CEC) Public Interest Energy Research Program has funded research on climate change since 2001 including funding the development of preliminary sea level rise projections for the San Francisco Bay area by the Scripps Institution of Oceanography/University of California at San Diego.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power vested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. The California Resources Agency, in cooperation with DWR, CEC, California's coastal management agencies, and the OPC, shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate, within 60 days after the signing of this Order, an independent sea level rise science and policy committee made up of state, national and international experts.

2. By March 31, 2009, the OPC, DWR and the CEC, in coordination with other state agencies, shall hold a public workshop to gather policy-relevant information specific to California for use in preparing the Sea Level Rise Assessment Report and to raise state awareness of sea level rise impacts.

3. The California Resources Agency shall request that the final Sea Level Rise Assessment Report be completed as soon as possible but no later than December 1, 2010. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California.

4. The OPC shall work with DWR, the CEC, California's coastal management agencies and the State Water Resources Control Board to conduct a review of the NAS assessment every two years or as necessary.

5. I direct that, prior to release of the final Sea Level Rise Assessment Report from the NAS, all state agencies within my administration that are planning construction projects in areas vulnerable to future sea level rise shall, for the purposes of planning, consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. However, all projects that have filed a Notice of Preparation, and/or are programmed for construction funding the next five years, or are routine maintenance projects as of the date of this Order may, but are not required to, account for these planning guidelines. Sea level rise estimates should also be used in conjunction with appropriate local information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

6. The Business, Transportation, and Housing Agency shall work with the California Resources Agency and the Governor's Office of Planning and Research (OPR) to prepare a report within 90 days of release of this Order to assess vulnerability of transportation systems to sea level rise that will include provisions for investment critical to safety, maintenance and operational improvements of the system and economy of the state.

7. By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by CEC's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly

coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts.

8. By May 30, 2009, OPR, in cooperation with the California Resources Agency, shall provide state land-use planning guidance related to sea level rise and other climate change impacts.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

EXECUTIVE ORDER B-30-15

WHEREAS climate change poses an ever-growing threat to the well-being, public health, natural resources, economy, and the environment of California, including loss of snowpack, drought, sea level rise, more frequent and intense wildfires, heat waves, more severe smog, and harm to natural and working lands, and these effects are already being felt in the state; and

WHEREAS the Intergovernmental Panel on Climate Change concluded in its Fifth Assessment Report, issued in 2014, that "warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia" and that "continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems;" and

WHEREAS projections of climate change show that, even under the best-case scenario for global emission reductions, additional climate change impacts are inevitable, and these impacts pose tremendous risks to the state's people, agriculture, economy, infrastructure and the environment; and

WHEREAS climate change will disproportionately affect the state's most vulnerable citizens; and

WHEREAS building on decades of successful actions to reduce pollution and increase energy efficiency the California Global Warming Solutions Act of 2006 placed California at the forefront of global and national efforts to reduce the threat of climate change; and

WHEREAS the Intergovernmental Panel on Climate Change has identified limiting global warming to 2 degrees Celsius or less by 2050 as necessary to avoid potentially catastrophic climate change impacts, and remaining below this threshold requires accelerated reductions of greenhouse gas emissions; and

WHEREAS California has established greenhouse gas emission reduction targets to reduce greenhouse gas emissions to 1990 levels by 2020 and further reduce such emissions to 80 percent below 1990 levels by 2050; and

WHEREAS setting an interim target of emission reductions for 2030 is necessary to guide regulatory policy and investments in California in the midterm, and put California on the most cost-effective path for long term emission reductions; and

WHEREAS all agencies with jurisdiction over sources of greenhouse gas emissions will need to continue to develop and implement emissions reduction programs to reach the state's 2050 target and attain a level of emissions necessary to avoid dangerous climate change; and

WHEREAS taking climate change into account in planning and decision making will help the state make more informed decisions and avoid high costs in the future.

NOW, THEREFORE, I, EDMUND G. BROWN JR., Governor of the State of California, in accordance with the authority vested in me by the Constitution and statutes of the State of California, in particular Government Code sections 8567 and 8571 of the California Government Code, do hereby issue this Executive Order, effective immediately

IT IS HEREBY ORDERED THAT:

1.A new interim statewide greenhouse gas emission reduction target to reduce greenhouse gas emissions to

40 percent below 1990 levels by 2030 is established in order to ensure California meets its target of reducing greenhouse gas emissions to 80 percent below 1990 levels by 2050.

2.All state agencies with jurisdiction over sources of greenhouse gas emissions shall implement measures, pursuant to statutory authority, to achieve reductions of greenhouse gas emissions to meet the 2030 and 2050 greenhouse gas emissions reductions targets.

3.The California Air Resources Board shall update the Climate Change Scoping Plan to express the 2030 target in terms of million metric tons of carbon dioxide equivalent.

4.The California Natural Resources Agency shall update every three years the state's climate adaptation strategy, Safeguarding California, and ensure that its provisions are fully implemented. The Safeguarding California plan will:
-Identify vulnerabilities to climate change by sector and regions, including, at a minimum, the following sectors: water, energy, transportation, public health, agriculture, emergency services, forestry, biodiversity and habitat, and ocean and coastal resources;
-Outline primary risks to residents, property, communities and natural systems from these vulnerabilities, and identify priority actions needed to reduce these risks; and
-Identify a lead agency or group of agencies to lead adaptation efforts in each sector.

5.Each sector lead will be responsible to:
-Prepare an implementation plan by September 2015 to outline the actions that will be taken as identified in Safeguarding California, and
-Report back to the California Natural Resources Agency by June 2016 on actions taken.

6.State agencies shall take climate change into account in their planning and investment decisions, and employ full life-cycle cost accounting to evaluate and compare infrastructure investments and alternatives.

7.State agencies' planning and investment shall be guided by the following principles
-Priority should be given to actions that both build climate preparedness and reduce greenhouse gas emissions;
-Where possible, flexible and adaptive approaches should be taken to prepare for uncertain climate impacts;
-Actions should protect the state's most vulnerable populations; and
-Natural infrastructure solutions should be prioritized.

8.The state's Five-Year Infrastructure Plan will take current and future climate change impacts into account in all infrastructure projects

9.The Governor's Office of Planning and Research will establish a technical, advisory group to help state agencies incorporate climate change impacts into planning and investment decisions.

10.The state will continue its rigorous climate change research program focused on understanding the impacts of climate change and how best to prepare and adapt to such impacts.
This Executive Order is not intended to create, and does not, create any rights or benefits, whether substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order be filed in the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 29th day of April 2015.

Implementing *Safeguarding California* – An Action Plan for Ocean and Coastal Ecosystems and Resources

The Governor's recent Executive Order B-30-15 requires state agencies to identify sector adaptation leads and to prepare plans for implementing *Safeguarding California: Reducing Climate Risk (2014)*. The California Ocean Protection Council (OPC) has been the sector lead on adaptation issues for coastal and ocean agencies. On behalf of the State Coastal Leadership Group for Sea-level Rise, whose members include the Coastal Commission, Coastal Conservancy, San Francisco Bay Conservation and Development Commission, State Lands Commission, and Department of Parks and Recreation, OPC has coordinated the development of an Action Plan for implementing the cross-agency coastal recommendations identified in *Safeguarding California*.

Action Plan

The Action Plan seeks to:

- Inform actions taken by the member agencies of the State Coastal Leadership Group,
- Articulate agencies' shared and/or common goals pertaining to climate resilience in coastal areas,
- Identify opportunities for improving coordination and collaboration among member agencies of the State Coastal Leadership Group to support implementation of the cross-agency actions in *Safeguarding California*.
- Build on relevant previous and existing efforts of member agencies of the State Coastal Leadership Group and other agencies, and
- Utilize a participatory approach to capture the viewpoints of state agencies and other relevant stakeholders such as local land use planning authorities, tribes, and federal partners.

About the OPC

The OPC was created in 2004 to help protect, conserve, and maintain California's coastal and ocean ecosystems and the communities and economies they support. OPC's responsibilities include:

- Coordinating activities of ocean-related state agencies to improve the effectiveness of state efforts to protect ocean resources within existing fiscal limitations,
- Establishing policies to coordinate the collection and sharing between agencies of scientific data related to coastal and ocean resources,
- Identifying and recommending to the State Legislature changes in law, and
- Determining and recommending changes in federal law and policy to the Governor and State Legislature.

Resolution of the California Ocean Protection Council on Sea-Level Rise
Adopted on March 11, 2011

WHEREAS, numerous peer-reviewed scientific studies and exhaustive research have determined that sea-level rise (SLR) due to climate change will have a dramatic impact on coastal development and natural resources and will pose significant planning challenges; and

WHEREAS, research funded in part by the Ocean Protection Council (OPC) has shown that a 55-inch sea-level rise, with a 100-year storm event along the California coast places approximately 480,000 people (given today's population) and nearly $100 billion (in year 2000 dollars) of property at risk; and

WHEREAS, Governor's Executive Order S-13-08 directed state agencies to consider a range of SLR scenarios for the years 2050 and 2100 to assess project vulnerability, reduce expected risks, and increase resiliency to sea-level rise; and

WHEREAS, senior staff from 16 state agencies of the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT) reached agreement on a Sea-Level Rise Interim Guidance Document ("Interim Guidance Document"), with science-based input from the OPC's Science Advisory Team and the California Ocean Science Trust.

NOW, THEREFORE, the California Ocean Protection Council hereby

RESOLVES that the pollutants that cause climate change should be reduced early in this century in order to limit the amount of damage from SLR that will occur as a result of rising temperatures; and

FURTHER RESOLVES that state agencies, as well as non-state entities implementing projects or programs funded by the state or on state property, including on lands granted by the Legislature, should incorporate consideration of the risks posed by SLR into all decisions regarding areas or programs potentially affected by SLR; and

FURTHER RESOLVES that state agencies should carefully invest public funds and incentivize SLR risk reduction by following the recommendations within this resolution when providing funding to non-state entities, to the extent permissible by law; and

FURTHER RESOLVES that state agencies, as well as non-state entities implementing projects or programs funded by the state or on state property, including on lands granted by the Legislature, should follow the science-based recommendations developed by the CO-CAT, which are currently described in the Interim Guidance Document (including the projections in Table 1 below) and which will be revised in future guidance documents developed by the CO-CAT[1]; and

[1] Refer to the OPC website at www.opc.ca.gov for the latest guidance document.

FURTHER RESOLVES that the OPC will provide ongoing coordination with the OPC Science Advisory Team and the CO-CAT to support regular updates to guidance on SLR for state agencies based upon current scientific understanding and projections, including consideration of (1) observed ice melt and predictions of future catastrophic ice melting, (2) current atmospheric concentrations of the pollutants that cause climate change, (3) relevant feedback mechanisms and (4) assessment of the status of international efforts to reduce the pollutants that cause climate change and the likelihood of achieving different future emission scenarios; and

FURTHER RESOLVES that, state agencies, as well as non-state entities implementing projects or programs funded by the state or on state property, including on lands granted by the Legislature, should not solely use SLR values within the lower third of the range in the latest CO-CAT guidance document, and instead should generally assess potential impacts and vulnerabilities over a range of SLR projections, including analysis of the highest SLR values presented in the latest CO-CAT guidance document ; and

FURTHER RESOLVES that state agencies, as well as non-state entities implementing projects or programs funded by the state or on state property, including on lands granted by the Legislature, should avoid making decisions based on SLR values that would result in high risk; and

FURTHER RESOLVES that state agencies, as well as non-state entities implementing projects or programs funded by the state or on state property, including on lands granted by the Legislature, should coordinate with one another when selecting values of SLR and use the same baseline projections of SLR for the same project or program, with agency discretion to use higher projections and apply a safety factor as necessary; and

FURTHER RESOLVES that state agencies should make decisions regarding coastal and ocean management based upon the following guiding principles presented in the 2009 California Climate Adaptation Strategy (Adaptation Strategy):

- California must protect public health and safety and critical infrastructure;
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well being depend;
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources;
- New development and communities must be planned and designed for long-term sustainability in the face of climate change;
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time; and
- California must begin now to adapt to the impacts of climate change. We can no longer act as if nothing is changing; and

FURTHER RESOLVES that state agencies should bring renewed efforts to implement the state planning priorities from CA Government Code Section 65041.1 and the recommendations presented in the Adaptation Strategy; and

FURTHER RESOLVES that the OPC, in close coordination with state agencies, will engage in a public stakeholder process to develop decision guidance to clarify and expand upon the Adaptation Strategy and to identify actions that the state and the OPC can take to address the areas of greatest need regarding coastal and ocean climate change adaptation; and

FURTHER RESOLVES that the OPC will support the development of regional sea-level rise adaptation plans, to the extent that funding and staff capacity allow; and

FURTHER RESOLVES that the OPC will encourage collaborations, including with the federal government, to enhance data collection and monitoring and development of decision support tools and guidance that will directly improve adaptation decision-making, including those predicting extreme events and supporting coastal and ocean climate change impact assessments; and

FURTHER RESOLVES that the OPC will continue to support the development and application of common climate change modeling assumptions so that planning actions in different agencies are based on shared information and current scientific understanding to the greatest extent possible.

Table 1. Sea-Level Rise Projections[2,3] using 2000 as the Baseline[4]

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (13-21 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	**Low**	23 in (59 cm)	17-27 in (43-70 cm)
	Medium	24 in (62 cm)	18-29 in (46-74 cm)
	High	27 in (69 cm)	20-32 in (51-81 cm)
2100	**Low**	40 in (101 cm)	31-50 in (78-128 cm)
	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

[2] Based upon the SLR estimates presented in Martin Vermeer and Stefan Rahmstorf, "Global sea level linked to global temperature", *Proceedings of the National Academy of Sciences*, published online before print December 7, 2009; doi: 10.1073/pnas.0907765106.
[3] For dates after 2050, Table 1 includes three different values for SLR - based on low, medium, and high greenhouse gas emission scenarios. These values are based on the Intergovernmental Panel on Climate Change emission scenarios as follows: B1 for the low projections, A2 for the medium projections and A1Fi for the high projections.
[4] These values are based on the October 2010 version of the SLR Interim Guidance Document. For future reference, check the OPC website at www.opc.ca.gov to see if there is an updated guidance document that has been developed by the CO-CAT.

Resolution of the California Ocean Protection Council on Implementation of the Safeguarding California Plan for Reducing Climate Risks

Adopted on August 27, 2014

WHEREAS, the State of California released the *Safeguarding California Plan for Reducing Climate Risks: an Update to the 2009 Climate Adaptation Strategy ("Safeguarding Plan")*, on July 31, 2014, to provide policy guidance for state decision makers as part of continuing efforts to prepare for climate risks; and

WHEREAS, the *Safeguarding Plan* sets forth policy on hazard avoidance for new development to minimize the adverse effects of sea-level rise, erosion and storms and calls for new development to be carefully considered in light of principles described in the Safeguarding Plan and any recommendations resulting from the State Coastal Leadership Group on Sea-level Rise, of which the Ocean Protection Council ("OPC") is a member; and

WHEREAS, the *Safeguarding Plan* identifies several actions for OPC leadership, including working with the State Coastal Leadership Group on Sea-level Rise to lead a process to improve the capacity of entities at multiple scales to more effectively act to reduce risks from sea-level rise, storms and erosion; and

WHEREAS, the 2011 OPC Resolution on Sea-level Rise provides recommendations that are still relevant and important for all state agencies and non-state entities implementing projects or programs with state funds or on state lands, to include consideration of sea-level rise in all relevant decisions and to avoid high risk decisions.

NOW, THEREFORE, the California Ocean Protection Council hereby

RESOLVES that OPC staff continue to collaborate with senior management of the agencies that comprise the State Coastal Leadership Group on Sea-level Rise and with others to develop a concise visionary action plan to describe what success looks like for different time periods; to present a framework for bold action to reduce climate risks and protect what Californians value about our coast and ocean; and to identify changes to state and federal policies and funding streams that are necessary to implement the vision. This process will include engaging entities working on many scales to learn what is working, what could be expanded and what else needs to be done. OPC staff will bring this visionary action plan to the Council by the fall of 2015; and

FURTHER RESOLVES that state agencies and non-state entities implementing projects or programs with state funds should encourage innovative design of new structures and infrastructure in areas vulnerable to sea-level rise, storms and erosion and priority should be given to green or nature-based solutions that use natural processes and habitats to reduce risk from flooding and erosion; and

FURTHER RESOLVES that state agencies and non-state entities implementing projects or programs with state funds or on state lands should support and encourage progress toward a more integrated ecosystem approach to ocean management; and

FURTHER RESOLVES that state agencies and non-state entities implementing projects or programs with state funds or on state lands should reduce risk from climate impacts to the coast and ocean, by implementing the *Safeguarding Plan's* recommendation to incorporate climate risk considerations into all relevant decision-making, including related to infrastructure, in such a way that it:

1. Encourages iterative approaches;
2. Protects California's most vulnerable populations;
3. Achieves multiple benefits from efforts to reduce climate risks and prioritizes green infrastructure solutions;
4. Integrates climate risk reduction with emissions reductions to the fullest extent possible; and
5. Develops metrics and indicators to track progress on efforts to reduce climate risk.

FURTHER RESOLVES that state agencies and non-state entities implementing projects or programs with state funds or on state lands should follow the guiding principles from the Safeguarding Plan:

- Use the best available science to identify risks and adaptation strategies;
- Understand that an effective strategy for preparing for climate risks should evolve as new information is available;
- Involve all relevant stakeholders;
- Establish and maintain strong partnerships across all levels of government, tribes, businesses, landowners, and non-governmental organizations;
- Give priority to strategies that also achieve benefits other than climate risk reduction benefits, including additional benefits to public health, the economy, environmental justice, and conservation of natural resources; and
- Ensure that strategies to reduce climate risk are coordinated, to the extent possible, with the state's efforts to reduce GHG emissions and other local, national and international efforts.

STATE OF CALIFORNIA SEA-LEVEL RISE GUIDANCE DOCUMENT

Developed by the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT), with science support provided by the Ocean Protection Council's Science Advisory Team and the California Ocean Science Trust

March 2013 update

Background, Purpose, and Intended Use

This document provides guidance for incorporating sea-level rise (SLR) projections into planning and decision making for projects in California. This document was developed by the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT) in response to Governor Schwarzenegger's Executive Order S-13-08, issued on November 14, 2008, which directed state agencies to plan for sea-level rise and coastal impacts. That executive order also requested the National Research Council (NRC) to issue a report on sea-level rise (SLR) to advise California on planning efforts.

The final report from the NRC, *Sea-Level Rise for the Coasts of California, Oregon, and Washington* [1], was released in June 2012. The *Sea-Level Rise Guidance Document* has been updated with the scientific findings of the 2012 NRC report. The intent of this guidance document is to inform and assist state agencies as they develop approaches for incorporating SLR into planning decisions with the most recent and best available science, as published in the 2012 NRC report. Specifically, this document provides information and recommendations to enhance consistency across agencies in their development of approaches to SLR. Because of their differing mandates and decision-making processes, state agencies will interpret and use this document in a flexible manner, taking into consideration risk tolerances, timeframes, economic considerations, adaptive capacities, legal requirements and other relevant factors. (Refer to Recommendation #2 below for a discussion of risk tolerance and adaptive capacity). Although the estimates of future SLR provided in this document are intended to enhance consistency across California state agencies, the document is not intended to prescribe that all state agencies use specific or identical estimates of SLR as part of their assessments or decisions.

SLR potentially will cause many harmful economic, ecological, physical and social impacts and incorporating SLR into agency decisions can help mitigate some of these potential impacts. For example, SLR will threaten water supplies, coastal development, and infrastructure, but early integration of projected SLR into project designs will lessen these potential impacts.

Summary of Guidance Development and Planned Future Updates

Staff from the CO-CAT member agencies worked collaboratively to develop the first version of this document, the *Interim Sea-Level Rise Guidance Document*[2] (2010), prior to the release of the NRC

[1] Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389

[2] Sea-Level Rise Interim Guidance Document (2010). http://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20110311/12.SLR_Resolution/SLR-Guidance-Document.pdf

report. The *Interim Sea-Level Rise Guidance Document* (2010) was developed based on the best available science at the time (the process for the development of the document is outlined in its Appendix). As the *Interim Sea-Level Rise Guidance Document* explicitly called for an update when the findings of the NRC report were available, the present document has been revised to include results from the NRC report (for more information on the development of this version, please see Appendix A). Because the science of SLR is continually advancing, this guidance document will be revised as necessary to reflect the latest scientific understanding of how the climate is changing and how this change may affect the rates of SLR.

Recommendations

CO-CAT reached agreement on the following policy recommendations based upon recent projections of future SLR from the National Research Council's 2012 report on Sea-Level Rise and input from the scientists as listed in Appendix A.

1. **Use the ranges of SLR presented in the June 2012 National Research Council report on *Sea-Level Rise for the Coasts of California, Oregon, and Washington* as a starting place and select SLR values based on agency and context-specific considerations of risk tolerance and adaptive capacity.** Table 1 (below) presents SLR projections based on the June 2012 NRC report on SLR. Refer to Recommendation # 2 for a discussion of time horizon, risk tolerance, and adaptive capacity, which should be considered when choosing values of SLR to use for specific assessments.

Table 1. Sea-Level Rise Projections using 2000 as the Baseline

Time Period	North of Cape Mendocino[3]	South of Cape Mendocino
2000 - 2030	-4 to 23 cm (-0.13 to 0.75 ft)	4 to 30 cm (0.13 to 0.98 ft)
2000 – 2050	-3 to 48 cm (-0.1 to 1.57 ft)	12 to 61 cm (0.39 to 2.0 ft)
2000 – 2100	10 to 143 cm (0.3 to 4.69 ft)	42 to 167 cm (1.38 to 5.48 ft)

[3] The differences in sea-level rise projections north and south of Cape Mendocino are due mainly to vertical land movement. North of Cape Mendocino, geologic forces are causing much of the land to uplift, resulting in a lower rise in sea level, relative to the land, than has been observed farther south.

Note: These projections incorporate a land ice component extrapolated from compilations of observed ice mass accumulation and loss. It is important to note that the NRC report is based on numerical climate models developed for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report[4] which do not account for rapid changes in the behavior of ice sheets and glaciers and thus likely underestimate sea-level rise (the new suite of climate models for the Fifth Assessment Report was not available when the NRC report was developed). The committee used the model results from the IPCC Fourth Assessment Report, together with a forward extrapolation of land ice that attempts to capture an ice dynamics component.[5]

2. **Consider timeframes, adaptive capacity, and risk tolerance when selecting estimates of SLR.** The timeframe identified for a project is an important consideration for SLR projections and will affect the approach for assessing SLR impacts. Until 2050, there is strong agreement among the various climate models for the amount of SLR that is likely to occur. After mid-century, projections of SLR become more uncertain; SLR projections vary with future projections due in part to modeling uncertainties, but primarily due to uncertainties about future global greenhouse gas emissions, and uncertainties associated with the modeling of land ice melting rates. Therefore, for projects with timeframes beyond 2050, it is especially important to consider adaptive capacity, impacts, and risk tolerance to guide decisions of whether to use the low or high end of the ranges presented. Due to differing agencies mandates, stakeholder input and other considerations, agencies may assess the adaptive capacity of a project or action differently.

   Consequences are a function of impacts and adaptive capacity

   The consequences of failing to address SLR adequately for a particular project will depend on both adaptive capacity and the *potential* impacts of SLR to public health and safety, public investments, and the environment. Figure 1 in Appendix C illustrates how adaptive capacity and potential impacts combine to produce consequences.

   Adaptive capacity is the ability of a system to respond to climate change, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.[6] In most situations, adaptive capacity must be front-loaded, or built into the initial project; it cannot be assumed that adaptive capacity can be developed when needed unless it has been planned for in advance. A project that has high adaptive capacity and/or low potential impacts will experience fewer consequences. For example, an unpaved trail built within a

[4] Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007). http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

[5] Page 13, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389

[6] Definition of adaptive capacity used in the 2*009 California Climate Adaptation Strategy,* based upon definition provided in *Climate Adaptation: Risk, Uncertainty and Decision-mak*ing, UK CIP (2003), UKCIP Technical Report, Oxford, Willows, R. I. and R. K. Cornell (eds.).

rolling easement with space to retreat has high adaptive capacity (because the trail and easement can be relocated as sea level rises) and therefore will experience fewer harmful consequences from SLR. In contrast, a new wastewater treatment facility located on a shoreline with no space to relocate inland has low adaptive capacity and high potential impacts from flooding (related to public health and safety, public investments, and the environment). The negative consequences for such a project of failing to consider a large amount of SLR would therefore be high.

Risk Tolerance

The amount of risk involved in a decision depends on both the consequences and the likelihood of *realized* impacts that may result from SLR. These realized impacts, in turn, depend on the extent to which the project design integrates an accurate projection of SLR. However, current SLR projections provide a range of potential SLR values and lack precision (see Table 1 above). Therefore, agencies must consider and balance the relative risks associated with under- and/or over-estimating SLR in making decisions.[7]

Figure 2 in Appendix C illustrates this relationship for a project in which underestimating SLR in the project design will result in harmful realized impacts such as flooding. In this case, harmful impacts are more likely to occur if the project design is based upon a low projection of SLR and less likely if higher estimates of SLR are used. In situations with high consequences (high impacts and/or low adaptive capacity), using a low SLR value therefore involves a higher degree of risk.

3. **Consider storms and other extreme events.** Coastal ecosystems, development, and public access are most at risk from storm events, including the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño.[8] Water levels reached during these large, short-term events have caused significant damage along coast. For example, a strong El Niño combined with a series of storms during high-tide events caused more than $200 million dollars in damage (in 2010 dollars) to the California coast during the winter of 1982-83. In the next few decades, most of the damage along the coast will likely result from extreme events. Historical records are one of the main sources for information on the extremes that are possible, and the damages that can result. Planning activities and project design would be improved by considering impacts from extreme events. Future sea level will be a starting point for project design considerations. Where feasible, consideration should

[7] Examples of harmful impacts that might result from underestimating SLR include damage to infrastructure, and inundation of marsh restoration projects located too low relative to the tides. Examples of harmful impacts that might result from overestimating SLR include financial costs of over-engineering shoreline structures, locating in-water development in too shallow a depth to avoid navigational hazards, and marsh restoration projects located too high relative to the tides.

[8] Page 7, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). http://www.nap.edu/catalog.php?record_id=13389

be given to scenarios that combine extreme oceanographic conditions on top of the highest water levels projected to result from SLR over the expected life of a project.

4. **Coordinate with other state agencies when selecting values of SLR and, where appropriate and feasible, use the same projections of sea-level rise.** For projects developed by or under the regulatory authority of multiple agencies, using the same SLR values will increase efficiency of analyses and promote consistency. Agencies may select other values depending on their particular guiding policies and considerations related to risk, ability to incorporate phased adaptation into design, and other factors.

5. **Future SLR projections should not be based on linear extrapolation of historic sea level observations.** For estimates beyond one or two decades, linear extrapolation of SLR based on historic observations is inadequate and would likely underestimate the actual SLR. According to the OPC Science Advisory Team, because of non-linear increases in global temperature and the unpredictability of complex natural systems, linear projections of historical SLR are likely to be inaccurate.

6. **Consider changing shorelines.** California's very dynamic coast will evolve under rising sea level and assessments of impacts from SLR to shoreline projects must address local shoreline changes. For example, there could be less significant coastal change due to SLR in areas of high sediment supply (e.g., offshore of large northern CA rivers), whereas the coast may recede or change very dramatically in other areas (low sediment supply, presence of eroding bluffs or dunes, etc.). Existing resources for assessing future erosion/accretion rates include: U.S. Geological Survey report on shoreline changes for California's beach habitat,[9] U.S. Geological Survey report on shoreline changes for California's bluff habitat.[10]

7. **Consider predictions in tectonic activity.** The 2012 NRC report highlights the significant risk posed to the region north of Cape Mendocino from a large earthquake (magnitude greater than 8) along the Cascadia Subduction Zone, which could cause significant land subsidence resulting in instantaneous sea-level rise as well as a tsunami. In subduction zones, strain builds within the fault zone causing land to rise slowly before subsiding abruptly during an earthquake. The last great earthquake of the region occurred in 1700, causing an instantaneous rise in relative sea level of up to 2m due to land subsidence. Because this guidance document is targeted towards advising on climate induced changes in sea level, it will not provide guidance on changes in sea level from tectonic activity. However, this information is included because it was an important finding of the NRC 2012 report.

[9] Cheryl Hapke et. al, *National Assessment of Shoreline Change Part 3: Historical Shoreline Change and Associated Coastal Land Loss along Sandy Shorelines of the California Coast* (U.S. Geological Survey Open File Report 2006-1219, 2006). http://pubs.usgs.gov/of/2006/1219/

[10] Cheryl Hapke et. al, *National Assessment of Shoreline Change Part 4: Historical coastal cliff retreat along the California coast* (U.S Geological Survey Open File Report 2007-1133, 2007). http://pubs.usgs.gov/of/2007/1133/

8. **Consider trends in relative local mean sea level.** Relative sea level is the sea level relative to the elevation of the land. In California, the land elevation along the coast is changing due to factors including tectonic activity and subsidence. The National Oceanic and Atmospheric Administration provides a summary of the trends in the measured relative sea level at tidal gauges (water level recorders) in California that have been operating for at least 30 years http://tidesandcurrents.noaa.gov/sltrends/index.shtml. Predictions of future sea levels at specific locations will be improved if relative trends in sea level from changes in land elevation are factored into the analysis.

APPENDIX A

Development of this Document

The Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT), led by the Ocean Protection Council (OPC), developed this document. CO-CAT includes staff from the following state entities:

- Business, Transportation and Housing Agency,
- Coastal Commission,
- Department of Fish and Game,
- Department of Parks and Recreation,
- Department of Public Health,
- Department of Toxic Substances Control,
- Department of Transportation,
- Department of Water Resources,
- Environmental Protection Agency,
- Governor's Office of Planning and Research,
- Natural Resources Agency,
- Ocean Protection Council,
- Ocean Science Trust,
- San Francisco Bay Conservation and Development Commission,
- State Coastal Conservancy,
- State Lands Commission, and
- State Water Resources Control Board.

Staff from these state entities worked collaboratively from July through October 2010 to develop the interim version of this document, the *Interim Guidance Document* (2010), and reached agreement on the document's recommendations. Upon the release of the NRC Report in June 2012, numerous meetings and workshops were held to familiarize agencies and the public with its findings. On November of 2012 CO-CAT members reconvened to discuss the update of this document. CO-CAT members came to consensus over retaining the policy recommendations stated in the *Interim Guidance Document* (2010), and updating the Guidance Document per the new set of ranges of SLR presented in the 2012 NRC report, and incorporating new scientific findings on the hazards associated with storms and tectonic activity as a potential source of change in relative sea level.

The 2012 NRC Report, unlike the Interim Guidance Document, divides the California coast into two separate regions – north of Cape Mendocino and south of Cape Mendocino. The projections for north of Cape Mendocino incorporate the uplift trends that are partially associated with the Cascadia Subduction Zone and result in very different projections for sea level rise than are anticipated for the rest of the coast. For the coast from Cape Mendocino to the Mexican Border, the 2012 NRC projections for the years 2030 and 2050 are similar to the projections presented in the *Interim Guidance Document* (2010), but have a wider range. For this same area, the NRC projections by 2100 are slightly lower than those in

Interim Guidance Document (2010), due to differences in modeling approaches and consideration of regional impacts.

OPC staff, directed by CO-CAT members, worked with the California Ocean Science Trust (whose Executive Director is the OPC's Science Advisor) to ensure that the update to this document best incorporated the scientific findings in the 2012 NRC report. A sub-committee of relevant subject matter experts from the OPC's Science Advisory Team responded to questions posed on how to adapt tables and figures from the NRC Study to better serve the Guidance Document's audience. The questions posed and responses can be found in Appendix B.

APPENDIX B

Responses to February 2013 Questions for the Ocean Protection Council's Science Advisory Team from the Sea Level Rise Task Force of the Ocean and Coastal Working Group of the California Climate Action Team (CO-CAT)

March 1, 2013

These responses were developed by a sub-committee of scientists from the OPC Science Advisory Team (OPC-SAT) who work directly on sea-level rise issues. Two of the scientists were also members of the NRC Committee that prepared the 2012 Report on West Coast Sea-Level Rise:

1. Dr. Dan Cayan, Research Meteorologist, UC San Diego Scripps Institution of Oceanography & United States Geological Survey
2. Dr. Gary Griggs, Director of Institute of Marine Sciences and Distinguished Professor of Earth and Planetary Sciences, UC Santa Cruz
3. Dr. Sam Johnson, Research Geologist, United States Geological Survey Pacific Science Center, Santa Cruz

Following the completion and release of the National Research Council's report*: Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future* (2012), CO-CAT sought to update the Sea-Level Rise Guidance Document. The following questions were posed to the OPC-SAT sub-committee:

Questions

Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future

1. The report outlines ranges of sea-level rise rates for the time horizons 2030, 2050 and 2100 (Table 5.3, page 96):
   a. We would like to be able to recommend ranges for the time horizons utilized (2030, 2050, and 2100) for zones north of Cape Mendocino and south of Cape Mendocino. However, we are not sure what range of numbers we could recommend to the area north of Cape Mendocino so that those communities can plan for sea-level rise given the tectonic risks specific to that region.
   b. Given the *components* in Table 5.3 (page 96), the *sum of all contributions* does not add up. Can you please explain how the contributions add up?
2. There are sea-level rise ranges presented for major cities along the West Coast. Would utilizing the rates presented for these cities more accurately reflect the science over utilizing the regional (north or south of Cape Mendocino) ranges?

Responses

Prior to answering these specific questions, the sub-committee wants to reiterate some key points from our September 1, 2010 response.

1. Over the next few decades, episodes of heightened sea level associated with large winter storms and anomalous short period climate patterns will be of greater concern to infrastructure and development in coastal areas than the relatively slow increases that are projected in association with global sea-level rise alone. The coast of California has experienced two very large El Niño events over the past 20 years, in 1982-83 and 1997-98, when large storms resulted in hundreds of millions of dollars in storm damage to private property and public infrastructure. The damages occurred from a combination of elevated sea levels and large storm waves, especially when these factors coincided with high tides. During the 1983 ENSO event, sea levels were the highest ever recorded in San Diego, Los Angeles and San Francisco, 29.0 cm) (11.4 in.), 32.3 cm (12.7 in), and 53.8 cm (21.2 in.), respectively, above predicted high tides.

This point was also made clear in the NRC Report (Executive Summary p. 6):

Most of the damage along the California, Oregon, and Washington coasts is caused by storms-particularly the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño. The water levels reached during these large, short-term events have exceeded mean sea levels projected for 2030 and are equivalent to values projected for 2050, so understanding their additive effects is crucial for coastal planning.

2. Coastal hazards in California vary geographically and will evolve through this century based on a combination of sea-level rise, possible changes in storm climate, and tectonic uplift or subsidence. Different coastal environments will be exposed to different risks and these risks are expected to increase in the future. Each of these needs to be understood, their risks assessed and adaptation measures developed.

a. Inundation of coastal flooding along the low lying portions of the open coast

b. Inundation of low-lying areas around San Francisco Bay

c. Coastal erosion of cliffs, bluffs and dunes

d. Rapid land-level change (primarily subsidence) north of Cape Mendocino during a subduction zone earthquake that is likely to occur in the next several hundred years

We do not believe that there is enough certainty in the sea-level rise projections nor is there a strong scientific rationale for specifying specific sea-level rise values at individual locations along California's coastline. The uncertainties in future sea-level rise projections increase as the projected time horizon is extended forward through the 21st Century. These uncertainties arise from an incomplete understanding of the global climate system, the inherent unpredictability of natural climate variation, the inability of global climate models to accurately represent all important global and regional components, and the need to make assumptions about important climate drivers over future decades (e.g., greenhouse gas emissions, aerosols, land use).

For the near future (out to 2030), confidence in the global and regional projections is relatively high, but uncertainty grows larger as the time horizon of the projection is extended forward. There are large uncertainties in projections for 2100 made using any existing methodology, including process-based numerical models, extrapolations, and semi-empirical methods. The actual sea-level rise value for 2100 is likely to fall within the wide uncertainty bounds provided in the NRC West Coast Sea Level Rise Report, but a precise value cannot be specified with any reasonable level of confidence.

The sections of coastline north and south of Cape Mendocino clearly are parts of different tectonic regimes and tide gages have recorded distinct regional values over their periods of record. The tide gage for the North Spit at Humboldt Bay extends back to 1977 and has recorded an average sea-level rise of +4.73 +/- 1.58 mm/yr., equivalent to 1.55 ft./100 years. This is considerably higher than the global average and indicates significant subsidence in this location. Sixty-five miles north at Crescent City, the tide gage record extends back to 1933 and shows, over the period of record, a local drop in sea level of -0.65 +/-0.36 mm/yr., equivalent to -0.21 ft./100 years. The drop in sea level is explained by a rising coastline near Crescent City due to flexure of the North American tectonic plate above the subducting Juan de Fuca plate. We believe it is advisable to use the two different rates (augmented by any future acceleration in rates of sea level rise) for the areas closest to these two gages, with intermediate values for the areas between them. What is certain to happen when the next large subduction zone earthquake occurs, however, is that there will likely be essentially instantaneous coastal subsidence north of Cape Mendocino that could be as much as three feet or more.

From Cape Mendocino to San Diego, based on the NRC report findings and the general lack of large variation between the data from the open coast NOAA tide gage stations with the longest and most consistent records, we believe that using a single sea-level rise value is the presently the best and most tractable approach. Historic sea-level rise rates from tide gages range from about 0.8 to 2.1 mm/yr. Table 5.2 in the NRC report projects essentially identical values for both San Francisco and Los Angeles for 2030 (14.4-14.7 +/- 5 cm), 2050 (28.0-28.4 +/- 9.1 cm) and 2100 (91.0-93.1 +/- 25 cm).

These values can be refined in future decades as we continue to gather additional sea-level rise and vertical land-motion data from tide gages, satellite altimetry, and GPS surveys, and as long-term trends become clearer, but careful, sustained monitoring is essential to carry this out.

For the near future it will continue to be short-term extremes that flood low-lying areas and increase rates of cliff, bluff and dune erosion that will generate the highest risks. These extremes will likely arise when a combination of factors occur, including ENSO events, high tides, storm surges, wave set up and wave run up. Along the California coast, these extreme storm events almost always occur in the winter months, and expose coastal development, whether public or private, to the greatest hazard. As global climate warms and global sea level continues to rise, these storm events, even if they do not increase in intensity or duration, will likely have even greater impacts on the California coast.

Additional factors for state agencies to consider in selecting a sea-level rise rate from the projected ranges that are included in the NRC report for any future coastal facility or infrastructure project include:

1. The projected lifespan of the project of facility
2. The cost or value of the project or a replacement facility
3. The impact or consequence of damage to or loss of a facility or project

APPENDIX C

FOR ILLUSTRATION PURPOSES ONLY – CONCEPTUAL MODELS

Figure 1. Consequence = Impacts x Adaptive Capacity

	Low Adaptive Capacity	Medium Adaptive Capacity	High Adaptive Capacity
High Impact	HIGH CONSEQUENCES	HIGH CONSEQUENCES	MEDIUM CONSEQUENCES
Medium Impact	HIGH CONSEQUENCES	MEDIUM CONSEQUENCES	LOW CONSEQUENCES
Low Impact	MEDIUM CONSEQUENCES	LOW CONSEQUENCES	LOW CONSEQUENCES

This figure demonstrates how the consequences of a decision are determined by the amount of impact and by the adaptive capacity. There are higher consequences when there are greater impacts and lower adaptive capacities.

Figure 2. Example of:
Risk = Consequence x Likelihood

For projects where too much sea-level rise would cause project impacts such as flooding,

	if use lower estimates of sea-level rise	if use medium estimates of sea-level rise	if use higher estimates of sea-level rise
	Higher Likelihood Impacts	Medium Likelihood Impacts	Lower Likelihood Impacts
High Consequence	HIGH RISK	HIGH RISK	MEDIUM RISK
Medium Consequence	HIGH RISK	MEDIUM RISK	LOW RISK
Low Consequence	MEDIUM RISK	LOW RISK	LOW RISK

This figure demonstrates how the amount of risk is determined by the consequences (impacts and adaptive capacity) and the likelihood of impacts occurring. In this example, using higher SLR estimates lower the project risks."

State Coastal Leadership Group on Sea-level Rise

The State Coastal Leadership Group consists of senior management from the Ocean Protection Council (OPC), Coastal Commission, Coastal Conservancy, Department of Parks and Recreation, State Lands Commission, and San Francisco Bay Conservation and Development Commission, and is convened monthly or bimonthly by the OPC. The shared mission of member agencies is to maintain the natural beauty, accessibility, economic power, ecological richness, and social diversity of the California coast by reducing risks from sea-level rise, storms, erosion and other coastal climate-related hazards. The State Coastal Leadership Group accomplishes this by:

- Improving information sharing between member agencies to reduce redundancy and identify opportunities for alignment, complementarity and synergy;
- Strengthening partnerships among member agencies to enable strategic, coordinated and collaborative actions;
- Promoting dialogue on priority issues such as public trust to ensure that member agencies have a shared understanding and, where relevant, can use this understanding to inform their interactions with other sectoral agencies, coordinating mechanisms, regional and local government, and tribes;
- Determining and implementing needed actions to promote adaptation and resilience in coastal areas throughout the state;
- Leveraging member agencies' expertise and experience to provide leadership on coastal and ocean adaptation; and
- Gauging collective progress and identifying shared agency needs and gaps to present to the legislature and other relevant entities to inform existing policy and funding processes.

2009 California Climate Adaptation Strategy

A Report to the Governor of the State of California in Response to Executive Order S-13-2008

CALIFORNIA natural resources AGENCY

VI. Ocean and Coastal Resources

Introduction

Approximately 85 percent of California's residents live and work in coastal counties; these populations will be at risk from a range of climate impacts that are specific to these regions.[1] California's coastal areas are home to unique and threatened ecosystems that offer unmatched recreation and tourism opportunities for people, provide invaluable habitat for rare species, and buffer coastal communities from flood and erosion. Yet, between 1980 and 2003, California's coastal population grew more than any other state's coastal population, increasing by a total of 9.9 million people, or 1,179 persons *every day.*[2] By 2025, the coastal population is expected to grow – albeit at a slower rate – to over 32 million people.[3] Along with people, infrastructure and assets are also concentrated along the coast. According to recent estimates developed for the 2009 California climate change impacts assessment, a 100-year flood event after a 1.4 meter (55 inches) sea-level rise will put 480,000 people at risk and nearly $100 billion in property.[4] In addition, California residents and out-of-state visitors make well over 500 million visits to the state's ocean beaches every year. People go to the coast to enjoy sun and sand, the vistas, and the unrivaled diversity of plants and animals that inhabit the region. All of these visits contribute greatly to California's ocean-dependent economy, which is estimated to be $46 billion per year.[5]

In 2006, the California Climate Change Center reported a historic sea-level rise of 7 inches in the last century and projected an additional rise of 22–35 inches by the end of this century. Since that time numerous other studies have published projected ranges of 7–23 inches,[6] 20–55 inches,[7] and 32–79 inches[8] of sea-level rise for this same period, with the differences in these projections attributable to different methodologies used and how well or whether glacier ice melt is included in the calculations. This report uses the 20-55 inch projection, as it was the best available science at the time of the 2009 impacts assessment. Future sea-level rise estimates will vary based on future GHG emissions.

Much of the damage from this accelerated sea-level rise will likely be caused by an increase in the frequency and intensity of coastal flooding and erosion associated with extreme weather events and storm surges. In addition to sea-level rise, California's coastal and ocean resources are expected to experience additional dramatic changes. These include more severe atmospheric events (e.g., El Niño events); changes in ocean chemistry (e.g., temperature and pH) and estuarine chemistry (e.g., temperature, pH, and salinity); and changes in ecosystem processes (e.g., nutrient upwelling).

While the exact future of the coast is uncertain, one thing is clear: we're going to have to change the way we think about managing our natural assets and human development. Existing laws (such as the California Coastal Act) provide state and local governments with tools for addressing the effects of climate change, but also impose some significant limitations. Laws written in and designed for the 20th century will need to be updated to reflect new ideas about climate change in the 21st century.

Californians will need to make tough decisions about which critical assets we want to protect, which ones can be relocated, which ones will have to be removed, and what is economically reasonable. Development and land-use is already putting stress on coastal ecosystems and resources, constraining their natural ability to adapt to a highly dynamic environment. New development along the coast should be designed and sited to anticipate expected sea-level rise, minimize future hazards, and maintain the biological productivity of the coastal environment. Yet, it will not always be possible to achieve the multiple goals of continued development, protection of critical infrastructure, sustained coastal recreation, and ecosystem protection. For example, shoreline protection structures negatively impact beach access, beach size, shoreline processes, recreation, tourism, and coastal habitats. Ultimately, when these goals are in conflict there will likely be winners and losers. We need to recognize this fact and develop priorities and the regulatory authorities that will allow decisions to be made in a reasonable manner that takes into account numerous factors and interests.

Future Climate Impacts to Oceans and Coastal Resources

A. Increased Temperature and Extreme Events

Air temperatures are expected to rise in coastal California at a slower pace than inland areas due to the cooling influence of the Pacific Ocean.[9] This may draw greater numbers of Californians to the coast. The implications of this possible migration for the economy, housing market, transportation infrastructure, coastal ecosystems, and quality of life have not been assessed to date but could be significant.

Ocean water temperatures will rise as air temperatures rise, causing changes in marine and coastal species behavior and distribution. Species within California's coastal and ocean environments are adapted for life within a particular range of temperatures.[10] Temperatures above or below optimal range can affect the metabolism, growth, and reproduction of stressed aquatic species.[11] As such, temperature is one of the primary environmental factors that determine the geographic range of a species.[12] Shallow coastal waters (e.g., bays and estuaries) will warm sooner than the deeper parts of the oceans, thus warming temperatures should have a direct impact first in the coastal ocean, including bays, estuaries, lagoons, and wetlands. One direct impact of changing water temperatures is a change in coastal water quality because warmer water holds less oxygen.

Increases in water temperatures off the coast of California have already led to a shift in the geographic range of species. As atmospheric and ocean temperatures continue to rise, species that currently have a geographic range from Point Conception south to the Mexican border will begin to shift their geographic range northward up the coast to find ocean temperatures within their physiological range. This has already been observed with the Humboldt squid that used to be an occasional visitor and is now a permanent resident in central California's coastal waters.[13] Just as on land, non-native/invasive species will migrate from more southern areas adding further displacement pressure on native species and taking hold in ocean and coastal ecosystems disturbed by climate change.[14]

Warming can also affect the ocean food web in indirect ways. El Niño patterns or Santa Ana winter wind intensity could significantly alter the nutrient cycling that underpins the marine food web and current species assemblages.[15] Santa Ana winds coincide with cool sea surface temperatures, upwelling, and a spike in biological activity. These winds are projected to decline in intensity, but it is not known how marine nutrient availability and food webs will change.[16]

OCEAN AND COASTAL RESOURCES IMPACTS DUE TO WARMING

- Population Changes in Coastal Areas Anticipated
- Public Health Education and Planning Needed for Extreme Heat
- Relocation of Marine Species and Southern and Exotic Species May Become Invasive
- Changes in Marine Food Systems (Upwelling and Nutrient Availability)
- Changes in Commercial and Recreational Ocean Fishery and Economic Impacts

Warmer ocean temperatures together with changed nutrient availability could result in a decrease in fish populations or a shift in the geographic range of harvested species.[17] During the 1997-1998 El Niño, California's commercial squid industry realized the vulnerability of the fishing industry to water conditions. Squid landings (the number or poundage of fish brought to shore by fishermen) decreased from 110,000 metric tons in 1996-1997 to just 1,000 metric tons over the course of the El Niño season.[18] Together with expected changes in coastal estuaries and wetland habitat resulting from sea-level rise (see below), commercial and recreational fish species may experience lower reproductive success and population decline.

While climate change may reduce or shift the habitable range of current fishery species, it may also allow new fish populations to move north. Some of these new species may become economically significant commercial or recreational fish populations (e.g., the Humboldt squid). The net effect upon the marine fishing industry is currently unknown and should be a subject of future study. Transitional costs (e.g., harvesting gear, marketing activity) to adapt to any new fishery would be expected. The health of California's fisheries will depend on each species' adaptive capabilities, the rate and complexity of interactions in the marine food web as a result of climate change, and the state's ability to implement measures to limit catches to sustainable levels and protect coastal habitats.

B. Precipitation Changes and Extreme Events

In California's coastal areas precipitation falls almost exclusively as rain, even in winter. Coastal fog also plays a large role in providing the moisture required for the maintenance of terrestrial coastal ecosystems; changes in coastal fog density will impact coastal forest types. A general pattern of a drying climate over the 21st century could result in rainstorms that are fewer in number, but greater in intensity; and less coastal fog. Changes to the timing and intensity of freshwater input from rainstorms could impact marine and near shore species. Changing precipitation patterns will potentially increase the occurrences of flooding in coastal drainages. In coastal floodplain areas, runoff from land may coincide with the coastal storm surge (also higher due to sea-level rise) and lead to greater flooding risks in the immediate coastal zone.[19]

Less frequent but more intense rainfall patterns could have serious consequences on water quality. With an increase in frequency and intensity of wildfires,[20] increased runoff and flooding will remain a considerable risk and may also result in higher levels of pollution and sediment runoff. The first flush during storm events is frequently heavily contaminated with toxins deposited on roads, driveways, parking lots and rooftops. Heavy runoff also offers a medium for infectious disease vectors to multiply and spread. Large amounts of runoff may overwhelm the capacity of sewers and sewage treatment plants to absorb and adequately cleanse waters before they reach coastal waters and beaches. Thus, both coastal and marine species and human health are at greater risk in the period following heavy storms (see the Public Health chapter). Infectious diseases in coastal waters and seafood may spread, and invasive species well-suited to more extreme conditions may flourish.[21] If the intensity of such extreme events increases, both human populations and natural habitats will be exposed to increased stresses and have less time to recover between occurrences.[22]

Potentially the most damaging extreme events in coastal California will be winter ocean storms. Past El Niño events have resulted in significant financial damages and exposed large numbers of people to flooding hazards. Climate change will likely exacerbate these impacts with larger waves and higher water levels. These storms will also affect coastal erosion and sediment transport patterns; larger and longer period winter waves have already been observed and may be a growing trend.[23]

Ocean and Coastal Resources Impacts due to Precipitation Changes

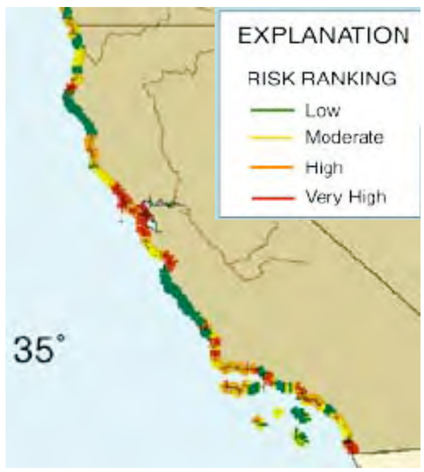
- Higher Runoff and Flooding
- Flood Risks from Inland and Coastal Flooding
- Contamination from Sewage Distribution and Treatment Systems
- Health Risks from Contaminated Runoff
- Increased Marine Pollution

C. Sea-level rise

Coastal Flooding and Permanent Inundation

California's coast is home to major population centers, many of which are situated in low-lying floodplains. Large numbers of people and important assets will be increasingly at risk from inundation during coastal storms as higher sea levels, high tides, storm surges, and inland flooding coincide.[24] Some low-lying areas will also be permanently inundated unless they are protected. Increasing rates of coastal erosion, beach loss, salinity intrusion into estuaries, and saltwater intrusion into groundwater will need to be addressed in future coastal land management decisions.

Figure 12: *Vulnerability of California coastal areas to sea level rise*



Source: Kahrl and Roland-Holst, 2008

Given the extent of high-value development already located in at-risk flood zones, California's coastal cities are not only at risk from storm-related inundation and flood-related damages, but also permanent property loss where land is eroded or constantly inundated. Currently, over 260,000 Californians live in areas designated as at-risk in a 100-year flood event (a one percent chance of occurring every year).[25] What we currently define to be the 100-year flood today will occur much more frequently as sea level rises; therefore, the number of people exposed to risks from 100-year floods will increase substantially as a result of sea-level rise in coming decades.[26]

Studies indicate that a 1.4 m (~5 feet) rise in the level of the San Francisco Bay by 2100 would place 33 percent more land at risk from flood-related inundation than is at risk today.[27] Without accounting for future growth and land use change, the amount of developed land at risk in the Bay area could more than double from current levels by the end of the century.[28] A majority of the structures at risk in that region are designated as residential property. The initial estimates of development in San Francisco Bay in 2100 indicate that over $62 billion worth of building and contents could be at risk.[29]

On the open ocean coast, challenges are similarly daunting. For example, the City of Santa Cruz has a levee system that protects some low-lying parts of the city against a 100-year flood. With a sea-level rise of approximately one foot, the anticipated 100-year flood event in Santa Cruz is expected to occur every 10 years, increasing the likelihood of storm-related inundation.[30] Over the entire California coast, over $100 billion worth of assets (buildings and contents) would be at risk from a 100-year flood in 2100 assuming a 1.4m (~5 feet) rise in sea level.[31]

Providing insurance coverage for coastal development under even a moderate sea-level rise scenario will be costly. One study estimated that the National Flood Insurance Program (NFIP), which provides backing for flood insurance in participating U.S. communities, will be confronted with an increase in insured property by 36 to 58 percent for a one-foot rise in sea level; and by 102 to 200 percent for a three-foot rise.[32] Not accounting for development and growth, this older study is indicative of the growing flood risk due to sea-level rise alone. The Federal Emergency Management Agency (FEMA) and the national treasury will more often be tapped to deal with growing flood damages in coastal areas unless insurance rates are increased to keep the program actuarially sound.

In addition to private property at risk, infrastructure is also at great risk from coastal flooding and erosion (see the Infrastructure chapter). A complex network of highways and roads, large ports, numerous airports, water supply canals, wastewater treatment facilities, and power plants are located in coastal areas, sometimes directly in floodplains, to support the region's and the state's economy and growing population. This coastal infrastructure is vulnerable to increased heat and flood events, potentially limiting the ability to deliver vital public services.

OCEAN AND COASTAL RESOURCES IMPACTS DUE TO SEA-LEVEL RISE

- Increased Risks of Coastal Flooding in Low-Lying Areas
  - More People and Assets - At Risk
  - Public Infrastructure - Increased Risk of Inundation
  - Levees and Structures - Require Retrofit
  - Coastal Wetlands - Potential Loss
- Increased Erosion of Beaches, Cliffs and Dunes
  - Private Property and Structures - At Risk
  - Beach Recreation and Tourism - May Decrease in Select Areas
  - Greater Expenditures for Beach Maintenance
- Increased Saltwater Intrusion into Coastal Groundwater Resources
  - Agricultural Land - Degraded by Saltwater

Impacts on transportation systems will include flooding of roads, railways, transit systems, and airport runways in coastal areas because of rising sea levels and higher storm surges. A substantial amount of ground transportation infrastructure is predicted to be at risk from sea-level rise by 2100, including 2,500 miles of roads and rails.[33] Such infrastructure is vital to the state's economy for both the movement of commercial freight and the ability of Californians to get to work and school. In the San Francisco Bay, the major airports of San Francisco and Oakland are near sea level and would require additional elevation, protection, or relocation to remain functional.

Municipal and industrial infrastructure would be directly and indirectly at risk from alteration of coastal resources due to climate change. Accelerated sea-level rise and storm-related flooding (from the coastal and the inland side) could threaten California's vital but aging levee and water transport system.[34] Additionally, water backflow could impair coastal water sanitary sewage systems during flood events.[35] Inundation of coastal infrastructure can also cause widespread pollution and contamination, jeopardizing marine and near-marine environments.

Wetland Loss and Habitat Degradation

Increasing sea levels will submerge many low-lying portions of California's coastal wetlands. Of particular concern are coastal salt marshes, which have already been decreased by 91 percent from historical levels.[36] If vegetation and sediment accretion occurs rapidly, wetlands could maintain their present location and the wetland footprint would not decline. For example, while some very high accretion rates occur in the San Francisco Bay region (i.e., up to 80 mm per year), the average rate is approximately 1-2 mm per year. This rate has kept pace with recent sea level rise, but will likely fall short of the projected future sea-level rise of 2-3 mm (or more) per year.[37] The high degree of development and infrastructure placed in near-shore areas restricts the inland migration of wetlands in many locations, thus more coastal wetlands are likely to be lost.[38]

If wetlands are submerged by rising water levels, one consequence would be that wave energy would be less attenuated and erosional forces against upland levees, such as within San Francisco Bay, would increase.[39] Additional potential impacts to wetlands due to sea-level rise include: changes to estuarine mixing, water quality, and carbon cycling; changes to upland habitats and sediment loads into downstream wetlands; and changes to wetland biological habitat, diversity, and changes in biological distribution which will potentially impact foraging opportunities and rearing habitats for key ocean species.[40] Furthermore, the degradation of sensitive ecosystems can be brought about not just by higher sea levels but also by other climate changes, including increased water and air temperatures and changes in precipitation patterns, which together can increase the abundance of invasive species. Changes in the abundance and distribution of critical native species can also have cascading, significant effects on sensitive coastal and ocean habitats.

Increased Coastal Erosion

In addition to coastal flooding, the rate of coastal erosion will also increase as a result of sea-level rise. Loss or movement of beach sand and increased cliff and bluff erosion would jeopardize the stability of many coastal developments and recreation areas. The extent of this impact on California's coastline will vary by the type of coast, the width of the beach, and the presence or absence of protective structures. Damage to coastal infrastructure will be more severe where extreme wave conditions combine with elevated sea levels to impact unprotected and/or erodible coastal areas.

The U.S. Geological Survey (USGS) has developed a preliminary map in 2000 classifying areas of the U.S. Pacific coast based on their physical vulnerability to coastal change due to sea-level rise. Areas classified as "very high" risk are those that have already experienced significant erosion problems, and are concentrated mainly around the state's major bays including the Humboldt, San Francisco, and Monterey Bays as well as Los Angeles and San Diego.[41]

Increased coastal erosion will impact private property owners and beach-dependent sectors of the state's economy. Beach recreation and tourism generate the largest economic value of all economic sectors in the California coastal zone.[42] The economic value of beach recreation and tourism is of particular importance in southern California, as expenditures in just three counties in southern California accounted for 44 percent of the state's total tourism-related spending in 2007.[43] Many of the state's intensively used beaches are backed by seawalls, bulkheads, roads, parking lots, or other infrastructure, which prevents landward migration. These beaches will gradually be inundated or will be reduced in width as sea level rises, translating into a reduction on beach area. These physical effects of climate change could significantly decrease the viability and attractiveness of coastal tourism locations, including a shift in tourist attendance patterns among local beaches.[44] Such changes would generate either direct or transitional costs for the expanse of tourism-related businesses within the service economy of coastal California. The incidence of beach erosion and accretion at individual California beaches indicates a net negative effect from both gradual sea-level rise and extreme events on the order of an $8.6 million loss in total annual expenditures and a $36.7 million decline in consumer surplus. However, these impacts will vary regionally. In addition to economic impacts associated with the loss of beaches, the ecological impacts will be significant as California beaches support hundreds of organisms, act as buffers to interior habitat during storms, and are essential for the persistence of rare dune habitats.

According to one recent study for southern California, erosion rates are expected to accelerate by 20 percent for a sea-level rise of 39.4 inches (100 cm).[45] Several alternatives exist to deal with rising sea level and the issues of coastal erosion and inundation: armor, nourishment, and a planned retreat. Each will have tradeoffs in terms of impacts and costs, dictated by the magnitude of sea-level rise that is expected and the amount of property, infrastructure, or public resources threatened. Creating protective structures can limit or alter the functioning of natural habitats, which in turn can decrease the overall adaptive capacity of coastal ecosystems. Ten percent (or 110 miles) of the entire coast of California is now armored, and 33 percent of the shoreline of the four most southerly California counties has been hardened. We can expect more applications and pressure on permitting agencies (local governments as well as the Coastal Commission) to approve additional hardened structures in the future as sea level continues to rise.

Saltwater Intrusion

Sea-level rise and changes in the intensity of storm events could impact low lying coastal areas and result in the loss or inundation of coastal wetlands and dune habitat resulting in salt water intrusion and loss of fresh water resources for fish and wildlife. Sea-level rise will also adversely affect coastal water supplies through saltwater intrusion into coastal aquifers, potentially increasing the need for other water sources (such as desalination) to address coastal water shortages and impact groundwater resources tapped for irrigation.[46] Compounding the problem, low-lying farmland such as the Oxnard Plain and the Bay-Delta region may also be inundated with salt water.[47]

Ocean Acidification

Coastal ecosystems and the industries that depend upon them are being significantly impacted by increased acidification of the ocean due to increases in atmospheric CO_2 concentrations. Globally, the ocean absorbs 30-50 percent of the annual emissions of CO_2.[48] As CO_2 is dissolved into ocean and estuarine waters, carbonic acid is formed lowering the pH of the water. This increased acidity can hamper the ability of a wide variety of marine organisms ranging from coral to abalone to form calcium carbonate shells and skeletal structures.

Acidification limits the growth and survival of species such as crabs, sea urchins, abalones, oysters and significant plankton species that have calcium carbonate shells and skeletons. The decreased survival of these calcifying organisms has rippling impacts on species that feed upon them (e.g., the loss of key plankton species will negatively impact the salmonids, seabirds, and other species that feed on them). Commercially important shellfish species are likely to be negatively affected: under a moderate emissions scenario (750 ppm CO_2 by 2100), calcification rates of mussel and oyster species are predicted to decline by 25 and 10 percent, respectively, by the end of the century.[49] The declining pH levels also impact fertilization, development, and metabolic function of many marine species including kelp, which is an essential component of productive coastal ecosystems on the West Coast, and a commercially harvested species. Acidification also affects the toxicity of a variety of substances and the biological availability of important nutrients and other compounds.

D. Risks for Ocean and Coastal Resources

To summarize the changing risks that California's ocean and coastal resources may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The resulting risk profile for California's oceans and coastal areas can be characterized as follows:

- Sea-level rise will increase the risks of coastal flooding in low-lying areas, inundating private property more frequently and exposing more people and more assets to flooding risks. Infrastructure, public facilities and industrial sites will also experience growing flooding risks. Levees, protective structures, and development may need to be elevated and flood-proofed to maintain protection.
- Threats to coastal wetlands are increasing. If wetlands cannot migrate inland due to man-made or natural barriers, wetland habitat will be lost.
- Sea-level rise will increase erosion of beaches, cliffs, and bluffs, threatening public and private property and structures and causing social, economic, and resource losses to coastal recreation and tourism through reduction in or damage to beaches, access ways, parks, trails, and scenic vistas.
- Loss of wetland, beach, and other coastal habitat will negatively impact many fish, bird, and other species, and diminish biodiversity.

- Californians are likely to experience a more moderate increase in average temperatures in coastal areas than in inland areas due to the cooling effect of the ocean, yet may suffer disproportionately from extreme heat waves.
- Warmer water temperatures will cause shifts in the distribution of coastal and marine species; southern species may extend their range northward. Additionally, exotic species may become invasive in new areas and new pathogens may appear. Together with other climate-driven changes in wind patterns, upwelling, nutrient availability, and hard-to-predict changes in the marine food web, warmer water temperatures may cause recreational and commercial fishing species to decline in abundance or shift their range, leading to widespread economic impacts on these fisheries.
- Fewer, but possibly more intense, rainstorm events will produce high runoff and flooding. In the immediate coastal areas, such inland flooding may coincide with coastal flooding, posing particularly high risks to communities and structures in coastal floodplains.
- High runoff may overwhelm storm drains and sewage treatment plants, potentially contaminating coastal ecosystems and beaches.
- Sea-level rise will increase saltwater intrusion into coastal aquifers (groundwater resources), degrading agricultural land and coastal groundwater resources.
- Rising temperatures and ocean acidification have the potential to negatively impact ecosystems and fisheries.

Ocean and Coastal Resources Adaptation Strategies

Introduction

The state agencies in the Coastal and Ocean Working Group (Ocean Protection Council, California Coastal Conservancy, California Coastal Commission, State Lands Commission, Department of Fish and Game, State Parks, and the Bay Conservation and Development Commission) contributed to the development of the following strategies and each organization will be essential to the successful implementation of the strategies. Given the extent of the threats predicted by current climate models, sea level projections, and the considerable value of California's coastal lands, resources, and development, coastal planning must adapt to prepare California for a variety of potentially significant outcomes of climate change. Preparing California's coastal infrastructure, industries, and ecosystems for the impacts of climate changes will be an expensive endeavor. Decision-makers will need to make short- and long-term risk-management decisions to address future impacts that will include deciding which human developments should be maintained, retrofitted, and protected; where hazard avoidance is not possible; where planned retreat is appropriate; and where natural systems should be protected, rehabilitated, or enhanced.

These decisions should be made using the following principles for guidance:

- California must protect public health and safety and critical infrastructure.
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well being depend.
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources.
- New development and communities must be planned and designed for long-term sustainability in the face of climate change.
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
- California must begin now to adapt to the impacts of climate change. We can no longer act as if nothing is changing.

Adaptation to sea-level rise drives most of the Ocean and Coastal Resources adaptation strategies presented in this report. The priority strategy is for state agencies to avoid establishing or permitting new development inside future hazard zones in most cases if new protective structures would be necessary (strategy 1a). Additional strategies include (1) directives to promote innovative approaches to redesigning coastal structures, where feasible, that are resilient to the impacts of climate change and can serve to protect existing development in low-lying areas (strategy 1b), and (2) creation of statewide guidance and regional planning forums to help local governments update local plans and make planning decisions in light of sea-level rise (strategies 2a and 4c).

All levels of government are encouraged to consider:

- Incentive programs to encourage property owners in high-risk areas to relocate or limit future development.
- Clustering new development in areas considered to have a low vulnerability to sea-level rise.
- Creating additional buffers and setbacks for new construction to minimize risks to people and property and to protect coastal resources such as natural habitat and recreational areas (see strategy 4c).

Critical coastal and ocean habitats and recreational areas should be protected and maintained to the extent feasible. The state should identify priority conservation areas and recommend lands that should be considered for acquisition and preservation, especially vulnerable shoreline areas containing critical habitat or opportunities for habitat creation (strategy 1c). Future sea-level rise estimates should be considered during restoration efforts (i.e., grading levels for wetland restorations), and natural shoreline enhancements (e.g., species such as native oysters, eelgrass) should be designed to promote sedimentation and protect against shoreline erosion.

Adaptation Strategies and Actions

The Coastal Adaptation Working Group has identified the following priorities in addressing climate adaptation for California state agencies. The near-term actions referenced below are those actions that have been identified and which can be initiated or completed by 2010, if, in some cases, related statutory or regulatory changes are made. The long-term actions include those that will require support from that state and collaboration with multiple state agencies or that require significant legal or regulatory changes.

Strategy 1: Establish State Policy to Avoid Future Hazards and Protect Critical Habitat.

<u>Near -Term Actions:</u>

a. **Hazard Avoidance Policy** – State agencies should consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding or erosion due to climate change.
The most risk-averse approach for minimizing the adverse effects of sea level rise and storm activities is to carefully consider new development within areas vulnerable to inundation and erosion, and to consider prohibiting development of undeveloped, vulnerable shoreline areas containing critical habitat or opportunities for habitat creation. State agencies should generally not plan, develop, or build any new significant structure in a place where that structure will require significant protection from sea-level rise, storm surges, or coastal erosion during the expected life of the structure. However, vulnerable shoreline areas containing existing development or proposed for new development that has or will have regionally significant economic, cultural, or social value may have to be protected, and in-fill development in these areas should be closely scrutinized. State agencies should incorporate this policy into their decisions, and other levels of government are also encouraged to do so. Some state agencies already base decisions on hazard avoidance, for example Coastal Act provisions require that new development in the coastal zone be designed to minimize risks from current and future hazards, which would include

risks from expected sea-level rise, the Act restricts new development in hazardous areas, especially if it would require the construction of a protective device.

b. **Innovative Designs –** If agencies do plan, permit, develop or build any new structures in hazard zones, agencies should employ or encourage innovative engineering and design solutions so that the structures are resilient to potential flood or erosion events or can be easily relocated or removed to allow for progressive adaptation to sea level rise, flooding, and erosion.

c. **Habitat Protection –** The state should identify priority conservation areas and recommend lands that should be considered for acquisition and preservation. The state should consider prohibiting projects that would place development in undeveloped areas already containing critical habitat, and those containing opportunities for tidal wetland restoration, habitat migration, or buffer zones. The strategy should likewise encourage projects that protect critical habitats, fish, wildlife and other aquatic organisms and connections between coastal habitats. The state should pursue activities that can increase natural resiliency, such as restoring tidal wetlands, living shoreline, and related habitats; managing sediment for marsh accretion and natural flood protection; and maintaining upland buffer areas around tidal wetlands. For these priory conservation areas, impacts from nearby development should be minimized, such as secondary impacts from impaired water quality or hard protection devices.

Long -Term Actions:

d. **Coordinate Policy Implementation** – State agencies should use outreach and incentive programs to promote hazard avoidance policies and sound management decisions for coastal habitat protection and development to all levels of government.

Strategy 2: Provide Statewide Guidance for Protecting Existing Critical Ecosystems, Existing Coastal Development, and Future Investments

Significant and valuable development has been built along the California coast for over a century. Some of that development is currently threatened by sea-level rise or will be threatened in the near future. Similarly, the coastal zone is home to many threatened or endangered species and sensitive habitats. We must acknowledge that the high financial, ecological, social and cultural costs of protecting everything may prove to be impossible; in the long run, protection of everything may be both futile and environmentally destructive. Decision guidance strategies should frame cost-benefit analyses so that all public and private costs and benefits are appropriately considered.

Near -Term Actions:

a. **Establish Decision Guidance** – The OPC in close coordination with other state resource agencies should develop a statewide framework that can be used by state and local agencies as guidance in preparation of adaptation plans. This guidance should discuss current regulatory and legal frameworks and whether changes are necessary to pursue this approach to adaptation. In addition the OPC should incorporate this new guidance within existing decision-making processes as much as possible and tailor it, when necessary, to specific regional approaches (see strategy 4c)..

It should consider three key questions for helping to design and locate proposed or existing structures that may be threatened by sea-level rise:

1. Is the existing or proposed structure either necessary for the health, safety, or welfare of an entire region, or is it located within a hazard area for which protection will be provided because of surrounding high-value development?
2. Is it infeasible to relocate an existing structure or site a new structure outside the hazard area and still provide this health, safety, or welfare function?

3. Will relocating an existing or proposed structure provide habitat protection or recreational opportunities that may be otherwise lost if that structure is built or is protected along the coast?

Additional questions that should be considered in the preparation of the framework include:

- Is there a feasible "soft" protection solution (i.e., can a barrier beach or wetland be used instead of a seawall)?
- Will the protection approach, retrofit, or new design:
    i. Be necessary to protect an existing structure threatened by erosion?
    ii. Allow continuation of important natural processes, such as littoral drift, and avoid any impacts to neighboring habitats or structures?
    iii. Result in the loss of state tidelands or beaches?
    iv. Provide a long-term solution to the threats caused by sea-level rise?
    v. Be resilient over a range of sea-level rise possibilities?
    vi. Provide broad protection to existing developed areas?
    vii. Protect structures of high cultural or social value?
    viii. Provide for a natural shoreline (i.e., can seawalls be designed to include habitat)?
    ix. Be coordinated with proposed actions for other infrastructure in the same flood hazard area?
    x. Cost less than the value of the structure to be protected?
    xi. Provide mitigation for adverse impacts that cannot be avoided?

Long -Term Actions:

b. **Pilot Studies** – Develop pilot studies in cooperation with specific cities/state agencies that will examine the efficacy and utility of the framework highlighted above.

Strategy 3: State Agencies Should Prepare Sea-Level Rise and Climate Adaptation Plans

Near -Term Actions:

a. **Adaptation Planning** – By September 2010 state agencies responsible for the management and regulation of resources and infrastructure subject to potential sea-level rise should prepare agency-specific adaptation plans, guidance, and criteria, as appropriate. Agencies with overlapping jurisdictions in the coastal zone will coordinate when drafting these plans to reduce or eliminate conflicting approaches.
    i. The Coastal Commission, the San Francisco Bay Conservation and Development Commission, the state and Regional Water Quality Control Boards, California State Parks, and the State Lands Commission should continue to develop adaptation strategies that can be implemented through their existing planning and regulatory programs.
    ii. The Coastal Conservancy, the Ocean Protection Council, and the Wildlife Conservation Board should continue to develop criteria to guide their financial decisions and ensure that projects are designed to consider a range of climate change scenarios.
    iii. The California Department of Transportation, State Parks, the Department of Water Resources, the Department of Fish and Game, the State Lands Commission, and other state agencies that own land and facilities along the coast should develop policies to guide them in land-use projects and the development of infrastructure in vulnerable areas in the future.
    iv. The aforementioned agencies should:
        a. Consider requiring applicants to address how sea-level rise will affect their project, include design features that will ensure that the project objectives are feasible and that the project will not be rendered unusable or inoperable over its lifespan, that critical habitat is protected, and that public access is provided, where appropriate.

b. Prepare climate strategies, indicators, and thresholds that respond to changing ocean temperatures, air temperatures, predator-prey interactions, and ocean acidification. These strategies should include alternative management strategies that could be employed, such as alternative fisheries management approaches dependent upon temperature regimes, alternative marine protected areas for stressed species, or changes to aquaculture and fishing practices under lower pH conditions.
c. Identify areas where their jurisdiction and authority should be clarified or extended to ensure effective management and regulation of resources and infrastructure subject to potential sea-level rise.

v. The Department of Insurance should develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas.

Long -Term Actions:

b. **Adaptation Plan Updates** – State agencies should regularly update, modify, and refine these adaptation guidance documents and plans based on new information and lessons learned from previous implementation actions.

Strategy 4: Support Regional and Local Planning for Addressing Sea-Level Rise Impacts

Near -Term Actions:

a. **Public Outreach** – The Ocean Protection Council (OPC) in close coordination with other state ocean resource agencies should (beginning in 2010) conduct public meetings within coastal communities to examine adaptive strategies available to state and local agencies to prepare for potential sea-level rise impacts. Strategies, tools, and information will be compiled and made publically available for use by local governments when updating their local and general plans.

b. **Funding Mechanisms** – The OPC should collaborate with state agencies to identify potential funding sources (i.e., AB32 or an amendment to Prop 218) for state agencies and local governments to undertake revisions to local plans.

c. **Regional Coordination** – The state should work with local governments and existing regional organizations, such as the Los Angeles Regional Collaborative for Climate Action and Sustainability, associations of local governments, or SB 375 regional planning teams, to provide for regional adaptation planning. The state should continue to conduct, synthesize, and disseminate regionally relevant research and information with this purpose in mind.

   Shoreline and land use planning should be informed by regional and sub-regional level considerations. Shoreline dynamics must be understood within the context of discrete littoral cells and other natural systems. In addition, geography, development patterns, and tectonic forces differ a great deal regionally; and the success of alternatives to respond to the challenges of sea level rise and coastal hazards will depend, in large part, on these regional differences. In addition, numerous strategies when implemented may have consequences for neighboring habitats or communities, and coastal communities should have the ability to jointly plan for impacts to the full region to reduce mutually unbeneficial approaches. Developing regional information and understanding regional consequences of various adaptation options will be useful to location governments as they update individual local coastal plans or general plans within a region.

d. **Local Government Guidance** – All relevant state agencies should collaborate with local jurisdictions to encourage them to consider the following strategies when updating plans:
    i. **Setbacks –** Mandatory construction setbacks can be imposed to prohibit construction and significant redevelopment in areas that will likely be impacted by sea-level rise within the life of the structure.
    ii. **Additional Buffer Areas** – Additional buffer areas can be established in some places to protect important cultural and natural resource assets.
    iii. **Clustered Coastal Development –** Coastal development can be concentrated in areas of low vulnerability and may reduce carbon emissions from transportation.
    iv. **Rebuilding Restrictions** – Rebuilding can be restricted when structures are damaged by sea-level rise and coastal storms.
    v. **New Development Techniques** – Building codes can be amended to require that coastal development incorporate features that are resilient to sea-level rise (e.g., require that development begin on the second floor).
    vi. **Relocation Incentives** – Federal, state and local funding or tax incentives to relocate out of hazard areas.
    vii. **Rolling Easements** – Policies and funding to facilitate easements to a) relocate developments further inland, b) remove development as hazards encroach into developed areas, or c) facilitate landward movement of coastal ecosystems subject to dislocation by sea-level rise and other climate change impacts.
    viii. **Engineering Solutions** – New engineering approaches will need to be applied to ports, marinas and other infrastructure that must be located on the shoreline to maintain their function as the sea level rises.

    The Governor's Office of Planning and Research will provide a guidance document in 2009 to address state land use planning.

e. **Amend Local Coastal Plans and General Plans to Address Climate Change Adaptation:** By 2011, or within one year after development of the tools or guidance necessary to support such amendments and if funding is secured, all coastal jurisdictions, in coordination with the Coastal Commission, should begin to develop amended LCPs that include climate change impacts; and local jurisdictions around San Francisco Bay should begin to update their general plans, in coordination with BCDC.

Strategy 5: Complete a Statewide Sea-Level Rise Vulnerability Assessment Every Five Years

Long -Term Actions:

a. **Vulnerability Assessment** – In coordination with all relevant state agencies, OPC should produce a coastal and ocean vulnerability assessment every five years that consolidates and builds upon existing efforts by the California Energy Commission and other agencies. Each new assessment will discuss the most recent knowledge about climate impacts to ocean and coastal resources, inventory coastal natural and man-made assets, and assess what is at risk (including an economic valuation). The data from these assessments should be periodically incorporated into state agency adaptation plan updates (discussed above, 3b).

Strategy 6: Support Essential Data Collection and Information Sharing

Research and data are needed to perform and update vulnerability assessments. Agencies should work in cooperation with federal partners to seek funding for the collection of essential data. The state should continue to establish baseline climate change data and common modeling assumptions so that planning actions in the different agencies are based on common information to the greatest extent possible.

Near -Term Actions:

a. **High-Resolution Mapping** – The state, in cooperation with federal partners, should immediately fund the collection of high-resolution topography and bathymetry mapping (i.e., LiDAR) to provide elevation information needed as a baseline for monitoring change, for the modeling of flood hazards, and to help identify and document habitats and ecosystems.

b. **Tidal Datum** – Monitoring on tidal datums should be maintained and expanded, including establishing additional tide gage stations. Tidal datums are used to measure local water levels and can project how global sea-level rise will be experienced at the local scale. These data are needed to determine the mean high tide and other reference points used in regulatory and legal settings.

c. **Ecosystem Research** – Research should be conducted on potential changes to ocean and coastal ecosystems, and species ranges, which are already changing - resulting in divergence in breeding and feeding behavior. Understanding ecosystem changes will be essential to future management decisions related to fisheries, species protection, and restoration projects.

d. **Coastal and Wetland Process Studies** – Research should be conducted to understand and model coastal, estuarine, and wetland circulation and sediment distribution and transport. This information is essential to successful wetland and beach maintenance, restoration, and nourishment projects.

Long -Term Actions:

e. **Decision Support** – The OPC should work with state ocean resource agencies and other appropriate partners (such as academia and nongovernmental organizations) to help provide the necessary data and tools to state and local agencies for decision support to protect development and habitat from sea-level rise.

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CALIFORNIA COASTAL COMMISSION SEA LEVEL RISE POLICY GUIDANCE

Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits

Sunset Beach, Photo by Mario Fernandez

Chula Vista, Photo by Lisa Cox

San Francisco, Photo by Mike Baird

Arcata, Photo by Humboldt Baykeeper

PUBLIC REVIEW DRAFT – MAY 27, 2015

SUMMARY OF DOCUMENT REVISIONS

A Draft version of this *Sea Level Rise Policy Guidance* was released for public review on October 14, 2013. The public comment period was open for 120 days, until February 14, 2014. During that time, the Commission received over 100 comment letters that broke down into over 800 distinct comments. Since the close of the public comment period, Commission staff responded to each comment and incorporated the feedback into this Revised Draft. A document containing all comments and responses is available on the Commission's website. Many alterations were made to the Draft Guidance, and the most significant include:

- A new section on using scenario-based analysis to approach sea level rise planning
- A new section on storms, extreme events, abrupt change, and sea level rise
- A new section on sea level rise adaptation planning and environmental justice
- A revised chapter on sea level rise adaptation strategies, including additional strategies
- A new chapter on the legal context of adaptation planning

These revisions were coordinated with other California state efforts related to climate change and adaptation, including the 2014 *Safeguarding California* document (CNRA 2014). This Revised Draft reflects the broad concepts and strategies in *Safeguarding California* — particularly the Coast and Oceans chapter — and complements it by providing information more specific to the Coastal Act, including Local Coastal Programs and Coastal Development Permits.

The Revised Draft will be considered by the Coastal Commission in a public hearing in Summer 2015.

How to Use this Document

This document is:	This document is NOT:
Guidance	**Regulations**
This Guidance is advisory and not a regulatory document or legal standard of review for the actions that the Commission or local governments may take under the Coastal Act. Such actions are subject to the applicable requirements of the Coastal Act, the federal Coastal Zone Management Act, certified Local Coastal Programs, and other applicable laws and regulations as applied in the context of the evidence in the record for that action.	
Dynamic	**Static**
This Guidance will be updated periodically to address new sea level rise science, information, and approaches regarding sea level rise adaptation, and new legal precedent. The Commission will also continue working on sea level rise through other projects and in a collaborative manner, as outlined in Chapter 9: Next Steps.	
Multi-purpose for multiple audiences	**Meant to be read cover-to-cover**
This Guidance is a comprehensive, multi-purpose resource and it is intended to be useful for many audiences. As such, it includes a high level of detail on many subjects. However, chapters were written as stand-alone documents to provide usable tools for readers.	
A menu of options	**A checklist**
Since this document is intended for use statewide, it is not specific to a particular geographic location or development intensity (e.g., urban or rural locations).Therefore, not all of the content will be applicable to all users, and readers should view the content as a menu of options to use only if relevant, rather than a checklist of required actions.	

Reading Tips

- Look carefully at the Table of Contents and identify sections of interest.
- Do not expect all of the content to apply to your particular situation. As a statewide document, a wide variety of information is included to address the concerns of various users.
- Navigate to your desired level of detail: The *Executive Summary* provides a basic summary of the content; the body of the document provides a detailed discussion; and the *Appendices* provide more scientific and technical detail and a variety of useful resources.

TABLE OF CONTENTS

List of Figures

List of Tables

Commonly Used Acronyms and Agency Names

Terms:

CCT – California Coastal Trail

CDP – Coastal Development Permit

CoSMoS – Coastal Storm Modeling System

ENSO – El Niño Southern Oscillation

ESHA – Environmentally Sensitive Habitat Area

GHG – Greenhouse gas

IPCC – Intergovernmental Panel on Climate Change

LCP – Local Coastal Program

LUP – Land Use Plan

NRC Report – National Research Council Report "*Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future*"

PDO – Pacific Decadal Oscillation

SLR – Sea level rise

TNC – The Nature Conservancy

Agency Names:

BCDC – San Francisco Bay Conservation and Development Commission

BOEM – Bureau of Ocean Energy Management

BSEE – Bureau of Safety and Environmental Enforcement

Cal OES – California Governor's Office of Emergency Services

Caltrans – California Department of Transportation

CCC/Commission – California Coastal Commission

CDFW – California Department of Fish and Wildlife

CNRA – California Natural Resources Agency

CO-CAT – Coast and Oceans Climate Action Team

Conservancy – California State Coastal Conservancy

EPA – Environmental Protection Agency

FEMA – Federal Emergency Management Agency

NERR – National Estuarine Research Reserve

NMS – National Marine Sanctuary

NOAA – National Oceanic and Atmospheric Administration

NPS – National Park Service

OPC – California Ocean Protection Council

OPR – California Governor's Office of Planning and Research

State Lands – California State Lands Commission

State Parks – California Department of Parks and Recreation

SWRCB – State Water Resources Control Board

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Executive Summary

Climate change is upon us, affecting almost every facet of California's natural and built environment. Increasing global temperatures are causing significant effects at global, regional, and local scales. In the past century, average global temperature has increased by about 0.8°C (1.4°F), and average global sea level has increased by 7 to 8 in (17 to 21 cm) (IPCC 2013). Sea level at the San Francisco tide gauge has risen 8 in (20 cm) over the past century, and the National Research Council (NRC) projects that by Year 2100, sea level in California may rise by 4 to 56 in (10 to 143 cm) for areas north of Cape Mendocino and 17 to 66 in (42 to 167 cm) for areas south of Cape Mendocino (NRC 2012). While the California coast regularly experiences erosion, flooding, and significant storm events, sea level rise will exacerbate these natural forces, leading to significant social, environmental, and economic impacts. The third National Climate Assessment notes that there is strong evidence showing that the cost of doing nothing to prepare for the impacts of sea level rise exceeds the costs associated with adapting to them by about 4 to 10 times (Moser *et al*. 2014). Therefore, it is critically important that California plan and prepare for the impacts of sea level rise to ensure a resilient California coast for present and future generations.

The California Coastal Act is one of the state's primary coastal management laws for addressing land use, public access and recreation, and the protection of coast and ocean resources in the coastal zone. It is also the primary coastal hazards law governing development along the coast. Using the Coastal Act, the Coastal Commission and local governments have more than four decades of experience managing coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion as well as responses to these hazards such as armoring. However, sea level rise and the changing climate present management challenges of a new magnitude, with the potential to significantly threaten many coastal resources, including shoreline development, coastal beach access and recreation, habitats, agricultural lands, cultural resources, and scenic resources, all of which are subject to specific protections and regulations in the Coastal Act. Therefore, effective implementation of the Coastal Act and the protection of California's coast must address global sea level rise and the greater management challenges it will bring.

This document focuses specifically on how to apply the Coastal Act to the challenges presented by sea level rise through Local Coastal Program (LCP) certifications and updates and Coastal Development Permit (CDP) decisions. It organizes current science, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local level. While the document is intended to guide LCP planning and development decisions to ensure effective coastal management actions, it is advisory and does not alter or supersede existing legal requirements, such as the policies of the Coastal Act and certified LCPs. However, one of the Commission's priority goals is to coordinate with local governments to complete and update LCPs in a manner that adequately addresses sea level rise and reflects the recommendations in this Guidance.

This Guidance document is also part of a larger statewide strategy to respond to climate change that includes both emissions reductions and adaption planning to address the impacts of a changing climate. In 2008, Governor Schwarzenegger issued an Executive Order (S-13-08) directing state agencies to consider sea level rise as part of planning projects and to support the preparation of the National Research Council report on sea level rise. Additionally, on April 29, 2015, Governor Brown issued an Executive Order (B-30-15) to establish a new greenhouse gas emission reduction target and called for further action on adaptation. This guidance is also being coordinated with many statewide initiatives to address climate change and sea level rise, including the 2014 *Safeguarding California* plan (an update to the 2009 *California Adaptation Strategy*; CNRA 2009, 2014), the ongoing update to the *General Plan Guidelines* (Cal OPR 2015), the 2013 update to the California Governor's Office of Emergency Services' (Cal OES) *State Hazard Mitigation Plan*, and others.[1] Commission staff has also been and will continue to participate in multi-agency partnerships, including the Coast and Ocean Workgroup of the multi-state agency Climate Action Team and the *State Coastal Leadership Group on Sea-Level Rise*. For more detail on these efforts, see the Introduction.

PRINCIPLES FOR ADDRESSING SEA LEVEL RISE IN THE COASTAL ZONE

This guidance is rooted in certain fundamental guiding principles, many of which derive directly from the requirements of the Coastal Act. These Guiding Principles are summarized below.

Use Science to Guide Decisions [Coastal Act Sections 30006.5; 30335.5]

1. Acknowledge and address sea level rise as necessary in planning and permitting decisions.
2. Use the best available science to determine locally relevant and context-specific sea level rise projections for all stages of planning, project design, and permitting reviews.
3. Recognize scientific uncertainty by using scenario planning and adaptive management techniques.
4. Use a precautionary approach by planning and providing adaptive capacity for the highest amounts of possible sea level rise.
5. Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.

Minimize Coastal Hazards through Planning and Development Standards [Coastal Act Sections 30253, 30235; 30001, 30001.5]

6. Avoid significant coastal hazard risks to new development where feasible.
7. Minimize hazard risks to new development over the life of authorized structures.
8. Minimize coastal hazard risks and resource impacts when making redevelopment decisions.
9. Account for the social and economic needs of the people of the state; assure priority for coastal-dependent and coastal-related development over other development.
10. Ensure that property owners understand and assume the risks, and mitigate the coastal resource impacts, of new development in hazardous areas.

[1] See the Governor's Office of Planning and Research's webpage for the California Climate Change Document, which includes a matrix of additional efforts. Available at: http://opr.ca.gov/s_publications.php

Maximize Protection of Public Access, Recreation, and Sensitive Coastal Resources [Coastal Act Chapter 3 policies]

11. Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.
12. Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.
13. Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.
14. Address other potential coastal resource impacts (wetlands, habitat, agriculture, scenic, *etc.*) from hazard management decisions, consistent with the Coastal Act.
15. Address the cumulative impacts and regional contexts of planning and permitting decisions.
16. Require full mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.
17. Consider best available information on resource valuation when mitigating coastal resource impacts.

Maximize Agency Coordination and Public Participation [Coastal Act Chapter 5 policies; Sections 30006; 30320; 30339; 30500; 30503; 30711]

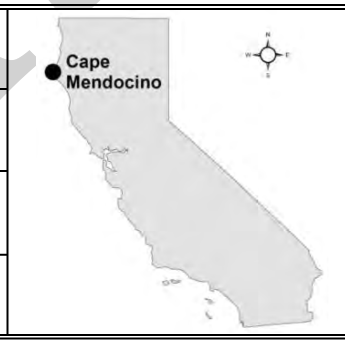
18. Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.
19. Consider conducting vulnerability assessments and adaptation planning at the regional level.
20. Provide for maximum public participation in planning and regulatory processes.

Best Available Science and Consequences of Sea Level Rise

The Coastal Act directs the Coastal Commission and local governments to use the best available science in coastal land use planning and development. This Guidance recommends using the best available science on sea level rise projections to inform planning decisions and project design. The State of California supported the preparation of the 2012 National Research Council's Report, *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past Present and Future*, which is currently considered the best available science on sea level rise for California. The report contains sea level rise projections for three time periods over the coming century for north and south of Cape Mendocino (Table 1).[2,3]

In addition to these sea level rise projections, the 2012 NRC report provides information on the impacts of sea level rise in California. According to the report, sea level rise will cause flooding and inundation, increased coastal erosion, changes in sediment supply and movement, and saltwater intrusion to varying degrees along the California coast. These effects in turn could have a significant impact on the coastal economy and could put important coastal resources and coastal development at risk, including ports, marine terminals, commercial fishing infrastructure, public access, recreation, wetlands and other coastal habitats, water quality, biological productivity in coastal waters, coastal agriculture, and archaeological and paleontological resources.

Table 1. Sea Level Rise Projections for California (NRC 2012)

TIME PERIOD*	NORTH OF CAPE MENDOCINO	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

2 The NRC Committee divided the Pacific coast for California, Oregon and Washington into two regions, north and south of Cape Mendocino, due to differences in tectonics that occur at this point. North of Cape Mendocino, land is rising by 1.5 to 3.0 mm/yr as ocean plates descend below the North American plate at the Cascadia Subduction Zone. South of Cape Mendocino, the coast is sinking at an average rate of about 1 mm/yr, although local rates vary widely (NRC 2012, p. 3). Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary. Please see *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.

3 Any future updates to the state guidance document will be available at http://www.opc.ca.gov/2009/12/climate-change/.

ADDRESSING SEA LEVEL RISE IN LOCAL COASTAL PROGRAMS

This document provides a step-by-step process for addressing sea level rise and adaptation planning in new and updated Local Coastal Programs. These Steps, summarized below in text and in Figure 1, can be tailored to fit the needs of individual communities and to address the specific coastal resource and development issues of a community, such as dealing with bluff erosion or providing for effective redevelopment, urban infill, and concentration of development in already developed areas. Ideally, Commission and local government staff will establish regular coordination and work together in the early steps of any LCP planning process. For a detailed explanation of these LCP planning Steps, see Chapter 5. Communities in areas where sea level rise vulnerability assessment work is already underway can start later in the process, at Step 4, or other relevant Step(s).

Step 1. **Determine a range of sea level rise projections relevant to LCP planning area/segment** using best-available science, which is currently the 2012 NRC Report.

Step 2. **Identify potential physical sea level rise impacts in the LCP planning area/segment**, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.

Step 3. **Assess potential risks from sea level rise to coastal resources and development in the LCP planning area/segment,** including those resources addressed in Chapter 3 of the Coastal Act.

Step 4. **Identify adaptation measures and LCP policy options** to include in the new or updated LCP, including both general policies and ordinances that apply to all development exposed to sea level rise, and more targeted policies and land use changes to address specific risks in particular portions of the planning area.

Step 5. **Draft updated or new LCP for certification with California Coastal Commission**, including the Land Use Plan and Implementing Ordinances.

Step 6. **Implement the LCP and monitor and re-evaluate strategies as needed** to address new circumstances relevant to the area.

Planning Process for Local Coastal Programs and Other Plans

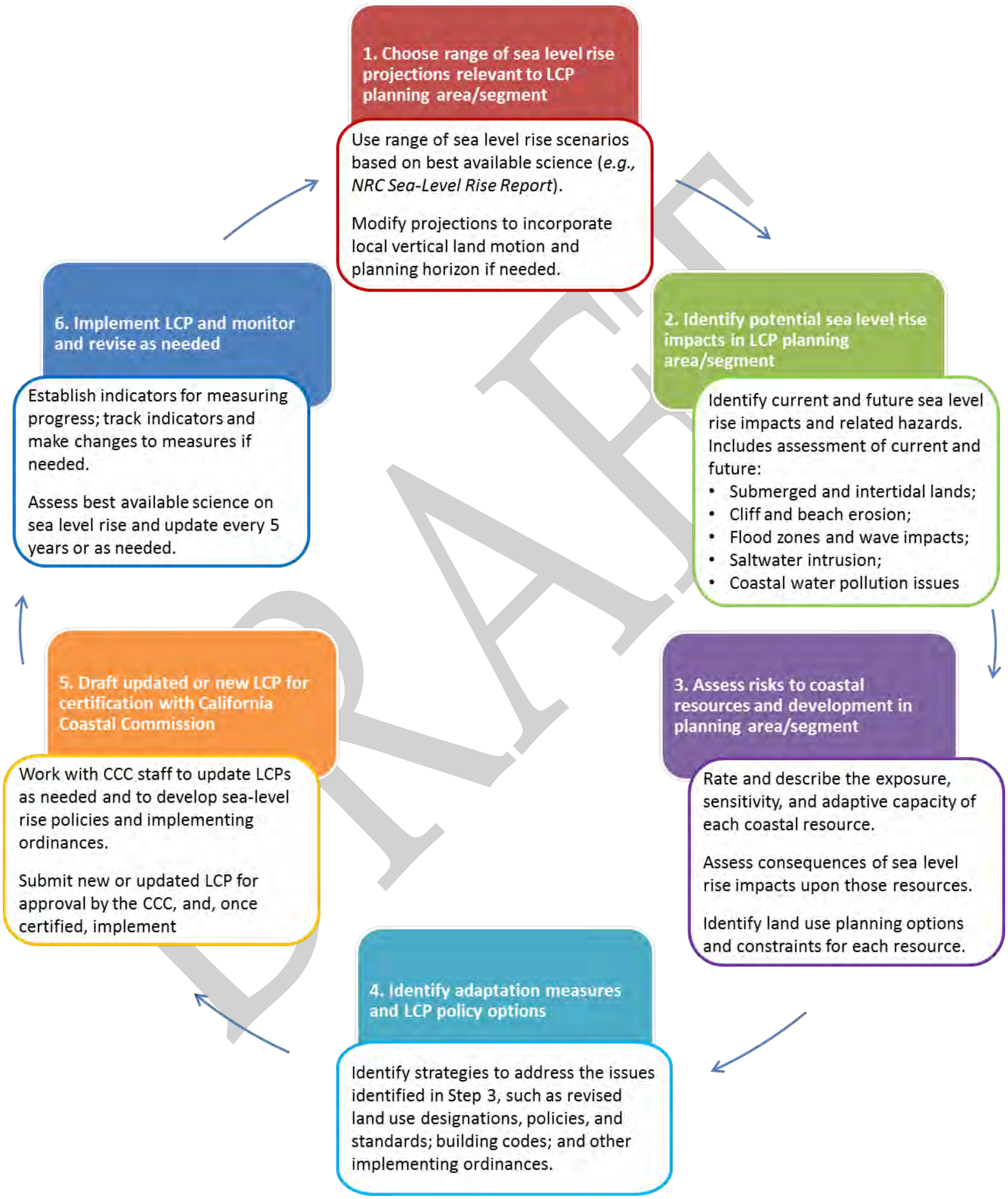


Figure 1. Flowchart for addressing sea level rise in Local Coastal Programs and other plans

ADDRESSING SEA LEVEL RISE IN COASTAL DEVELOPMENT PERMITS

New development within the coastal zone generally requires a Coastal Development Permit (CDP). Many projects reviewed through the CDP application process already examine sea level rise impacts as part of the hazards analysis, though not every CDP application will need to consider sea level rise. In general, sea level rise is only likely to affect those projects that are on low-lying land, on eroding coastal bluffs, are in close proximity to water, or rely upon a shallow aquifer for water supply. This document offers a step-by-step outline, summarized below in text and in Figure 2, for how to conduct such an analysis as a standard part of the CDP application process. The goal of these Steps is to ensure careful attention to minimizing risk to development and avoiding impacts to coastal resources over the life of the project. Early coordination with the Coastal Commission staff is highly recommended, and staff will be available to consult with applicants during this process. Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where a closer review of sea level rise concerns is necessary. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate. For a detailed explanation of these steps, see Chapter 6 of this Guidance.

Step 1. **Establish the projected sea level rise range for the proposed project**'s planning horizon using the best available science, which is currently the 2012 NRC Report.

Step 2. **Determine how physical impacts from sea level rise may constrain the project site,** including erosion, structural and geologic stability, flooding, and inundation.

Step 3. **Determine how the project may impact coastal resources, considering the influence of future sea level rise upon the landscape** as well as potential impacts of sea level rise adaptation strategies that may be used over the lifetime of the project.

Step 4. **Identify alternatives to avoid resource impacts and minimize risks** throughout the expected life of the development.

Step 5. **Finalize project design and submit CDP application.**

Planning Process for Coastal Development Permits

1. Establish the projected sea level rise range for the proposed project

- Determine time period of concern using expected project life.
- Use range of sea level rise scenarios based on best available science (*e.g., NRC Sea-Level Rise Report*).
- Modify projections to incorporate local vertical land motion and planning horizon if needed.

2. Determine how sea level rise impacts may constrain the project site

Using locally-relevant sea level rise projections, determine site- or project-specific hazards or impacts for the time period of concern, including current and future hazard impacts. Consider:

- Geologic Stability and Erosion
- Flooding and Inundation
- Wave Impacts
- Other Impacts

3. Determine how the project may impact coastal resources over time, considering sea level rise

Determine how the project may impact coastal resources (below) considering how sea level rise may alter the resources over the expected lifetime of the project.

- Public Access and Recreation
- Coastal Habitats
- Agriculture
- Water Quality
- Archaeological/Paleontological resources
- Scenic Resources

4. Identify project alternatives to both avoid resource impacts and minimize risks to the project

- Ideally, locate the project in a site that avoids conflicts with natural resources and sea level impacts
- Alternatively, minimize the likelihood that the project will come into contact with hazards, and design an adaptation strategy for unavoidable impacts.
- Modify project if impacts cannot be avoided
- Summarize these alternatives

5. Finalize project design and submit permit application

Complete the CDP application. Submit the application. Receive permit action. Monitor and revise project as needed.

Figure 2. Flowchart for addressing sea level rise in Coastal Development Permits

ADAPTATION STRATEGIES

Steps 1 through 3 of the processes for addressing sea level rise in LCPs and CDPs will help planners and project applicants identify particular vulnerabilities to the planning region and specific project sites. Such vulnerabilities may include impacts to a number of resources identified in the Coastal Act, including development and infrastructure; public access and recreational opportunities; beaches, wetlands, environmentally sensitive habitat areas (ESHA), and other coastal habitats; agricultural resources; water quality; archaeological and paleontological resources; and scenic and visual resources. Planners and project applicants will need to identify, develop, and implement various adaptation strategies designed to protect coastal resources. These strategies should fulfill the hazard minimization and resource impact avoidance policies of the Coastal Act and should account for local conditions. In many cases, strategies will need to be implemented incrementally as conditions change, and planners, project applicants, and partners will need to think creatively and adaptively to ensure that coastal resources and development are protected over time. Chapter 7 of this Guidance summarizes a number of strategies to protect different coastal resources and meet the goals and requirements of the Coastal Act.

ADDITIONAL INFORMATION

In addition to providing a summary of best available science on sea level rise, step-by-step approaches for addressing sea level rise in LCPs and CDPs, and a discussion of numerous adaptation strategies, the Guidance includes the following supplemental information:

- A brief discussion of the legal context of adaptation
- Next steps for Commission staff in coordination with other relevant partners and research institutions, based on objectives and actions from the Commission adopted *California Coastal Commission Strategic Plan 2013-2018* (2013a)
- Additional research needs directed toward research institutions at academic, state, federal, and local levels to help communities understand and prepare for sea level rise
- Detailed information on the drivers of sea level rise and sea level rise projections
- A step-by-step methodology for assessing local hazard conditions based on regional sea level rise projections, which is applicable to both LCPs and CDPs
- Lists of useful resources and references, including examples of sea level rise adaptation documents from other state agencies
- Key Coastal Act policies relevant to sea level rise and coastal hazards

CONTEXT OF THIS DOCUMENT

This Guidance is part of a larger body of work on climate change by State agencies, regional collaborations, local leadership, academic research, and other organizations. Many of these efforts are included as resources in Appendix C. Users of the document should take advantage of these existing resources, collaborate with others, and share best practices as much as possible.

Finally, this document is intended to function as interpretive guidance for effective implementation of the Coastal Act and LCPs in light of sea level rise. It is not a regulatory document and does not contain any new regulations. Further, it does not amend or supersede existing legal authorities or the standard of review for Local Coastal Programs and coastal development permit decisions pursuant to the Coastal Act. Those actions are subject to the applicable requirements of the Coastal Act, the Coastal Zone Management Act, certified LCPs, and other applicable laws and regulations as applied in the context of the evidence in the records for those actions. The Commission is adopting this Guidance as interpretive guidelines pursuant to its authority under Public Resources Code Sections 30620.

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Chapter 1

Introduction

Climate change is happening now. Rapidly melting ice caps, rising sea levels, floods, extreme heat waves, droughts, and fires are just a few of the effects of climate change. These effects are having profound impacts on our coast and are changing coastal management planning and decision making at global, national, state, regional, local, and individual scales.

Given current trends in greenhouse gas emissions, sea levels are expected to rise at an accelerating rate in the future, and scientists project an increase in California's sea level in coming decades. Until mid-century, the most damaging events for the California coast will likely be dominated by large El Niño-driven storm events in combination with high tides and large waves. Eventually, sea level will rise enough that even small storms will cause significant damage, and large events will have unprecedented consequences (Caldwell *et al*. 2013).

This Guidance provides a framework for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). The intended audience for this document includes the Commission and Commission staff, local governments, other public agencies, permit applicants, members of the public, and others who are interested in how to implement and comply with the California Coastal Act (Coastal Act) while taking steps to address sea level rise.

ENVIRONMENTAL, ECONOMIC, AND SOCIAL IMPACTS OF SEA LEVEL RISE

The potential environmental, economic, and social impacts of sea level rise in California underscore the importance of addressing the issue in land use planning and regulatory work. Just over 21 million people lived in California's coastal counties as of July 2014 (CDF 2014), and the state supports a $40 billion coastal and ocean economy (NOEP 2010).

Many aspects of the coastal economy, as well as California's broader economy, are at risk from sea level rise, including coastal-related tourism, beach and ocean recreational activities, transfer of goods and services through ports and transportation networks, coastal agriculture, and commercial fishing and aquaculture facilities.

In addition to potential losses in revenue, Herberger *et al.* (2009) estimate that $100 billion worth of property is at risk of flooding during a 100-year flood with 4.6 ft (1.4 m) of sea level rise (the amount projected to occur by the year 2100 in their Pacific Institute study). This property includes seven wastewater treatment plants, commercial fishery facilities, marine terminals, Coastal Highway One, 14 power plants, residential homes, and other important development and infrastructure.

Sea level rise also poses environmental and social justice challenges. This is particularly true for communities that may be dependent upon at-risk industries, are already suffering from economic hardship, or which have limited capacity to adapt, including lower-income, linguistically isolated, elderly, and other vulnerable populations.

Proactive steps are needed to prepare for sea level rise and to protect the coastal economy, California livelihoods, and coastal resources and the ecosystem services they provide. The magnitude of the challenge is clear – not only might the impacts of sea level rise be severe, the costs and time associated with planning for them can be daunting. The third National Climate Assessment, released in May 2014, notes that there is strong evidence to suggest that the costs of inaction are 4 to 10 times greater than the costs associated with proactive adaptation and hazard mitigation (Moser *et al*. 2014). It is critical for California to take proactive steps to address the impacts sea level rise may have on the state's economy, natural systems, built environment, human health, and ultimately, its way of life.

SEA LEVEL RISE AND THE CALIFORNIA COASTAL ACT

The potential impacts of sea level rise fall directly within the Coastal Commission's (and coastal zone local governments') planning and regulatory responsibilities under the Coastal Act. Sea level rise increases the risk of flooding, coastal erosion, and saltwater intrusion into freshwater supplies, which have the potential to threaten many of the resources[4] that are integral to the California coast, including coastal development, coastal access and recreation, habitats (*e.g.*, wetlands, coastal bluffs, dunes, and beaches), coastal agricultural lands, water quality and supply, cultural resources, community character, and scenic quality. In addition, many possible responses to sea level rise, such as construction of barriers or armoring, can have adverse impacts on coastal resources. For example, beaches, wetlands, and other habitat backed by fixed or permanent development will not be able to migrate inland as sea level rises, and will become permanently inundated over time, which in turn presents serious concerns for future public access and habitat protection.

The Coastal Act mandates the protection of public access and recreation along the coast, coastal habitats, and other sensitive resources, as well as providing priority visitor-serving and coastal-dependent or coastal-related development while simultaneously minimizing risks from coastal hazards. This guidance document has been created to help planners, project applicants, and other interested parties continue to achieve these goals in the face of sea level rise by addressing its effects in Local Coastal Programs and Coastal Development Permits.

Coastal Commission reports and briefings on sea level rise: Sea level rise is not a new concern for the Commission. The Coastal Act policies on hazard avoidance and coastal resource protection provide the basis for the Commission to consider the impacts of sea level rise (see *Appendix F: Coastal Act Policies Relevant to Sea Level Rise and Coastal Hazards*), and the Commission has long considered sea level rise, erosion rates, and other effects of a dynamic climate in its analysis of permits and LCPs, staff recommendations, and Commission decisions. In 1992, Section 30006.5 was added to the Coastal Act which, among other things, directs the Commission to both develop its own expertise and interact with the scientific community on various technical issues, including coastal erosion and sea level rise. The Commission's staff also coordinates its work on sea level rise with other state and federal agencies, local governments, academic institutions, non-profit organizations, citizen groups, permit applicants, property owners, and others.

[4] The term "coastal resources" is used throughout this Guidance and is meant to be a general term for those resources addressed in Chapter 3 of the California Coastal Act including but not limited to beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

The Commission has documented its sea level rise adaptation and climate change efforts in numerous papers and briefings, including:

- 1989 Report: *Planning for Accelerated Sea Level Rise along the California Coast*
- 2001 Report: *Overview of Sea Level Rise and Some Implications for Coastal California*
- 2006 Briefing: *Discussion Draft: Global Warming and the California Coastal Commission*
- 2008 Briefing: *A Summary of the Coastal Commission's Involvement in Climate Change and Global Warming Issues for a Briefing to the Coastal Commission*
- 2008 White paper: *Climate Change and Research Considerations*
- 2010 Briefing: *A Summary of the Coastal Commission's Involvement in Sea Level Rise Issues for a Briefing to the Coastal Commission*[5]

THE IMPORTANCE OF ADDRESSING SEA LEVEL RISE IN LOCAL COASTAL PROGRAMS

The impacts of sea level rise will be felt at the local level, and therefore local responses will necessarily be part of effective management of these impacts. Fortunately, the California Coastal Act lays out a legal and planning framework for community climate preparedness and resiliency planning. LCPs, in combination with Coastal Development Permits (CDPs), provide the implementing mechanisms for addressing many aspects of climate change within coastal communities at the local level.

The goal of updating or developing a new LCP to prepare for sea level rise is to ensure that adaptation occurs in a way that protects both coastal resources and public safety and allows for sustainable economic growth. This process includes identifying how and where to apply different adaptation mechanisms based on Coastal Act requirements, acceptable levels of risk, and community priorities. LCP and Coastal Act policies are also reflected in CDPs, which implement sea level rise management measures and adaptation strategies through individual development decisions. By planning ahead, communities can reduce the risk of costly damage from coastal hazards, can ensure the coastal economy continues to thrive, and can protect coastal habitats, public access and recreation, and other coastal resources for current and future generations.

The Coastal Commission has made it a priority to support the update of LCPs to address climate change, as demonstrated by Goal 3 of the Commission's *Strategic Plan* (CCC 2013a), which is to "address climate change through LCP planning, coastal permitting, inter-agency collaboration, and public education." Specifically, Objective 3.1.1 directs the Commission to "adopt general sea level rise (SLR) policy guidance for use in coastal permitting and LCP planning and amendment based on best available science, including the final report from the National Research Council (NRC) of the National Academy of Science entitled, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future* (released June 2012)."

[5] Verbal presentation to the Coastal Commission on December 17, 2010 by Susan Hansch (Item 4.5). This presentation can be viewed at the Cal-Span website (<http://www.cal-span.org/media.php?folder[]=CCC>) from approximately minute 22.00 to 24:30.

This guidance document fulfills Objective 3.1.1 and is one of multiple ongoing Commission efforts to support local governments in updating LCPs to address sea level rise.

Funding for LCP updates: Both the *California Climate Adaptation Strategy* (CNRA 2009) and the *Safeguarding California* plan (CNRA 2014) identified amendments to LCPs as a key strategy for addressing sea level rise in California. However, there are significant funding constraints at both the Commission and local government levels that limit the capacity to update LCPs. Fortunately, three grant programs have recently been funded to support California local governments in updating LCPs to address sea level rise. These grant programs have partially overlapping objectives, as described below. Grant-related information as of the publication of this Guidance is summarized below. For up-to-date information regarding grants, please visit the Local Assistance Grant Program page on the Coastal Commission website.

- **Coastal Commission LCP Local Assistance Grant Program:** For fiscal years 2013/2014 and 2014/2015, the Coastal Commission received $1 million per year ($2 million total) in grant funds through a budget augmentation approved by Governor Brown and the California Legislature. The grant program provides funding to local governments to complete the certification of new and updated LCPs, with an emphasis on addressing impacts from sea level rise and climate change. In January 2014, the Coastal Commission awarded $1 million in LCP Grant funds to 11 jurisdictions throughout the state, with awards ranging from $29,000 to $130,000. In November 2014, the Coastal Commission awarded $1 million to 12 jurisdictions, with awards ranging from $13,000 to $250,000. This second round of funding was coordinated through a joint application and review process with the OPC LCP SLR Grant program (below) in order to maximize funding opportunities.

- **Ocean Protection Council LCP Sea Level Rise Grant Program:** The OPC grant program includes $2.5 million to support local governments in updating LCPs to address sea level rise, including support of sea level rise modeling, vulnerability assessments, and adaptation planning and policy development. The OPC is administering the program in partnership with the Coastal Commission and the Coastal Conservancy. In November 2013, the OPC awarded $1,305,000 to seven jurisdictions based on recommendations from the three coordinating agencies. The remaining funds were awarded in the second round of the grant program in December 2014. Seven jurisdictions received funding ranging from $90,000 to $200,000. This second round of funding was coordinated through a joint application and review process with the Coastal Commission Grant Program, as described above.

- **State Coastal Conservancy Climate Ready Grant Program:** The Climate Ready Grant Program provides funding for climate change-related projects including projects to update LCPs to address sea level rise. The Conservancy awarded $3 million in January 2014, and awarded an additional $2.4 million for a second round of grants in January 2015. The second round focuses on implementation of coastal climate change adaptation projects. A third round of grant applications is currently being reviewed. These grant funds are available to both local governments and non-governmental organizations.

Coastal Commission Staffing Increase to Support LCP planning: Governor Brown and the California Legislature also approved an augmentation to the Coastal Commission's FY 2013/2014 budget of $4 million ($3 million for state operations and $1 million for grants to local governments) for local governments and the Coastal Commission to prepare, update, amend, and review LCPs with an emphasis on including climate change issues.

The Governor's Budget for FY 2015/2016 implements the Spring Finance Letter issued April 1, 2014 that was approved as part of the FY 2014/2015 Enacted Budget. The Spring Finance Letter (April 1, 2014), added two additional years (FY 14/15 and FY 15/16) of state operations funding of $3 million for 25 limited term positions and operating expenses to the Coastal Commission's enacted budget for FY 14/15. For FY 14/15, the approved LCP staff funding is coming from $1 million in carryover General Fund and $2 million from the Coastal Act Services Fund (CASF) (3123). For FY 15/16 the Governor's Budget proposes the LCP staff funding to come from $1 million in Environmental License Plate Funds (ELPF) and $2 million from the Coastal Act Services Fund.

The Coastal Act Services Fund holds the filing and permit fees that the Coastal Commission receives from applicants for regulatory actions (*e.g.,* development application fees). Because of the current reserve in the Coastal Act Services Fund, there are adequate resources to fund appropriation of $2 million for FY 14/15 and FY 15/16.

To extend the augmented LCP staff funding after FY 15/16, the Commission will need to submit a Budget Change Proposal in September 2015 for requested funding for FY 16/17 and thereafter.

Coastal Resiliency and Preparing for Sea Level Rise: the Federal and State Context

Sea level rise planning efforts are currently taking place at the local, regional, state, and national levels. Framing the efforts in California is a federal strategy to address climate change by both reducing greenhouse gas emissions and adapting to climate change impacts. Recent efforts promoted by the White House include President Obama's January 2015 Executive Order 13960, which modifies Executive Order 11988, Floodplain Management, by expanding the federal approach for establishing flood risk to include the consideration of climate change. Specifically, it recommends using a new flood standard that accounts for climate change in establishing flood elevation and hazard areas when federal funds are used to build, significantly retrofit, or repair structures.

Additionally, Governor Brown, Supervisor Carbajal (Santa Barbara County), Mayor Garcetti (Los Angeles), and Mayor Johnson (Sacramento) are on the President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, which recently released recommendations for how to modernize programs and policies to incorporate climate change.[6] The Coastal Commission's Guidance document implements many of the Task Force's recommendations by providing tools and assistance to support sea level rise decision making, by establishing a framework for state, local, and federal partnership and coordination on sea level rise, and by providing guidance on how to improve resilience of California's coastal infrastructure, natural resources, human communities, and coastal industries.

[6] http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience/taskforce

The State of California has long been a leader in preparing for sea level rise, and in 2008, Governor Schwarzenegger issued an Executive Order (S-13-08) directing state agencies to prepare guidance on sea level rise and to address sea level rise in any state projects located in vulnerable areas. Since then, state agencies have worked collaboratively to accomplish a variety of different actions related to sea level rise adaptation, many of which are listed below. Ten state and federal agencies[7] also commissioned the National Research Council's report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* (2012), to improve understanding of sea level rise projections for California.

More recently, Governor Brown's April 2015 Executive Order B-30-15 addresses climate change and sea level rise adaptation, stating that state agencies shall take climate change into account in their planning and investment decisions. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas emissions, provide flexible and adaptive approaches, protect the state's most vulnerable populations, and promote natural infrastructure solutions. Additionally, AB2516, authored by Assemblymember Gordon and approved in September 2014, established a Planning for Sea Level Rise Database that is anticipated to be available online in early 2016. The database will provide the public with an educational tool from which to learn about the actions taken by cities, counties, regions, and various public and private entities to address sea level rise.

Much of the state's climate change adaptation work has been coordinated with the *Coast and Ocean Workgroup* of the *Climate Action Team* (CO-CAT), of which the Commission is a member. In addition, Commission staff has been involved in the *State Coastal Leadership Group on Sea-Level Rise*, which was established in early 2014 to develop and implement coordinated approaches to address sea level rise across state agencies. The Partnership includes senior management from the Coastal Zone Management Agencies (Coastal Commission, San Francisco Bay Conservation and Development Commission, and State Coastal Conservancy) and land management agencies (State Lands Commission and State Parks) along with the Ocean Protection Council and Natural Resources Agency. This Guidance is being coordinated closely with this work[8] to ensure that various initiatives do not conflict and to assure an effective response to challenges such as sea level rise.

To that end, the content of this Guidance is aligned with several key concepts in the *Safeguarding California* plan, including hazard avoidance for new development, encouraging innovative designs and adaptation strategies for structures in areas vulnerable to sea level rise hazards, and addressing climate impacts in Local Coastal Programs and General Plan updates, among many others. *Safeguarding California* also calls out the need for state agencies to produce guidance documents addressing climate adaptation, and this sea level rise guidance is part of the statewide effort to fulfill that mandate. As *Safeguarding California* promotes, this Guidance will

[7] The assessment of sea level rise was commissioned by California Department of Water Resources, California Energy Commission, California Department of Transportation, California State Water Resources Control Board, California Ocean Protection Council, Oregon Watershed Enhancement Board, Washington Department of Ecology, National Oceanic and Atmospheric Administration (NOAA), US Army Corps of Engineers (USACE), and US Geological Survey (USGS).

[8] See the Governor's Office of Planning and Research's webpage for the California Climate Change Document which includes a matrix of additional efforts. Available at: http://opr.ca.gov/s_publications.php

be a living document that will be updated and revised as sea level rise science advances and new insights are gained regarding adaptation.

State agency policies and guidance on climate change and sea level rise: As a result of the Executive Order S-13-08 and agency needs for guidance, many state agencies have developed climate change and sea level rise policies and guidance documents. For example:

- The California Natural Resources Agency (CNRA) developed the 2009 *California Climate Adaptation Strategy* and the 2014 update, *Safeguarding California*
- CNRA and the Governor's Office of Emergency Services (Cal OES) collaboratively developed the *California Climate Adaptation Planning Guide* (2012)
- The Governor's Office of Planning and Research is updating its *General Plan Guidelines* to address climate change (a draft update is anticipated in 2015)
- The Ocean Protection Council established *State Sea-Level Rise Guidance* (interim, 2010, and update, 2013) and passed a *State Sea-Level Rise Resolution* (March 11, 2011)
- The San Francisco Bay Conservation and Development Commission (BCDC) amended the *San Francisco Bay Plan* (1968) to update its policies regarding sea level rise (2011) and has been working on actions to reduce vulnerability to sea level rise throughout the San Francisco Bay through the Adapting to Rising Tides (ART) project
- The California State Coastal Conservancy (Conservancy) established climate change policies, application guidelines for sea level rise, and climate ready principles (2011)
- Cal OES updated the State Multi-Hazard Mitigation Plan in 2013
- The California Department of Transportation (Caltrans) developed guidance on incorporating sea level rise into the planning and development of Project Initiation Documents (2011), and how to address adaptation in Regional Transportation Plans (2013), and has completed numerous other climate change related activities

Other agencies including the California Department of Parks and Recreation and the California State Lands Commission are in the process of developing guidance. The California Department of Fish and Wildlife, the Division of Boating and Waterways, and the Department of Water Resources are all actively addressing sea level rise and have taken steps to conduct research on sea level rise impacts, integrate sea level rise into planning documents, and educate staff on climate change impacts (see Appendix C for a description of these efforts).

Other efforts: Sea level rise planning efforts taking place at all levels of government and across numerous sectors helped inform this guidance. Commission staff reviewed scientific publications on sea level rise and climate change, adaptation guidebooks, and existing adaptation principles and best practices described in documents such as *Indicators of Climate Change in California* (Cal EPA 2013), *Adapting to Sea Level Rise: A Guide for California's Coastal Communities* (Russell and Griggs 2012), *Climate Smart Conservation: Putting Adaptation Principles into Practice* (Stein *et al.* 2014), *Ecosystem Adaptation to Climate Change in California: Nine Guiding Principles* (RLF 2012), and *Climate Smart Principles* (PRBO 2013), and applied relevant information to the Guidance where applicable and consistent with the Coastal Act.

LOOKING AHEAD: PLANNING AND PROJECT DESIGN WITH SEA LEVEL RISE

The coast has always been a place of change due to land modifications such as erosion and vertical land motion, and to water variability such as tides, waves, and storms. Despite this dynamic nature, many areas of the California coast have been developed with an expectation that there will be some permanence to the land area and site safety. Development efforts have used such techniques as setbacks, avoidance of existing floodplain areas, elevation above some base flood level, and compliance with design standards to reduce or minimize coastal risks and to ensure an acceptable level of safety.

However, hazards are rarely eliminated or avoided completely. Sea level rise will exacerbate existing hazards and reduce the period of time over which some existing development can remain relatively safe. As noted in *Governing California through Climate Change*, "The notion of stable, predictable geography in which to live, work and build permanent buildings will be off the table in decades ahead" (Little Hoover Commission 2014, p. 2). Locations that might have seemed relatively safe from erosion or flooding 20 or 30 years ago may now be shown to have greater vulnerability due to sea level rise. Sites that might have seemed safe for 80 or 100 years might now only be safe for 40 or 50 years.

As coastal change accelerates, it will become more apparent that development close to the coast cannot be treated in the same way as more inland development, where hazardous conditions may be less dynamic. Coastal dynamics have long been part of land use planning considerations and project design; however, the focus on this change will grow in importance with rising sea level. This may mean that as properties are evaluated for proposed development, the type and intensity of the proposed development may need to change to address the dynamic nature of the property and changing nature of the hazards. As coastal areas erode, the carrying capacity of the area may need to be revised. The trend of redeveloping with additions and larger structures may need to change to one of maintaining what is there or redeveloping with smaller structures that better suit site constraints. The changing expectations are an important aspect of sea level rise adaptation and are an important part of the following discussions on how to include sea level rise in Local Coastal Programs, applications for Coastal Development Permits, and adaptation planning.

Sea level rise is one of many climate change effects that will have impacts on coastal resources and development along the California coast. Accelerated coastal erosion, changing precipitation patterns, increasing temperatures, and more extreme storms will pose planning challenges in concert with sea level rise. There are other climate change impacts in the coastal zone, such as changes in water supply, terrestrial habitats, and fire hazards, that are also important to consider in decision making, and the Commission intends to provide guidance on a range of anticipated climate change impacts in the future.

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Chapter 2

Principles for Addressing Sea Level Rise in the Coastal Zone

This chapter summarizes the Coastal Commission's framing principles for addressing sea level rise, many of which derive directly from the requirements of the Coastal Act. There are four categories of principles: using science to guide decisions; minimizing coastal hazards through planning and development standards; maximizing protection of public access, recreation, and sensitive coastal resources; and maximizing agency coordination and public participation. Each category groups important and related concepts that are central to addressing the challenge of rising sea levels. Building on the cumulative knowledge and experience of the Commission, subsequent chapters of this Guidance use these principles to frame practical guidance for addressing sea level rise through planning and permitting decisions in the coastal zone, consistent with the statewide policies of the California Coastal Act as well as the statewide vision of climate resilience outlined in the 2014 *Safeguarding California* plan.

USE SCIENCE TO GUIDE DECISIONS [Coastal Act Sections 30006.5; 30335.5]

1. **Recognize and address sea level rise as necessary in planning and permitting decisions.** Address sea level rise science in all applicable coastal management and decision-making processes, including Local Coastal Programs (LCPs), Port Master Plans (PMPs), Public Works Plans (PWPs), Long Range Development Plans (LRDPs), Coastal Development Permits (CDPs), federal consistency reviews, and other Coastal Act decision processes. Sea level rise should be addressed in both hazard analyses and identification of adaptation strategies/alternative analyses, consistent with the Chapter 3 policies of the Coastal Act and LCPs as applicable[9].

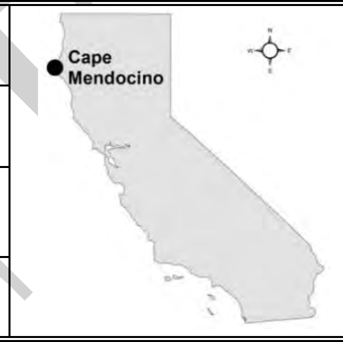
2. **Use the best available science to determine locally relevant (context-specific) sea level rise projections and potential impacts for all Coastal Act planning processes, project design, and permitting reviews.** Sea level rise science continues to evolve, and some processes that are not fully understood (*e.g.*, ice sheet dynamics) could potentially have large effects on future sea level rise. At the time of this report's publication, the best available science on sea level rise in California is the 2012 National Research Council (NRC) Report, *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future* (NRC 2012) (See Table 2), as stated in the 2014 *Safeguarding California* document and the Ocean Protection Council's 2013 State of California Sea-level Rise Guidance Document. As discussed in greater detail in Chapter 3 of this Guidance, these projections should be used in a scenario-based analysis to identify potential local impacts from sea level rise, incorporating storms, extreme water levels, and shoreline change. Other authoritative

[9] This guidance document is intended to help implement the Coastal Act and LCPs in the context of sea level rise concerns. However, the standard of review for commission actions remains the California Coastal Act or applicable certified LCPs. In particular, the recommendations of this guidance do not constitute "enforceable policies" for purposes of CZMA federal consistency reviews. The enforceable policies for conducting federal consistency reviews will remain the policies of Chapter 3 of the Coastal Act. Also, for federal agency activities, the standard is consistency "to the maximum extent practicable," with Chapter 3, *i.e.*, federal agency activities must be fully consistent unless existing law applicable to the federal agency prohibits full consistency. See 15 CFR. §§ 930.32 and 930.43(d). However, the Commission looks at sea level rise as one part of determining the coastal effects from an activity through CZMA federal consistency reviews and the use of this guidance by all parties should help determine what those coastal effects may be or how effects from sea level rise may be mitigated. Pursuant to 15 CFR § 930.11(h), implementation of this guidance would not be grounds for an objection (because it is not an "enforceable policy") but it might be one means that "would allow the activity to be conducted consistent with the enforceable policies of the program" in order to avoid an objection.

sea level science and projections may also be used, in part or in full, provided they are peer-reviewed, widely accepted within the scientific community, and locally relevant.

The Commission will re-examine the best available science periodically and as needed with the release of new information on sea level rise.[10] In addition, Commission staff intends to submit a periodic status report to the Commission describing updates on the best available science and adaptation practices, and any potential recommended changes to the guidance document.

Table 2. Sea Level Rise Projections for California[11] (NRC 2012)

TIME PERIOD*	NORTH OF CAPE MENDOCINO	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

3. **Recognize and address scientific uncertainty using scenario planning and adaptive management techniques.** Given the uncertainty in the magnitude and timing of future sea level rise, particularly over longer time periods, planners and project designers should use scenario-based analysis to examine a range of possible shoreline changes and sea level rise risks to shape LCPs and other plans and project development designs. As appropriate, development projects, resource management plans, and LCP and other planning updates should incorporate an adaptive management framework with regular monitoring, reassessments, and dynamic adjustment in order to account for uncertainty.

4. **Use a precautionary approach by planning and providing adaptive capacity for the highest amounts of possible sea level rise.** LCPs and CDPs should analyze the highest projections of sea level rise in order to understand the implications of a worst case scenario. In some cases, it may be appropriate to *design* for the local hazard conditions that will result from more moderate sea level rise scenarios, as long as decision makers and project

[10] Major scientific reports include the release of the 2014 National Climate Assessment (Melillo *et al*.) and the 2013 IPCC 5th Assessment Report.

[11] The NRC Committee divided the Pacific coast for California, Oregon and Washington into two regions, north and south of Cape Mendocino, due to differences in tectonics that occur at this location. North of Cape Mendocino, land is rising as ocean plates descend below the North American plate at the Cascadia Subduction Zone. South of Cape Mendocino, the coast is subsiding (NRC 2012, p. 3). Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary. Please see *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.

applicants *plan* to implement additional adaptation strategies if conditions change more than anticipated in the initial design. Similar to the recommendation in the Ocean Protection Council's 2011 *State Sea-Level Rise Resolution*, the Commission does not recommend using values solely in the lower third of the NRC's projections as this does not give a full picture of the risks. Looking instead at both the high and low projections allows users to build an understanding of the overall risk sea level rise poses to the region or site.

5. **Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.** Design adaptation strategies using best management practices for adaptation, and tailor the design to the specific conditions and development patterns of the area, in accordance with the Coastal Act and certified LCPs. LCPs should continue to serve as a key implementing mechanism for these adaptation strategies. Adaptation strategies should be evaluated for their ability to both minimize hazards and protect coastal resources.

MINIMIZE COASTAL HAZARDS THROUGH PLANNING AND DEVELOPMENT STANDARDS

[Coastal Act Sections 30253; 30235; 30001, 30001.5]

6. **Avoid significant coastal hazard risks to new development where feasible.** Section 30253 of the Coastal Act requires new development to minimize risks to life and property in areas of high geologic and flood hazard. The strongest approach for minimizing hazards is to avoid siting new development within areas vulnerable to flooding, inundation, and erosion, thus ensuring stable site conditions without the need for long-term financial and resource commitments for protective devices. Methods to direct new development away from hazardous locations are included in Chapter 7 of this Guidance.

7. **Minimize hazard risks to new development over the life of the authorized development.** Coastal Act Section 30253 requires that new development minimize coastal hazard risks without the use of bluff retaining or shoreline protection devices that would substantially alter natural landforms. When hazards from sea level rise cannot be avoided, new development should include provisions to ensure that hazard risks are minimized for the life of the development without shoreline protection, including through future modification, relocation, or removal when they become threatened by natural hazards, including sea level rise.

8. **Minimize coastal hazard risks and resource impacts when making redevelopment decisions.** LCPs should encourage and require, as applicable, existing at-risk structures to be brought into conformance with current standards when redeveloped. Improvements to existing at-risk structures should be limited to basic repair and maintenance activities and not extend the life of such structures or expand at-risk elements of the development, consistent with the Coastal Act.

9. **Account for the social and economic needs of the people of the state, including environmental justice; assure priority for coastal-dependent and coastal-related development over other development.** In planning and project development concerning sea level rise, assure that the social and economic needs of the people of the state are accounted

for in accordance with Coastal Act Section 30001.5(b), with special consideration for working persons employed within the coastal zone (Coastal Act Section 30001(d)). Ensure that LCP and CDP decisions account for environmental justice concerns.

10. **Ensure that property owners understand and assume the risks, and mitigate the coastal resource impacts, of new development in hazardous areas.** Property owners should assume the risks of developing in a hazardous location (often referred to as internalizing risk). They should be responsible for modifying, relocating or removing new development if it is threatened in the future. Any actions to minimize risks to new development should not result in current and/or future encroachment onto public lands or in impacts to coastal resources inconsistent with the Coastal Act. LCPs and coastal permits should require recorded assumptions of risk, "no future seawall" conditions, and other appropriate mitigation measures to internalize risk decisions with the private land owner.

MAXIMIZE PROTECTION OF PUBLIC ACCESS, RECREATION, AND SENSITIVE COASTAL RESOURCES [Coastal Act Chapter 3 policies]

11. **Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.** New and existing development, redevelopment, and repair and maintenance activities as well as associated sea level rise adaptation strategies should avoid or minimize impacts to coastal resources, including public access, recreation, marine resources, agricultural areas, sensitive habitats, archaeological resources, and scenic and visual resources in conformity with Coastal Act requirements. Impacts from development and related activities should be avoided or minimized; unavoidable impacts should be mitigated as necessary.

12. **Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.** If existing development (both private and public) is threatened by sea level rise hazards, it should employ the least environmentally damaging feasible alternatives and minimize hard shoreline protection. Priority should be given to options that enhance and maximize coastal resources and access, including innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. If traditional hard shoreline protection is necessary and allowable under the Coastal Act, use the least-environmentally damaging feasible alternative, incorporate projections of sea level rise into the design of protection, and limit the time-period of approval, for example, to the life of the structure the device is protecting. Major renovations, redevelopment, or other new development should not rely upon existing shore protective devices for site stability or hazard protection. Where feasible, existing shoreline protection that is no longer being relied upon in this way, or no longer needed otherwise, should be phased out.

13. **Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.** Where allowed under the Coastal Act or the relevant LCP, shoreline protective devices should be sited, designed,

and conditioned to ensure that they do not result in the loss of public trust lands[12] or encroach onto public trust lands without the permission of the appropriate trustee agency. When sea level rise causes the public trust boundary to move inland such that a protective device that was located on uplands becomes subject to the public trust, the permittee should either obtain permission from the appropriate trustee agency for the encroachment or apply for a permit to remove any encroachments.

14. **Address potential secondary coastal resource impacts (to wetlands, habitat, agriculture, scenic and visual resources, *etc.*) from hazard management decisions, consistent with the Coastal Act.** Actions to address sea level rise in LCPs or permits should not exacerbate other climate-related vulnerabilities or undermine conservation/protection goals and broader ecosystem sustainability. For example, siting and design of new development should not only avoid sea level rise hazards, but also ensure that the development does not have unintended adverse consequences that impact sensitive habitats or species in the area.

15. **Address the cumulative impacts and regional contexts of planning and permitting decisions.** Sea level rise will have impacts at both the site-specific and regional scales. In addition to the evaluation of site-specific sea level rise impacts, LCPs and projects should include an evaluation of the broader region-wide impacts, in two different contexts. First, the LCP or project should consider how sea level rise impacts throughout an entire littoral cell or watershed could affect the LCP jurisdiction or project. Second, the LCP or project should consider how options to adapt to sea level rise could result in cumulative impacts to other areas in the littoral cell or watershed. Actions should be taken to minimize any identified impacts.

16. **Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.** Require mitigation for unavoidable public resource impacts over the life of the structure as a condition of approval for the Coastal Development Permit. For example, for impacts to sand supply or public recreation due to armoring and the loss of sandy beach from erosion in front of shoreline protection devices, require commensurate in-kind mitigations, a sand mitigation fee, and other necessary mitigation fees (for example, public access and recreation mitigation). Because the longer term effects can be difficult to quantify, especially given uncertainty about the exact rate of future sea level rise, consider requiring periodic re-evaluation of the project authorization and mitigation for longer term impacts.

17. **Consider best available information on resource valuation when planning for, managing, and mitigating coastal resource impacts.** Planning, project development, and mitigation planning should evaluate the societal and ecosystem service benefits of coastal resources at risk from sea level rise or actions to prepare for sea level rise. These benefits can include flood protection, carbon sequestration, water purification, tourism and recreation

[12] The State holds and manages all tidelands, submerged lands, and beds of navigable waterways for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine ("public trust"). In coastal areas, the landward location and extent of the State's trust lands are generally defined by reference to the ordinary high water mark, as measured by the mean high tide line. Public trust uses include such uses as maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration.

opportunities, and community character. Resource values can be quantified through restoration costs or various economic valuation models.

MAXIMIZE AGENCY COORDINATION AND PUBLIC PARTICIPATION [Coastal Act Chapter 5; Sections 30006; 30320; 30339; 30500; 30503; 30711]

18. **Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.** Given the multitude of sea level rise planning, research, and guidance efforts occurring in California, it is critical for agencies and organizations to share information, coordinate efforts, and collaborate where feasible to leverage existing work efforts and improve consistency. Additionally, since many sea level rise hazards affect multiple jurisdictions, their management may also need to be coordinated through multi-agency reviews and coordinated decision making. The Commission will continue to meet this goal through coordination, engagement with stakeholders, and trainings. However, ongoing financial support for these Commission efforts is critical.

19. **Consider conducting vulnerability assessments and adaptation planning at the regional level**. Where feasible, local governments should coordinate vulnerability assessments and adaptation planning with other jurisdictions in the region that face common threats from sea level rise. A regional vulnerability assessment provides an opportunity to evaluate impacts that span multiple jurisdictions, assess and implement regional adaptation strategies, coordinate responses, and leverage research and planning funds.

20. **Provide for maximum public participation in planning and regulatory processes.** The Coastal Commission will continue to provide avenues for maximum public participation in planning and regulatory processes, and will continue to establish and/or expand non-traditional alliances (*e.g.*, between/among public and private resource managers, tribal groups, scientists, decision makers), share knowledge openly and actively, and regularly and clearly communicate to the public on the science as well as on a range of solutions to prepare for sea level rise.

This document and its guiding principles both reflect and complement the priorities outlined in the State of California's climate adaptation strategy, the 2014 *Safeguarding California* plan. While this Guidance specifically focuses on the California Coastal Act and the regulatory work of the Coastal Commission, it also echoes key concepts in *Safeguarding California* that apply statewide. For example, a central theme in *Safeguarding California* is to provide risk reduction measures for California's most vulnerable populations, something that is addressed here in Guiding Principle #9. Similarly, this Guidance and *Safeguarding California* both emphasize the use of best available science (Guiding Principle #2) and the need for communication, outreach, and public participation to increase understanding of climate risks and adaptation options (Guiding Principle #20).

Safeguarding California's Coast and Oceans chapter also states that "new development and communities must be planned and designed for long-term sustainability in the face of climate change," which captures a central purpose and focus of this Guidance. It goes on to specify that

"California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources" and "the state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need." Again, these values are reflected here, as Guiding Principles #6 and #12. In these ways, and through the shared goal of ensuring planning for and resilience against climate change impacts, the two documents are readily consistent and complementary.

Chapter 3

Sea Level Rise Science

This chapter provides information on sea level rise science and covers the following subjects:

- The best available science on sea level rise
- Using scenario-based analysis in response to sea level rise projection ranges
- The physical impacts of sea level rise
- Storms, extreme events, and abrupt change

Sea level rise science continues to evolve, and the discussion below reflects the best available science at the time this document was published.

BEST AVAILABLE SCIENCE ON SEA LEVEL RISE

Scientists widely agree that the climate is changing and that it has led to global increases in temperature and sea level. In the past century, global mean sea level (MSL) has increased by 7 to 8 in (17 to 21 cm; IPCC 2013). It is extremely likely (>95% probability of occurrence) that human influence has been the dominant cause of the observed warming of the atmosphere and the ocean since the mid-20th century (IPCC 2013).

There are a number of methods for projecting future changes in global sea level, including using extrapolations from historical trends and observations, estimations from physical models, and combinations of observations and modeling, known as semi-empirical methods. For a detailed description of these techniques, see Appendix A.

Scientists also measure sea level change at a variety of scales, from the global down to the local level. For example, the sea level rise projections in Intergovernmental Panel on Climate Change (IPCC) reports are based on large scale models that give global projections. But sea level does not change uniformly around the globe, so modifications for local conditions are necessary for adaptation planning.

In particular, global average sea level rise is driven by the expansion of ocean waters as they warm, the addition of freshwater to the ocean from melting land-based ice sheets and glaciers, and from extractions in groundwater (Figure 3). However, regional and local factors such as tectonics and ocean and atmospheric circulation patterns result in relative sea level rise rates that may be higher or lower than the global average. As such, global-scale models are often "downscaled" through a variety of methods to provide locally relevant data.

For California, the National Research Council (NRC) 2012 report, described below, provides sea level rise projections that have been refined for the regions North and South of Cape Mendocino. Except for Humboldt Bay and the Eel River Estuary, more detailed refinement of sea level rise projections is not considered necessary at this time. While some, more localized refinements are possible, these local refinements are highly technical and data-intensive, and local variability from the regional projections will often be quite small. It is important to note, though, that while the sea level rise projections are fairly similar throughout the state, the physical impacts may be quite different, and locally-specific analysis of impacts will be very important. Detail on physical impacts and how to assess them is provided in Section C of this chapter and in Appendix B.

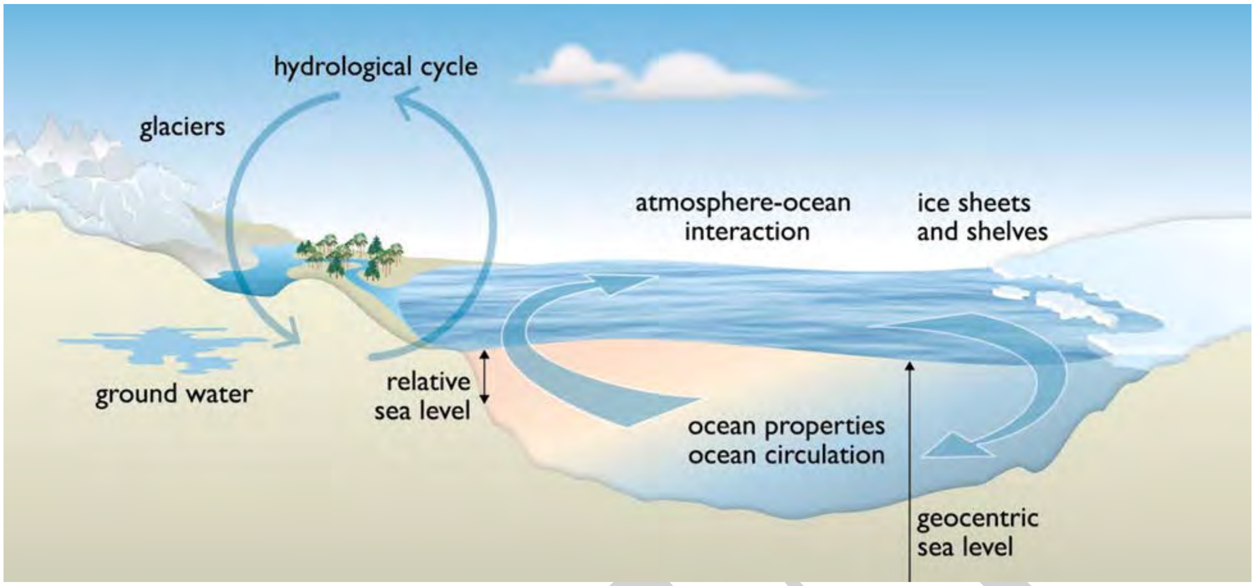


Figure 3. Climate-sensitive processes and components that can influence global and regional sea level. Changes in any one of the components or processes shown will result in a sea level change. The term “ocean properties” refers to aspects such as temperature, salinity, and density, which influence and are dependent on ocean circulation. (*Source*: IPCC 2013, Figure 13.1)

Global Sea Level Rise Projections

The IPCC 5th Assessment Report (AR5), which was released in September 2013, is the most recent global scale assessment of sea level rise. The report projects a rise in *global* average sea level by 10-39 in (26 to 98 cm) by the year 2100 (relative to mean sea level from 1985 to 2005) depending on the emissions scenario[13] (Figure 4). These projections are about 50% higher than the projections from the IPCC 4th Assessment Report (AR4, released in 2007). This is because the IPCC changed the climate model inputs between AR4 and AR5. In particular, much of the increase in the amount of sea level rise projected in the AR5 is due to the inclusion of sea level rise resulting from the loss of ice sheets. Ice sheet dynamics were not included in the AR4, but enhancements in physical models that account for such ice sheet dynamics have allowed for a better understanding and greater confidence in this input, and as such were included in the AR5[14].

[13] See Appendix A for more detail on emissions scenarios and the IPCC reports.

[14] Many of the other reports and studies cited in this Guidance used the AR4 as a reference (and for this reason detail on the AR4 is included in Appendix A). It is important to note, though, that while these other reports relied on the AR4 scenarios and model outputs for some climatic changes, many (*e.g.*, the *National Climate Assessment* (Melillo *et al*. 2014) and the NRC (2012) reports highlighted below) accounted for the loss of ice sheets through the use of semi-empirical models or other methods, further honing their results.

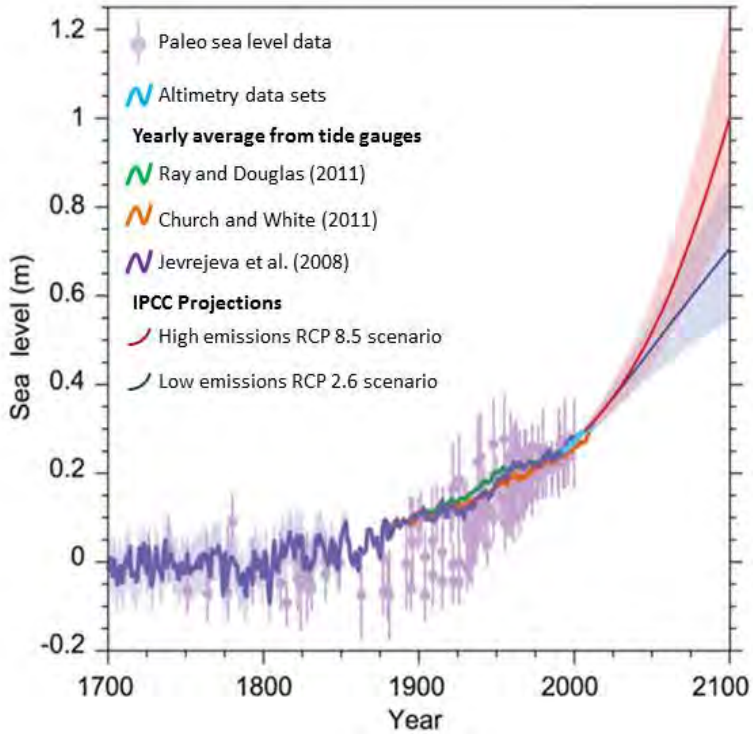


Figure 4. Past and projected future sea level trends (IPCC). Compilation of paleo sea level data, tide gauge data, altimeter data, and central estimates and likely ranges for projections of global mean sea level rise for low emissions RCP2.6 (blue) and high emissions RCP8.5 (red) scenarios, all relative to pre-industrial values. (*Source*: IPCC 2013, Figure 13.27)

National Sea Level Rise Projections

The third National Climate Assessment (NCA; Melillo *et al*.) was released in May 2014, and includes the current best-available science on climate change and sea level rise at the *national* scale. The sea level rise projections in the NCA were informed by the 2012 NOAA report titled *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris *et al*. 2012). This report provides a set of four global sea level rise scenarios ranging from 8 in to 7 ft (0.2 to 2.0 m) by the year 2100 (using mean sea level in 1992 as a baseline) reflecting different amounts of future greenhouse gas emissions, ocean warming and ice sheet loss (Figure 5). The low and intermediate-low scenarios assume very significant reductions in greenhouse gas emissions, and limited changes in ocean warming and ice sheet loss. The intermediate-high scenario is based on the average of the high projections from semi-empirical models, which are based on the highest IPCC 4th Assessment Report (AR4; 2007) emissions scenario (A1FI).[15] The highest scenario (2.0 m) combines the IPCC AR4 projections with the maximum possible ice sheet melt that could occur by 2100. Given the recent studies that suggest that glacier and ice

[15] The IPCC emissions scenarios make assumptions about future changes in population growth, future economic growth and the introduction of clean and efficient technology. The A1FI scenario assumes continued intensive use of fossil fuels, high economic growth, and low population growth that peaks mid-century. The B1 scenario assumes significant reduction in fossil fuel use, an increase in clean technologies, and the same low population growth that peaks mid-century. The A1F1 yields the highest CO_2 emissions by 2100 and the B1 scenario yields the lowest.

sheet loss could contribute significantly to rising sea levels (*e.g.*, Rahmstorf 2007; Vermeer and Rahmstorf 2009; IPCC 2013; McMillan *et al*. 2014; Morlighem *et al*. 2014) and evidence that current greenhouse gas emissions are tracking with intermediate IPCC AR4 scenarios (Rahmstorf *et al*. 2012), the low and intermediate-low scenarios likely underrepresent future sea level rise unless demonstrable reductions in global greenhouse gas emissions occur soon.

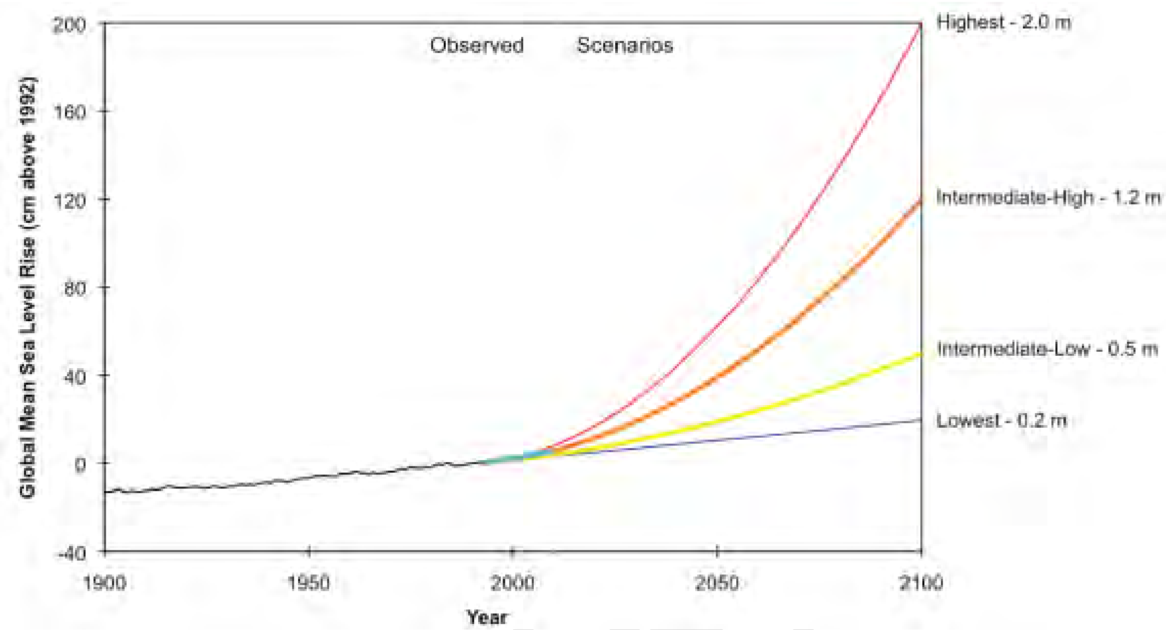


Figure 5. Observed and projected future sea level rise scenarios (Melillo *et al.* 2014). Global mean sea level rise scenarios used in the *US National Climate Assessment*. The Intermediate High Scenario is an average of the high end of ranges of global mean SLR reported by several studies using semi-empirical approaches. The Intermediate Low Scenario is the global mean SLR projection from the IPCC AR4 at 95% confidence interval. (*Source: Global Sea Level Rise Scenarios for the United States National Climate Assessment (*Parris *et al*. 2012))

Sea Level Rise Projections for California

Tide gauges and satellite observations show that in the past century, mean sea level in California has risen 8 in (20 cm), keeping pace with global rise. In the past 15 years or so, mean sea level in California has remained relatively constant, and may have been suppressed due to factors such as offshore winds and other oceanographic complexities. Bromirski *et al*. (2011, 2012) postulate that persistent alongshore winds have caused an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. Both of these factors could offset the global sea level rise trend in this region. However, localized sea level suppression will not continue indefinitely. As the Pacific Decadal Oscillation, wind, and other conditions shift, California sea level will continue rising, likely at an accelerated rate (NRC 2012; Bromirski *et al.* 2011, 2012).

Over the coming decades, sea level is projected to increase by 17 to 66 in (42 to 167 cm) along much of the California coast by Year 2100, according to the 2012 National Research Council *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* report. In March 2013, the Ocean Protection Council adopted a revised *State of California Sea-*

Level Rise Guidance Document that established the NRC 2012 report as the best available science on sea level rise for California (OPC 2013).[16]

The Commission will periodically re-examine and update sea level rise projections as they evolve with the release of new scientific reports and information on local and regional sea level trends. For now, however, the Commission recommends that local governments and applicants use the 2012 NRC report for the best available projections of regional sea level rise in California, though equivalent resources may be used by local governments and applicants provided the sources are peer-reviewed, widely accepted within the scientific community, and locally relevant.

The full range of sea level rise projections from the NRC report is provided below in Table 3. The range of sea level rise projections reflects uncertainties in future greenhouse gas emissions, future changes in the rate of ice sheet melt, and uncertainties related to the data. The low end of the range is based on the lowest IPCC 4th Assessment Report (AR4) future CO_2 emissions scenario (B1) and the high end is based on the highest IPCC AR4 emissions scenario (A1FI) (2007). Note that these amounts are what the NRC report refers to as "ranges." The report also includes "projections" that are based on the A1B emissions scenario. Please refer to Appendix A for a greater description of the "ranges" and "projections"[17]. Again, given current greenhouse gas emission levels and projections of future ice sheet loss, the lowest range of the sea level rise projections likely underrepresent future sea level rise (Rahmstorf *et al*. 2012; Horton *et al*. 2014).

Table 3. Sea Level Rise Projections for California (NRC, 2012)

TIME PERIOD*	NORTH OF CAPE MENDOCINO[18]	SOUTH OF CAPE MENDOCINO
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)

*with Year 2000 as a baseline

The NRC report breaks the California coast into two regions – South of Cape Mendocino and North of Cape Mendocino. South of Cape Mendocino, much of the land is experiencing subsidence, which will augment the consequences of rising sea level. For much of the area north

[16] Visit www.opc.ca.gov/climate-change/ for the *State Sea-Level Rise Guidance Document*.

[17] Table 5.3 from the NRC 2012 report uses the term "projections" to refer to sea level rise amounts for the A1B emission scenario (herein referred to as the NRC A1B projection). However, unless otherwise noted, this Guidance uses the term "projections" to refer more generally to sea level rise amounts from the broad set of emission scenarios.

[18] Since portions of Humboldt Bay are experiencing subsidence, and thus differ from the regional uplift conditions, the projections for north of Cape Mendocino may not be appropriate for use within parts of Humboldt Bay. See Appendix B for additional discussion about vertical land movement and relative sea level rise.

of Cape Mendocino, the consequences of rising sea level are being reduced by the vertical land uplift along much of the Cascadia Subduction Zone. However, much of this vertical uplift could change rapidly during the next large Cascadian earthquake. During such an earthquake, areas north of Cape Mendocino could experience rapid subsidence of up to about 6 ft (2 m), which means relative sea level in the area would correspondingly rise (NRC 2012).

In contrast to the vertical uplift occurring throughout the majority of the area north of Cape Mendocino, Humboldt Bay's North Spit and the Eel River Estuary are subsiding and experiencing the highest rate of sea level rise in the state: a rate of 18.6 in over the last century (NOAA 2013). As a result, the projections for north of Cape Mendocino will not be appropriate for use in or near Humboldt Bay and the Eel River Estuary and will instead need to be modified to account for local vertical land movement. Please see *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.

The NRC report (2012) only provides estimated sea level rise ranges through the year 2100, though sea level will continue to rise, possibly at an accelerating rate, beyond the end of the century (IPCC 2013; Horton *et al*. 2014). Additionally, sea level rise in a particular location along the coast will likely vary from these regional projections due to changes in vertical land motion and ocean circulation, though such variation may be insignificant in places other than Humboldt Bay and the Eel River regions. Regardless, local governments, applicants, and staff may choose to modify these projections to account for local conditions and/or specific time periods, using the steps provided in Appendix B.

The Coastal Commission will be using and recommends that local governments and applicants use best available science, currently identified as the projections provided in the NRC 2012 report (Table 3), in all relevant local coastal planning and coastal development permitting decisions.

USING SCENARIO-BASED ANALYSIS IN RESPONSE TO SEA LEVEL RISE PROJECTION RANGES

Despite the recent advances in sea level rise science, sea level rise projections, including those in the 2012 NRC Report (Table 3) and the 2013 IPCC AR5, are typically presented in ranges due to several sources of significant uncertainty.

The two primary sources of uncertainty in *global* sea level projections include:

1) Uncertainty about future greenhouse gas emissions and concentrations of sulfate aerosols, which will depend on future human behavior and decision making, and
2) Uncertainty about future rates of land ice loss (NRC 2012; McMillan *et al*. 2014; Morlighem *et al*. 2014).

The NRC report (2012) also notes additional sources of uncertainty when projecting *regional* sea level for California, Oregon, and Washington, including:

1) Uncertainty in the influence of thermal expansion on local sea level, and
2) Uncertainty in future vertical land motion.

Additionally, the further into the future sea level rise is projected, the greater the uncertainty becomes. This occurs because the longer the projection period, the greater the likelihood that models will deviate from the actual impacts of climate change (NRC 2012).

This Guidance recommends using scenario-based analysis to address the uncertainty in sea level projections. Scenario-based analysis (or planning) refers to the idea of developing multiple scenarios from which to analyze vulnerabilities, generate new ideas and adaptation options, and/or test strategies. In the context of this guidance, scenario-based analysis includes choosing several possible sea level rise amounts as a starting point to evaluate impacts to coastal resources and potential risks to development over time. This type of scenario-based approach is useful because it reveals the full range of possible consequences of sea level rise that can be reasonably expected for particular regions or sites according to the best available science. Additionally, a scenario-based analysis helps to reveal the tipping points indicating if or when sea level rise will become a serious issue in a particular location. In many cases, using multiple sea level rise scenarios will help to hone in on the types of hazards for which to prepare.

In general, the Coastal Commission recommends using best available science (currently the 2012 NRC report) to identify a range of sea level rise scenarios including the high projection, low projection, and one or more intermediate projections[19]. An even higher value than the NRC range might also be considered if there is the potential for severe impacts to coastal resources and human health and safety from sea level rise impacts. In practice, the process for choosing scenarios and performing scenario-based analysis will be slightly different for LCP planning and CDP applications due to the different planning goals and levels of technical detail required for each.

For a Local Coastal Program (LCP), the general goal is to assess the potential impacts from sea level rise over the entire planning area and over a range of time horizons so that both short and long term adaptation strategies can be identified and implemented. Another important facet of LCP planning is identifying locations that are particularly vulnerable so that additional, more detailed studies can be performed if necessary, and adaption options and actions can be prioritized. Scenario-based analysis in the context of LCP planning includes choosing a range of sea level rise projections to analyze so as to understand the best and worst case scenarios and to identify amounts of sea level rise and related conditions that would trigger severe impacts and the associated time period of when such impacts might occur. Choosing sea level rise scenarios in the context of LCP planning is described in greater detail in Chapter 5.

In the context of a Coastal Development Permit (CDP) application, the goal is to understand how sea level rise will impact a specific site and a specific project over its expected lifetime so as to ensure that the proposed development is safe from hazards and avoids impacts to coastal

[19] Similar to the recommendation in the OPC's 2011 *State Sea-Level Rise Resolution*, the Commission does not recommend using values solely in the lower third of the NRC's projections as this does not give a full picture of the risks. Looking instead at both the high and low projections allows users to build an understanding of the overall risk sea level rise poses to the region or site.

resources. Thus, in the context of a CDP, it is important to identify the amounts of sea level rise that could result in effects to a particular site as well as the time period(s) over which those effects could occur so that the proposed development can be safely sited and designed to avoid resource and development impacts. However, some sites will be completely safe from sea level rise under even the highest projection scenarios, while others will depend on the timing and magnitude of sea level rise to determine safety. Therefore, scenario-based planning analysis can be used as a screening process to identify if and when sea level rise might become a problem. Identifying sea level rise scenarios in the context of CDPs is described in greater detail in Chapter 6.

Overall, scenario-based planning should help planners make reasonable and informed decisions about whether their projects or plans are compatible with the local hazards influenced by sea level rise, and identify the types of adaptation measures that might be appropriate given the local circumstances and requirements of the Coastal Act. By exploring the range of future scenarios based on the best available science, users of this document can make decisions based on full understanding of possible future hazards, ultimately achieve outcomes that are safer for both development and coastal resources, and avoid costly damages to projects.

For more information on scenario-based planning in the context of LCPs and CDPs see Chapters 5 and 6, respectively. A number of additional resources related to scenario-based planning are available, including a handbook from the National Park Service (2013) and guidance from Point Blue Conservation Science and the California Coastal Conservancy (Moore *et al*. 2013). See Appendix C for these and other resources related to scenario-based analysis and adaptation planning.

Physical Effects of Sea Level Rise

Continued and accelerated sea level rise will have widespread adverse consequences for California's coastal resources (See summary in Figure 8). The main physical effects of sea level rise include increased flooding, inundation, wave impacts, coastal erosion, changes in sediment dynamics, and saltwater intrusion. These impacts are interrelated and often occur together. Absent any preparatory action, an increase in sea level may have serious implications for coastal resources and development, as described in Chapter 4. In addition, these physical effects could have disproportionate impacts on vulnerable communities that have lower capacity to adapt.

Physical effects from sea level rise to the coastal zone include the following:

- **Flooding and inundation:** Low lying coastal areas may experience more frequent flooding (temporary wetting) or inundation (permanent wetting), and the inland extents of 100-year floods may increase. Riverine and coastal waters come together at river mouths, coastal lagoons, and estuaries, and higher water levels at the coast may cause water to back up and increase upstream flooding (Heberger *et al*. 2009). Drainage systems that discharge close to sea level could have similar problems, and inland areas may become flooded if outfall pipes back up with salt water. In addition, other climate change impacts such as increases in the amount of precipitation falling as rain rather than snow will add to river flooding in some areas.

- **Wave impacts:** Wave impacts can cause some of the more long-lasting consequences of coastal storms, resulting in high amounts of erosion and damage or destruction of structures. The increase in the extent and elevation of flood waters from sea level rise will also increase wave impacts and move the wave impacts farther inland. Erosion rates of coastal cliffs, beaches, and dunes will increase with rising sea level and are likely to further increase if waves become larger or more frequent (NRC 2012).

- **Erosion:** Large sections of the California coast consist of oceanfront bluffs that are often highly susceptible to erosion. With higher sea levels, the amount of time that bluffs are pounded by waves would increase, causing greater erosion (NRC 2012). This erosion could lead to landslides and loss of structural and geologic stability of bluff top development such as homes, infrastructure, the California Coastal Trail, Highway 1, and other roads and public utilities. The Pacific Institute (Heberger *et al*. 2009) estimated that 41 square miles (106 square km) of coastal land from the California-Oregon border through Santa Barbara County could be lost due to increased erosion with 4.6 ft (1.4 m) of sea level rise by the year 2100, and approximately 14,000 people now live in those vulnerable areas. Increased erosion will not occur uniformly throughout the state. Mendocino and Humboldt Counties have the greatest areas projected to be lost by erosion. For example, dunes in Humboldt County could erode a distance of approximately 2000 ft (nearly 600 m) by the year 2100 (Heberger *et al*. 2009; Revell *et al*. 2011). Mad made structures like dikes and levees may also be impacted by erosion, increasing flooding risk of the areas protected by those structures, such as low-lying agricultural land. Over the long term, rising sea levels will also cause landward migration of beaches due to the combined effects inundation and loss of sediment due to erosion (NRC 2012).

Figure 6. Photo of Esplanade Apartments threatened by cliff erosion in 2013 in Pacifica, CA. (*Source:* California Coastal Records Project).

- **Changes in sediment supply and movement:** Sediment is important to coastal systems in, for example, forming beaches and mudflats and as the substrate for wetlands. Sea level rise will result in changes to sediment availability. Higher water levels and changing precipitation patterns could change erosion and deposition patterns. Losses of sediment could worsen beach erosion and possibly increase the need for beach nourishment projects (adding sand to a beach or other coastal area), as well as decrease the effectiveness and long-term viability of beach nourishment if sand is quickly washed away after being placed on a beach (Griggs 2010). Sediment supplies in wetland areas will also be important for long-term marsh survival. Higher water levels due to sea level rise, however, may outpace the ability of wetlands to trap sediment and grow vertically (Titus 1988; Ranasinghe *et al*. 2012; Van Dyke 2012).

- **Saltwater intrusion:** An increase in sea level could cause saltwater to enter into ground water resources, or aquifers. Existing research suggests that rising sea level is likely to degrade fresh ground water resources in certain areas, but the degree of impact will vary greatly due to local hydrogeological conditions. Generally, the most vulnerable hydrogeological systems are unconfined aquifers along low-lying coasts, or aquifers that have already experienced overdraft and saline intrusion. In California, saline intrusion into groundwater resources is a problem in multiple areas, including but not limited to the Pajaro Valley (Hanson 2003), Salinas Valley (Hanson *et al*. 2002a; MCWRA 2012), Oxnard Plain (Izbicki 1996; Hanson *et al*. 2002b), and the heavily urbanized coastal plains of Los Angeles and Orange Counties (Edwards and Evans 2002; Ponti *et al*. 2007; Nishikawa *et al*. 2009; Barlow and Reichard 2010). Ground water sources for coastal agricultural lands may also be susceptible to saltwater intrusion. Additional research is needed to understand the site-specific consequences of sea level rise and saltwater intrusion to these and other coastal aquifers in California.

STORMS, EXTREME EVENTS, AND ABRUPT CHANGE

Much of the California coast is currently vulnerable to flooding and wave damage during large storm events, and even more of the coast is vulnerable to storm impacts when they occur during times of heightened water levels, such as high tides, El Niño events, a warm phase of the Pacific Decadal Oscillation, or a combination of these factors. Sea level rise will increase coastal vulnerability to storms even more because rising water levels will result in more areas being impacted.

Climate change will likely modify or change much more than just sea level. One potential climate change-related impact that will interact most directly with sea level rise hazards is a change in frequency or intensity of coastal storms (storminess) and extreme events. The extremes associated with high-intensity events may be particularly devastating since they have the potential to cause broad-scale damage, as seen from recent events such as Hurricanes Katrina and Rita, Superstorm Sandy, and the Tohoku tsunami. Abrupt change in sea levels is another potential impact of climate change. Both potential impacts are described below.

Extreme Events and Storms

There are several ways to describe extreme events, and most definitions tend to frame these events in terms of consequences or past observations. Kruk *et al*. 2013 define extreme events as "the floods that displace us from our homes, the high waves that wash out coastal roads, or the toppling of trees and power poles from a passing storm." The IPCC defines climate extremes as "The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variables" (IPCC 2012, p.

5). For storm waves and flood conditions, an extreme event will normally be anything worse than the 100-year event.

Extreme events are of particular concern to the examination of coastal vulnerability and damage because they tend to cause the greatest community upheaval and can result in irreversible changes to the coastal landscape. In the El Niño winter of 1982-1983, for example, a series of storms, several of which coincided with high tide, caused more than $200 million in damage (in 2010 dollars) to coastal California (OPC 2013). The 2012 NRC report notes that “waves riding on these higher water levels will cause increased coastal damage and erosion—more than that expected by sea level rise alone” (NRC 2012, p.107). These impacts result because a rise in sea level will mean that flooding and damage will likely reach further inland. The IPCC *Fifth Assessment Report* (2013) states that it is very likely[20] that there will be a significant increase in the occurrence of future sea level extremes primarily as a result of an increase in mean sea level, with the frequency of a particular sea-level extreme increasing by an order of magnitude or more in some regions by the end of the 21st century.

According to the 2012 NRC report, if the frequency or intensity of storms changes, then so will the frequency and intensity of extreme sea level events. However, the evidence that storminess will change in the North Pacific Ocean is conflicting and inconclusive (Cayan *et al*. 2009; Lowe *et al*. 2010; Dettinger 2011). Still, even if storminess does not change, sea level rise will exacerbate storm surge and high waves, magnifying their impact on the coastline. For this reason, it is important to include these factors in the analysis of sea level rise hazards. Methodologies for these analyses are included in Appendix B.

Abrupt change

Currently, the best available science is inconclusive as to whether sea level could change abruptly. Thermal expansion and direct melting of land ice is expected to be gradual, leading to slow and steady sea level rise. However, rapid collapse of land-based ice sheets could lead to sudden acceleration of sea level rise. Still, the likelihood of such collapses is uncertain (but probably low) and remains an area in need of future research (NRC 2013).

Rapid change in land elevation during an earthquake is another potential cause of an abrupt sea level change in a localized area. A large earthquake in the Cascadia Subduction Zone could cause land in northern California, Oregon, and Washington to suddenly subside relative to sea level, causing a sudden rise in relative sea level by 3-6.5 ft (1-2 m; NRC 2012). Large earthquakes in this zone are expected to occur about every several hundred to one thousand years, and the most recent such earthquake occurred in 1700. The sudden rise or drop in land elevation would occur in a matter of minutes. If the land were to subside, the relative rise in sea level would be rapid and it would add to sea level rise already occurring from climate-related forcing.

[20] The IPCC has assigned quantitative levels to various terms of confidence and likelihood. High confidence means there is about an 8 out of 10 chance of being correct. Very likely has a greater than 90% probability of occurrence. Other terms that will be used later in this discussion are likely (> 66% probability of occurrence), medium confidence (about a 5 out of 10 chance), low confidence (about a 2 out of 10 chance). *Source of terms*: http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note_ar4.pdf

There is also potential for oceanographic conditions to lead to a relatively rapid rate of sea level rise in California. Examination of the tidal gauge records indicate that there was no significant interannual rise in California's sea level from 1983 to 2011, despite a rise in global sea level over the same time period. One explanation, presented by Bromirski *et al*. (2011, 2012), links this suppression of sea level rise with persistent alongshore winds and an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. However, this suppression will not continue indefinitely and as the Pacific Decadal Oscillation, wind, and other conditions shift, California sea level will continue rising, likely at an accelerated rate (NRC 2012; Bromirski *et al.* 2011, 2012).

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Chapter 4

Consequences of Sea Level Rise for Communities, Coastal Resources, and Development

The physical effects of sea level rise described in the previous chapter could have significant consequences for California's citizens, coastal communities and the resources protected by the Coastal Act. This chapter describes some of these consequences and notes the relevant Coastal Act policies for convenience. It is important to consider both the direct impacts of sea level rise on coastal resources and what these impacts mean for the people and communities who use and enjoy these coastal resources. It is also important to consider environmental justice when analyzing sea level rise impacts, as described in greater detail in the section below.

SEA LEVEL RISE ADAPTATION PLANNING AND ENVIRONMENTAL JUSTICE

Sea level rise and how we respond to it may result in significant changes in the distribution of environmental benefits, or environmental justice, in California. General planning law in California specifically recognizes and defines environmental justice as "the fair treatment of people of all races, culture and income with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies" (Government Code Section 65040.12; and see Public Resources Code Section 71110-71116). Environmental justice demands that all people, regardless of their race, ethnicity, or level of income, are able to enjoy the benefits of our environmental protection programs and our environment generally. Safeguarding California (CNRA 2014) identifies environmental justice as an important cross-sector theme in the state's climate adaptation and resilience planning efforts.

The California Coastal Act also recognizes the fundamental importance of the fair distribution of environmental benefits in Section 30001:

> *The Legislature hereby finds and declares: (a) That the California coastal zone is a distinct and valuable natural resource of vital and enduring interest to all the people and exists as a delicately balanced ecosystem. (b) That the permanent protection of the state's natural and scenic resources is a paramount concern to present and future residents of the state and nation. (c) That to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction. (d) That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone.*

The Act thus declares that the protection of the coast is of vital interest to *all* the people, of paramount concern *to present and future residents* of the state and nation, and that careful planning and development is essential to *the economic and social well-being* of the people. This broad direction to protect the coast for everyone is underscored in Section 30006, which declares:

> *. . . the public has a right to fully participate in decisions affecting coastal planning, conservation and development; that achievement of sound coastal conservation and development is dependent upon public understanding and support; and that the continuing planning and implementation of programs for coastal conservation and development should include the widest opportunity for public participation.*

Hence, everyone is entitled to participate in the management decisions that determine how the benefits and burdens of managing California's coast will be distributed.

The Coastal Act's broad concern for all the people is best borne out in its public access policies, which require the maximum provision and protection of the public's rights of access to and along the shoreline (sections 30210-214). These policies reflect the judgement of the people of California in passing Proposition 20 in 1972 that public access and recreation along our coast is a fundamental environmental benefit to be protected for and enjoyed by all, not just by those with the good fortune or means to live along the shoreline.

Unfortunately, public access is also one of the coastal resources most at risk from accelerating sea level rise. As discussed elsewhere in this Guidance, beaches, accessways, recreational amenities, and even surfing resources may be dramatically impacted by rising seas. Where development already exists, and particularly where there is substantial shoreline armoring to protect this development, California stands to lose significant recreational beach areas. These places that are at increased risk provide environmental benefits for everyone, generally at very low cost, or even free. Thus, the potential loss of beach and shoreline recreation areas represents a significant potential impact to a resource that both is especially important to those with fewer economic resources and one that we endeavor to provide for everyone without discrimination, no matter their income levels, ethnicities or cultures; no matter if they are from coastal or inland areas or from outside the state.

The exacerbation of environmental injustices by anticipated sea level rise may be particularly concerning when the Commission and local governments need to make decisions about shoreline protection and hazard mitigation. As discussed elsewhere in this Guidance, the Coastal Act provides for the protection and mitigation of coastal hazards for existing and new development. But some hazard mitigation, such as seawall development or elevated development on beaches, may have significant impacts to public trust shoreline resources. Thus, we face a situation where widely available public beach resources may be diminished in order to protect private or public development along the shoreline – potentially a significant environmental justice concern. Because of this, it will be important for decision makers to proactively consider all aspects of this Guidance in an effort to avoid and mitigate the potential impacts to coastal resources from hazard response. This is particularly true for recommendations to consider alternatives to shoreline structure development and, where shoreline structures must be approved, for recommendations to fully mitigate the impacts of such structures on public shoreline resources.

A May 2015 decision made by the Coastal Commission emphasizes the importance of analyzing low-cost recreational opportunities in addition to other coastal resource impacts when evaluating shoreline protection and other responses to sea level rise and coastal hazards. The Coastal Commission approved a revetment at the west end of the Goleta Beach County Park to provide protection against erosion. This park is an important public resource in Santa Barbara County and receives up to 1.5 million visitors each year, a large fraction of which are low-income visitors. Park facilities include picnic areas, open parkland, and access to the ocean and a recreational beach for no or low cost. The revetment was approved contingent upon specific conditions, including continued free public access and vehicle parking for the term of the permit.

This decision highlights the importance of protecting wide accessibility to shoreline resources even as sea level rises.

The potential impacts of adaptation responses on public shoreline resources, and thus the potential environmental justice impacts of such actions, will need to be considered for all resources protected under the Coastal Act. It is also true that due to current development patterns along the coast, sea level rise hazards may affect various sections of the population differently, as could the implementation and effectiveness of various adaptation measures. The number of people living along the open coast in areas exposed to flooding from a 100-year flood would increase to 210,000 with a 4.6 ft (1.4 m) increase in sea level; approximately 27% or 56,000 of these are lower income people (those earning less than $30,000 annually); 45,000 are renters; and 4,700 are linguistically isolated and less likely to understand flood warnings (Heberger *et al*. 2009). According to Heberger *et al*. (2009), the greatest increases in the number of people vulnerable to flooding will occur in Los Angeles, San Diego, Ventura, Humboldt, and San Luis Obispo counties. Hazards in these vulnerable areas will have disproportionate impacts on communities with the least capacity to adapt, which could deepen and expand existing environmental injustice if adaptation responses are not managed appropriately.

For example, lower-income communities and those who live in rental units are more likely to be displaced by flooding or related impacts as compared to property owners because they lack the funds and/or abilities to rebuild, have less control over their safety, and often have limited access to insurance. Relatedly, these same populations are less likely to be able to take proactive steps to adapt to sea level rise. Additionally, loss of local public beaches or a reduction in public access and recreation opportunities would disproportionately affect low-income communities that have few alternative lower cost recreational opportunities. Tribal communities are also vulnerable to sea level rise because they are often tied to specific locations, and therefore can't easily relocate.

Overall, it will be important for planners and decision makers to not only consider the direct impacts and consequences of sea level rise on coastal resources, but to also consider what those consequences mean for the distribution of environmental benefits along the coast, and the communities that use and rely on those resources. Planners and decision makers should consider environmental justice concerns in the analysis of alternative project designs and adaptation measures. This will better ensure that adaptation efforts benefit all Californians, fairly, and that they do not increase vulnerability to sea level rise among any particular group or demographic, and do not have any unintended consequences that lead to social or environmental injustices. In particular, it will be important to consider the potential impacts of hazard mitigation actions to protect development that may only benefit a few, on the public access and shoreline resources that are available for all Californians to enjoy.

CONSEQUENCES OF SEA LEVEL RISE FOR COASTAL ACT RESOURCES

- **Coastal development (Coastal Act Sections 30235, 30236, 30250, 30253):** Sea level rise will increase the likelihood of property damage from flooding, inundation, or extreme waves, and will increase the number of people living in areas exposed to significant flooding. Increased erosion and loss or movement of beach sand will lead to an increase in the spatial extent of eroding bluffs and shorelines, and could increase instability of coastal structures and recreation areas. Levee systems could also experience damage and overtopping from an increase in water levels, extreme wave conditions, or a loss of wetlands, which buffer impacts from high water. The replacement value of property at risk from sea level rise for the California coast is approximately $36.5 billion (in 2000 dollars, not including San Francisco Bay) (Heberger *et al*. 2009).

  Impacts to public infrastructure, ports, and industrial development include:

  - **Public infrastructure:** Low-lying roads, wastewater treatment facilities, energy facilities, stormwater infrastructure, and utility infrastructure such as potable water systems and electricity transfer systems are at risk of impaired function due to erosion, flooding, and inundation. Heberger *et al*. (2009) estimated that 7 wastewater treatment plants, 14 power plants, including one in Humboldt County and 13 in Southern California, and 250 miles (402 km) of highways, 1500 miles (2414 km) of roads, and 110 miles (177 km) of railways could be at risk from a 100-year flood with 1.4-m rise in sea level (Heberger *et al*. 2009). Facilities and highways located on coastal bluffs subject to erosion will become more susceptible in the future. Sections of Highway 1 have already had to be realigned due to erosion or are in the planning stages for realignment projects, including areas in San Luis Obispo County, Monterey Bay, Half Moon Bay, and Marin County and the sections at risk in the future will likely increase.

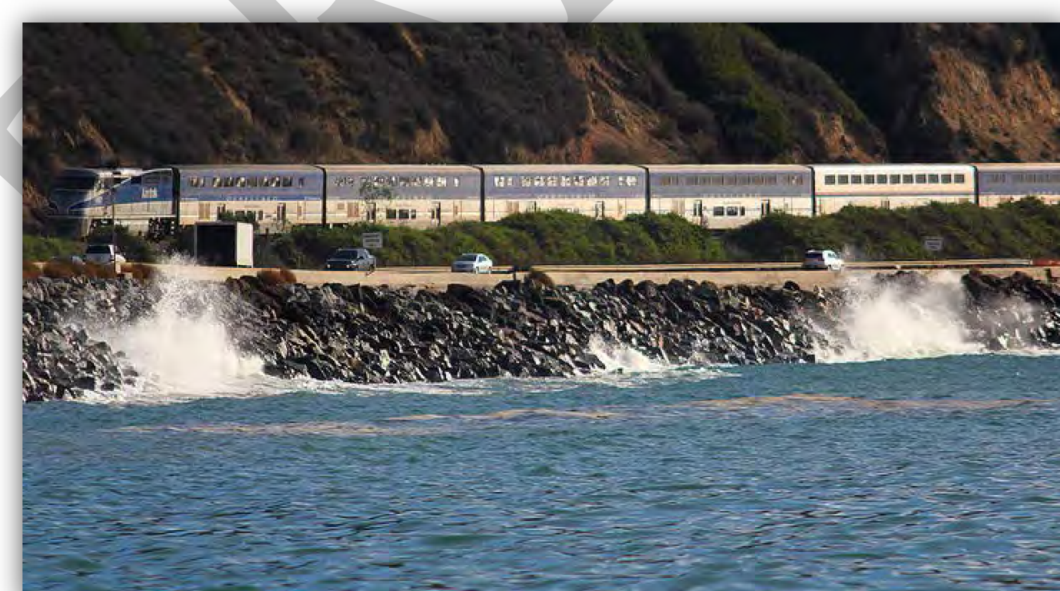

Figure 7. Photo of infrastructure at risk near Rincon Beach, Ventura, CA, during the King Tide in December 2012. (Photo courtesy of David Powdrell, California King Tides Initiative)

- **Ports (Coastal Act Sections 30703 – 30708):** Sea level rise could cause a variety of impacts to ports, including flooding and inundation of port infrastructure and damage to piers and marina facilities from wave action and higher water levels. A possible benefit could be a decreased need for dredging. But, unless facilities have already included accommodations for larger ships than they currently service, higher water levels could increase the difficulty for cargo handling facilities due to the higher vessel position (CCC 2001; CNRA 2014). Increased water heights could reduce bridge clearance, reducing the size of ships that can access ports or restricting movement of ships to low tides, and potentially increasing throughput times for cargo delivered to ports. Heberger *et al*. (2009) found that significant flooding from sea level rise is possible at the Ports of Los Angeles and Long Beach. Given that these two ports handle 45-50% of the containers shipped into the United States, and 77% of goods that leave the state, sea level rise could affect the efficiency of goods movement, and have serious economic implications for California and the nation (Heberger *et al*. 2009).
- **Industrial development, refineries, and petrochemical facilities (Coastal Act Sections 30260-30266.5):** Sea level rise could reduce areas available for siting or expansion of industrial development. Inundation of contaminated lands near industrial development could lead to problems with water quality and polluted runoff. Sea level rise could lead to an increase in flooding damage of refineries or petrochemical facilities, and impacts from sea level rise could be an issue when locating or expanding refineries or petrochemical facilities, or when mitigating any adverse environmental effects.
- **Construction altering natural shorelines (Coastal Act Section 30235):** Sea level rise may lead to an increase in demand for construction of shoreline protection for existing development, public access, and coastal-dependent uses in danger of erosion. Shoreline protection devices alter natural shorelines and also generally have negative impacts on beaches, near-shore marine habitat, and scenic and visual qualities of coastal areas.

o **Public access and recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221):** One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding, or erosion of beaches, recreational areas, or trails. In areas where beaches cannot migrate inland due to development or more resistant landforms, beaches will become narrower or will disappear completely. Access and functionality of water-oriented activities may also be affected. For instance, sea level rise, by increasing water levels and altering sediment patterns, could lead to a change in surfing conditions or affect the safety of harbors and marinas (Kornell 2012).

o **Coastal habitats (Coastal Act Sections 30230, 30231, 30233, 30240):** Coastal habitat areas likely to be affected by sea level rise include bluffs and cliffs, rocky intertidal areas, beaches, dunes, wetlands, estuaries, lagoons and tidal marshes, tidal flats, eelgrass beds, and tidally-influenced streams and rivers.

Importantly, there are many endemic and endangered species in California that are dependent on these coastal environments. For example, grunion need a sandy beach environment in order to reproduce and survive, the California clapper rail is dependent on marshes and wetlands, and the black abalone requires rocky intertidal habitat. Nesting habitat, nursery areas, and haul-out sites important for birds, fish, marine mammals and other animals could also disappear as sea levels rise (Funayama *et al*. 2012).

Impacts to wetlands, intertidal areas, beaches, and dunes include:

- **Beaches, dunes, and intertidal areas:** Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Sea level rise will cause landward migration of beaches over the long term, and could lead to a rapid increase in the retreat rate of dunes. Beaches with seawalls or other barriers will not be able to migrate landward and the sandy beach areas will gradually become inundated (NRC 2012). A loss of beach and dune areas will have significant consequences for beach and adjacent inland ecosystems. Beaches and dunes provide critical habitat for species and act as buffers to interior agricultural lands and habitat during storms (CNRA 2009).
- **Wetlands:** Sea level rise will lead to wetland habitat conversion and loss as the intertidal zone shifts inland. Of particular concern is the loss of saltwater marshes from sea level rise, which have already decreased by about 90% from their historical levels in California (CNRA 2010). California's 550 square miles (885 km) of critical coastal wetland habitat (Heberger *et al*. 2009, including wetlands in San Francisco Bay) could be converted to open water by 4.6 ft (1.4 m) rise of sea level if they are not able accrete upward or to migrate inland due to natural or anthropogenic barriers. Although barriers are plentiful, inland migration of these wetlands is possible for over 50% of the potentially inundated wetland area based on land use compatibility alone (Heberger *et al*. 2009). Consideration of adequate sediment supply and additional barriers to inland migration would further constrain wetland migration potential. A 4.6 ft (1.4 m) increase in sea level would flood 150 square miles (241 km) of land immediately adjacent to wetlands, which could become future wetlands if that land remains undeveloped. Loss or reduction of wetland habitat would impact many plant and animal species, including migratory birds that depend on these habitats as part of the Pacific Flyway. Species that are salt-tolerant may have an advantage as sea level rise occurs and exposes new areas to salt water, while species that have narrow salinity and temperature tolerances may have difficulty adapting to changing conditions.

o **Biological productivity of coastal waters (Coastal Act Sections 30230, 30231):** Sea level rise could affect biological productivity of coastal waters by changing the types of habitats that are available. This change could alter species composition, and could potentially result in cascading effects through the coastal food chain. Changes in water quality can have differing impacts on biological productivity. For instance, decreased water quality due to increased nutrient pollution has been found to increase biological productivity at the base of the food chain to undesirable levels, and has been linked to harmful algal blooms which result in hypoxic conditions for other marine species (Kudela *et al*. 2010; Ryan *et al.* 2010; Caldwell *et al*. 2013).

- **Water quality (Coastal Act Section 30231):** Sea level rise could lead to declines in coastal water quality in several ways. First, coastal water quality could be degraded due to inundation of toxic soils and an increase in nonpoint source pollution from flooding. In particular, the presence of facilities or land containing hazardous materials in coastal areas susceptible to flooding or permanent inundation presents toxic exposure risks for human communities and ecosystems. Second, rising seas could impact wastewater facility infrastructure and other methods and structures designed to protect water quality near the coast. In addition to damaging equipment and blocking discharge from coastal outfall structures, floods could force facilities to release untreated wastewater, threatening nearby water quality (Heberger *et al*. 2009). Salt water draining into sewer lines as part of extreme weather flooding might also damage biological systems at wastewater facilities if the organisms present in these systems are not salt-tolerant. Third, sea level rise could lead to salt water intrusion into valuable ground water aquifers, potentially rendering some existing wells unusable and decreasing the total ground water supply in coastal areas. The extent of salt water intrusion will likely vary based upon local hydrological conditions, with the worst impacts occurring in unconfined aquifers along low-lying coasts that have already experienced overdraft and saline intrusion. This change could force affected communities to turn to more costly water sources such as surface water transfers or desalination. Finally, loss of wetlands could decrease water quality given that wetlands act to improve water quality by slowing and filtering water that flows through them.
- **Coastal agriculture (Coastal Act Sections 30241- 30243):** Sea level rise could lead to an increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and a decrease in the amount of freshwater available for agricultural uses. Flooding of agricultural lands can cause major impacts on local businesses, national food supplies, and the state's economy.
- **Archaeological and paleontological resources (Coastal Act Section 30244):** Archaeological or paleontological resources could be put at risk by inundation, flooding, or by an increase in erosion due to sea level rise. Areas of traditional cultural significance to California Native American tribes, including villages, religious and ceremonial locations, middens, burial sites, and other areas, could be at risk from sea level rise. For example, the Santa Barbara Channel area has thousands of archaeological sites dating over 13,000 years that are at risk of being destroyed or altered from small amounts of sea level rise (Reeder *et al*. 2010).

For a summary of some of the sea level rise impacts and potential consequences for the coast, see Figure 8. Many of these consequences are conditions that coastal managers already deal with on a regular basis, and strategies already exist for minimizing impacts from flooding, erosion, saltwater intrusion, and changing sediment patterns. Preparing for sea level rise involves integrating future projections of sea levels into existing hazard analyses, siting, design, and construction processes, ecosystem management, and community planning practices. Processes for integrating sea level rise in Local Coastal Programs and Coastal Development Permit applications are described in the following chapters.

Drivers of Global SLR

Expansion of ocean water as temperature increases

Addition of freshwater to the ocean from melting glaciers and ice sheets

Addition of freshwater to the ocean from groundwater extraction, use, and discharge

Drivers of Local/Regional SLR Variability

Vertical land movement

Oceanographic phenomena including El Nino Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO)

Physical Impacts of SLR

Inundation (permanent wetting)

Flooding (temporary wetting)

Increased erosion and bluff collapse

Increased tidal prism

Increased wave heights and force

Increased saltwater intrusion

Change in sediment movement patterns

Summary of Consequences of SLR for Coastal Resources & Development

Coastal Development: Greater likelihood of tidal damage, flooding, inundation, and extreme waves, which could lead to loss of property or physical injury; instability from increased erosion and loss/movement of beach sand; increased areas exposed to a 100-year flood.

Public infrastructure: Low-lying roads, wastewater treatment facilities, energy facilities, stormwater infrastructure, potable water systems, and electricity transfer systems are at risk of inundation and flooding, and impaired function. Infrastructure located on eroding bluffs is also subject to increased geologic hazards.

Coastal Agriculture: Increase in flooding and inundation of low-lying agricultural lands; saltwater intrusion into agricultural water supplies; potential decrease in amount of freshwater available for agricultural uses, or inability of wetlands to keep pace vertically with rising water levels.

Public Access & Recreation: Loss of beach areas where beaches cannot migrate inland due to development; inaccessibility of public accessways and recreation sites due to flooding and erosion.

Coastal Habitats: Transformation of habitats as intertidal zone shifts inland; loss of wetlands and other habitats where areas cannot migrate up or inland due to inland barriers such as coastal development.

Water Quality: Coastal water quality could decrease due to inundation of toxic soils and an increase in nonpoint source pollution from flooding. Rising seas could also impact wastewater facilities and cause salt water intrusion into groundwater supplies.

Biological productivity of coastal waters: Sea level rise could affect biological productivity of coastal waters by changing the types of habitats that are available. This change could alter species compositions, and could potentially result in cascading effects through the coastal food chain.

Cultural Resources: Archeological and paleontological sites, including many Native American villages, religious and ceremonial locations, burial sites, and other areas could be at risk from sea level rise.

Figure 8. Summary of sea level rise impacts and consequences

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Chapter 5

Addressing Sea Level Rise in Local Coastal Programs

The Coastal Act requires that the 61 cities and 15 counties in coastal California prepare Local Coastal Programs (LCPs) to govern land use and development in the coastal zone inland of the mean high tide. LCPs become effective only after the Commission certifies their conformity with the policies of Chapter 3 of the Coastal Act.

LCPs contain the ground rules for future development and protection of resources in the coastal zone. Each LCP includes a Land Use Plan (LUP) and an Implementation Plan (IP). The LUP specifies the kinds, locations, and intensity of uses, and contains a required Public Access Component to ensure that maximum recreational opportunities and public access to the coast is provided. The IP includes measures to implement the LUP, such as zoning ordinances. LCPs are prepared by local governments and submitted to the Coastal Commission for review for consistency with Coastal Act requirements.[21]

Once an LCP's certification becomes effective, the local government becomes responsible for reviewing most Coastal Development Permit (CDP) applications. However, the Commission retains continuing permit authority over some lands (for example, over tidelands, submerged lands, and public trust lands) and authority to act on appeals for certain categories of local CDP decisions.

To be consistent with the Coastal Act hazard avoidance and resource protection policies, it is critical that local governments with coastal resources at risk from sea level rise certify or update Local Coastal Programs that provide a means to prepare for and mitigate these impacts. The overall LCP update and certification process has not changed. Now, however, the impacts of accelerated sea level rise should be addressed in the hazard and coastal resource analyses, alternatives analyses, community outreach, public involvement, and regional coordination. This Guidance is designed to complement and enhance the existing LCP certification and update steps. Although the existing LCP certification and update processes are still the same, sea level rise calls for new regional planning approaches, new strategies, and enhanced community participation.

LCPs are essential tools to fully implementing sea level rise adaptation efforts. Since many existing LCPs were certified in the 1980s and 1990s, it is important that future amendments of the LCPs consider sea level rise and adaptation planning at the project and community level, as appropriate. The *California Climate Adaptation Strategy* (CNRA 2009) and *Safeguarding California* (CNRA 2014) specifically identify LCPs as a mechanism for adaptation planning along the California coast. For general guidance on updating LCPs, see the LCP Update Guide, available here: http://www.coastal.ca.gov/la/lcp.html.

[21] In addition there are other areas of the coast where other plans may be certified by the Commission, including Port Master Plans for ports governed by Chapter 8 of the Coastal Act, Long Range Development Plans for state universities or colleges, and Public Works Plans for public infrastructure and facilities. Following certification of these types of plans by the Commission, some permitting may be delegated pursuant to the Coastal Act provisions governing the specific type of plan.

Steps for Addressing Sea Level Rise in Local Coastal Programs and Other Plans

The Commission recommends the following six steps to address sea level rise as part of the development of an LCP, LCP Amendment, or other plan.[22] These steps can be modified and adapted to fit the needs of individual planning efforts and communities and to address the specific coastal resource and development issues of a community, such as addressing bluff erosion or providing for effective redevelopment, infill, and concentration of development in already developed areas. At the start of an LCP update to address sea level rise or a new LCP project, local government planners should contact their local Coastal Commission district office to discuss the LCP goals and to establish a plan for Coastal Commission staff coordination and public involvement throughout the entire process. A key element of any LCP project is public involvement. This can include establishing technical and community stakeholder advisory committees, establishing an interdepartmental sea level rise team of City and County staff representatives, and planning a series of public workshops to gather feedback, in addition to the required public hearings on the LCP.

The steps of this process are illustrated in Figure 9 and described below. They are similar to the standard steps of a long-range planning process and should be familiar to local planners. Steps 1-3 are often referred to as a "sea level rise vulnerability assessment" in other sea level rise planning contexts and therefore are similar to other sea level rise-related resources.

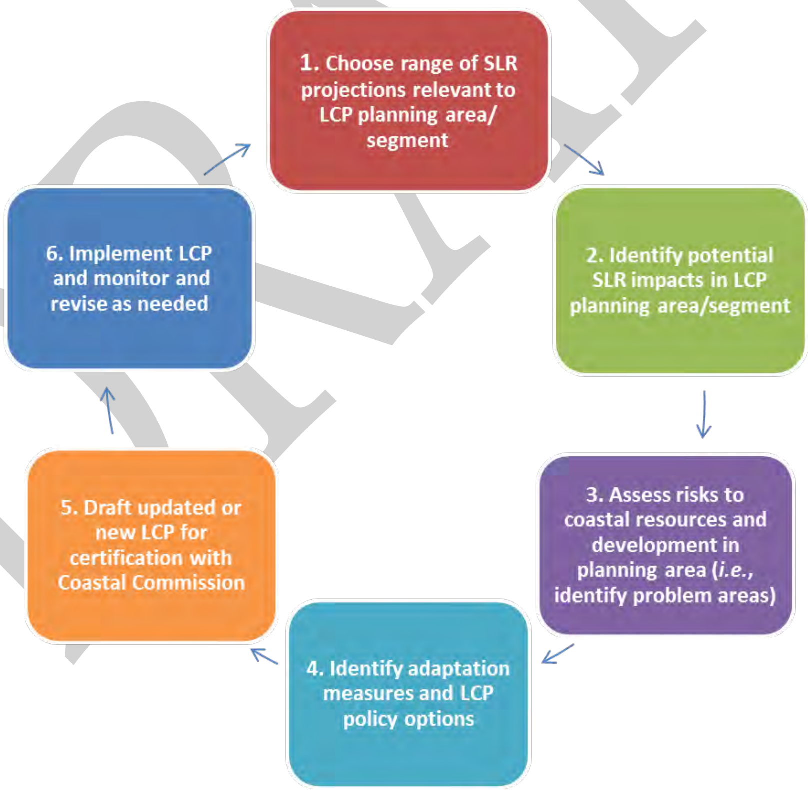

Figure 9. Sea level rise adaptation planning process for new and updated Local Coastal Programs

[22] This Guidance uses the term 'LCP process' to refer to the LCP process, but many of the concepts included here are applicable to other planning processes, including Long Range Development Plans, Public Works Plans, and Port Master Plans.

The Coastal Commission also offers a *Local Coastal Program (LCP) Update Guide* (2013b) that outlines the broad process for amending or certifying an LCP, and there is naturally some overlap between the content of that document and this sea level rise guidance document. The general LCP amendment steps are outlined below, in a flow chart (see Appendix D), and in the LCP Tips/Best Practices document (2013c), which is available in the *Resources for Local Governments* section of the Commission's website. Local governments should contact the Coastal Commission planner for their area when pursuing a new LCP or LCP amendment.

1. **Initial Amendment scoping and development:** Conduct issues assessment, identify need for amendment, prepare preliminary draft, coordinate with Commission staff, and share early drafts
2. **Local Amendment process:** Notify public, conduct local outreach and hearings, meet with Commission staff to discuss any issues, and adopt LCP at the local level
3. **Prepare Submittal:** assemble LCP materials, discuss with Commission staff prior to submittal, transmit to Coastal Commission, and make available to public
4. **Process Amendment at Coastal Commission:** Commission staff will review submittal within 10 working days for completeness; will address outstanding information needs; will prepare and write staff report; hold public hearing and vote; and transmit action to local government
5. **Effectuate Amendment:** Local acceptance of any modifications or resubmittal within 6 months, finalize local approval, and complete Coastal Commission Executive Director check-off
6. **Implement LCP Amendment, monitor and revise as necessary.**

The step-by-step process for incorporating sea level rise into LCPs outlined in the rest of this chapter fits into these broader LCP amendment steps. Local government planners should use the LCP Update Guide in conjunction with the sea level rise guidance to inform the LCP.

Use scenario-based analysis

The Guidance recommends using a method called "scenario-based analysis" (described in Chapter 3 of this Guidance). Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple sea level rise amounts, plus extreme water levels from storms and El Niño events. The goal of scenario-based analysis for sea level rise is to understand where and at what point sea level rise, and the combination of sea level rise and storms, pose risks to coastal resources or threaten the health and safety of a developed area. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise. For example, if there are large changes in the hazard zones between two sea level rise amounts, additional analyses may help determine the tipping points when viable land uses will change. In general, scenario-based analyses can help determine the long-term compatibility of certain areas with certain land uses. For further description of this method, see Chapter 3.

Include other topics as applicable or desired

This Guidance recommends a number of analyses that will generate useful information related to sea level rise and other environmental vulnerabilities. Performing these analyses (and the overall planning process) may provide a useful opportunity to include other studies that will complement the goals of Local Coastal Programs and provide valuable insights for community concerns. For example, planners could expand the Coastal Act consideration of lower cost visitor serving facilities to include considerations of social equity and environmental justice in the analyses by determining how climate hazards or the adaptation measures might differentially impact various demographics. Additionally, planners may want to incorporate analysis of the economic implications of various options for adaptation. Important topics such as these should be incorporated into the analyses already underway for the sake of efficiency.

Leverage analyses and share information with other planning-related processes and documents

Sea level rise is addressed in many other planning-related documents and by many other agencies and organizations. Planners should be aware of these documents and the on-going work of state and federal agencies and make an effort to share information in cases where analyses required for some of these documents may overlap with the studies appropriate for sea level rise planning in LCPs. Additionally, these agencies, organizations, and planning efforts may be good resources from which to gather information when performing these analyses for LCP updates.

For example, there is overlap between the required elements of a Local Hazard Mitigation Plan (LHMP) and Local Coastal Programs, and the Commission recommends coordinating an LHMP update with an LCP update if possible. As part of an LHMP, local governments identify the natural hazards that impact their community, identify actions to reduce the losses from those hazards, and establish a coordinated process to implement the plan.[23] In order to be eligible for certain types of non-emergency disaster assistance, including funding for hazard mitigation projects, local governments are required by FEMA to complete an LHMP[24] and to update the plan every 5 years. Any sea level rise hazard avoidance strategies included in an LCP certification or update, such as relocation of critical facilities must be included in the LHMP narrative to be eligible for funding from FEMA to implement future projects. If a local government has recently updated their LHMP, the city or county can add narrative information on sea level rise strategies through an addendum to the plan, referred to by FEMA as an annex.[25]

In many cases, the analyses and adaptation options identified in this Guidance could be used for hazard mitigation plans or vice versa, as the goal of each of these planning processes is to minimize or avoid impacts from coastal hazards. As a result, there may be opportunities to

[23] http://www.fema.gov/media-library-data/20130726-1524-20490-5927/67fr8844.pdf

[24] Note that recent revisions to the State Mitigation Plan Review Guide, set to go into effect in March 2016, will require states to analyze the probability and possible impacts due to future hazard events in a way that includes the projected changes in natural hazards resulting from climate change. Failure to include such considerations may result in a state's ineligibility for certain non-emergency mitigation grants.

[25] For more information on how to complete or update an LHMP, visit http://hazardmitigation.calema.ca.gov/ or contact the Cal OES office and a hazard mitigation technical expert can assist local governments with the planning process. For contact information, visit http://hazardmitigation.calema.ca.gov/contact.

leverage funding and share work efforts. A number of other similar planning processes, projects, and documents are listed in Figure 10, and planners may be able to use these studies in the LCP planning process, or, alternatively, share analyses and information performed for LCP planning with the groups working on related projects. In any case, information sharing is highly recommended to promote efficiency.

Coordinate regionally as appropriate

Many impacts of sea level rise will transcend jurisdictional boundaries. Similarly, the adaptation decisions made by coastal communities could themselves have consequences that affect areas outside the local jurisdiction. For these reasons, regional coordination will often enhance the effectiveness of local adaptation decisions. Indeed, many of the projects identified in Figure 10 have taken this regional approach. Planners should keep this concept in mind as they work through these steps and coordinate regionally where appropriate and possible.

Representative Adaptation Planning Stakeholders

Agencies

Local/Regional:

- City/county governments
- League of Cities
- Association of Counties
- Regional entities (e.g., air districts, water boards, metropolitan planning organizations, regional transportation planning agencies)

State:

- Natural Resources Agency
- Ocean Protection Council
- CA Coastal Commission
- State Coastal Conservancy
- State Lands Commission
- SF Bay Conservation & Development Commission
- Office of Planning & Research
- Caltrans
- Office of Emergency Services
- CA Geologic Survey
- Dept. of Parks and Rec.
- Dept. of Fish and Wildlife
- Dept. of Water Resources
- State Water Resources Control Board
- Air Resources Board
- Dept. of Conservation

Federal:

- FEMA
- EPA
- US Fish and Wildlife Service
- NOAA
- Gulf of the Farallones NMS
- Monterey Bay NMS
- SF Bay NERR
- Elkhorn Slough NERR
- Tijuana River NERR
- US Geologic Survey
- US Army Corps of Engineers
- BOEM, BSEE
- National Park Service
- Sea Grant

Partner Organizations

- Non-Government Organizations (e.g., environmental, social)
- Professional organizations (e.g., agricultural, fisheries, communications)
- Science organizations
- Universities
- Private consultants/industry

Examples include:

- The Nature Conservancy
- Surfrider Foundation
- Coastkeeper Alliance
- Center for Ocean Solutions
- Point Blue Conservation Science
- Pacific Institute
- Natural Capital Project
- American Society of Adaptation Professionals

Coordinated Planning Efforts

Regional Environmental Efforts

- Our Coast Our Future (CoSMoS)
- So. CA Coastal Impacts Project (CoSMoS)
- Humboldt Bay SLR Adaptation Working Group
- Monterey Bay Adaptation Group
- LA Regional Adaptation Group
- Coastal Resilience Ventura
- San Diego Regional Climate Collaborative
- Santa Barbara and Ventura Co. resilience planning

Local/Regional Plans

- Local Hazard Mitigation Plans
- General Plans
- Climate Action Plans
- Capital Improvement Plans/Programs
- Climate Change Adaptation Plans
- Integrated Regional Water Management Plans
- Regional Sediment Management Plans
- Sustainable Community Plans
- Regional Transportation Plans

Figure 10. Agencies, organizations, and planning efforts related to sea level rise adaptation

Step 1 – Determine range of sea level rise projections relevant to LCP planning area/segment

The first step in incorporating sea level rise into the LCP planning process is to identify locally relevant sea level rise scenarios that may occur at given time steps into the future. These scenarios will be carried through the rest of the steps in the sea level rise LCP planning process. Follow these steps to determine the locally relevant sea level rise projections to use in the subsequent steps:

- **Determine planning horizons of concern:** The National Research Council (NRC) report for California uses the time periods of 2030, 2050, and 2100 to project future sea levels. These time periods may be used, or local governments may identify other relevant planning horizons for their plans and development scenarios, as long as the projections for those time frames are based on the best available and relevant scientific projections.

- **Determine the full range of sea level rise projections from the best available science:** Using best available science, currently the NRC report (or other comparable study, provided that it is peer reviewed, widely accepted within the scientific community, and locally relevant), determine the range of sea level rise for the planning horizons of concern. The sea level rise projections from the NRC 2012 report are presented in Table 4 below. If the planning horizon of concern extends past Year 2100, extrapolate from the NRC projections (See Appendix B for more details on this step). See below for a discussion of scenario-based planning in the LCP context. The LCP should include a policy to use the best available science about sea level rise.

  For parts of the Humboldt Bay region and Eel River Estuary, modify projections for vertical land motion:[26] For project locations in the vicinity of Humboldt Bay and the Eel River Estuary, the regional NRC sea level rise projections will need to be modified to adjust for local vertical land motion (VLM).[27] Areas other than Humboldt Bay and Eel River Estuary may choose to undertake an adjustment for vertical land motion. However, since local trends generally follow the regional land trend for most coastal areas, this VLM adjustment is not necessary.[28] Since actual VLM is the combination of several

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[26] Vertical land motion describes the subsidence or uplift of land and is caused by different processes, including tectonic activity, sediment compaction, groundwater or other fluid withdrawal and recharge, and glacial isostatic rebound. Land North of Cape Mendocino is generally found to be rising at a rate of 1.5- 3.0mm/year, with the exception of parts of Humboldt Bay and the Eel River Estuary, which is subsiding. Land South of Cape Mendocino is subsiding at a rate of ~1mm/year, with variation in areas South of Cape Mendocino from -3.7 mm to 0.6 mm/year (NRC 2012, p. 78).

[27] See Appendix B and *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on VLM and sea level rise projections for the Humboldt Bay region.

[28] A three-member subcommittee of the OPC Science Advisory Team (OPC-SAT) advised using the NRC projections, without modification, for all California locations except between Humboldt Bay and Crescent City. The OPC-SAT subcommittee stated, "We do not believe that there is enough certainty in the sea level rise projections nor is there a strong scientific rationale for specifying specific sea level rise values at individual locations along California's coastline" (OPC 2013, p. 10).

unrelated factors, such as seismic events, water withdrawals, and glacial isostatic rebound, historic trends may not be a good indicator of future change. Thus, if sea level rise projections are modified for areas other than the Humboldt Bay region and the modified projections are lower than the unmodified NRC projections, at least one scenario for the analysis of impacts should use the high value from the unmodified NRC projections in order to assess a potential worst-case scenario possibility.

Table 4. Sea Level Rise Projections for California (NRC 2012)

TIME PERIOD*	NORTH OF CAPE MENDOCINO	SOUTH OF CAPE MENDOCINO
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)

*with Year 2000 as a baseline

- **Choose multiple sea level rise scenarios based on range of sea level rise projections.** The Coastal Commission recommends all communities evaluate the impacts of the highest water level conditions that are projected to occur in the planning area. Local governments may also consider including higher scenarios (such as a 6.6 ft (2 m) scenario[29]) where severe impacts to Coastal Act resources and development could occur from sea level rise. In addition to evaluating the worst-case scenario, planners need to understand the minimum amount of sea level rise that will cause impacts for their community, and how these impacts will change over time, with different amounts of sea level rise. Planners should evaluate enough scenarios to be able to answer the following:
  - What are the impacts from the worst-case scenario of the highest possible sea level rise plus elevated water levels from high tide, El Niño and a 100-year storm?
  - What is the minimum amount of sea level rise that causes inundation, flooding, or erosion concerns?
  - How do inundation, flooding, and erosion concerns change with different amounts of sea level rise?
  - Are there any tipping points where sea level rise impacts become more severe? (For example, is there a point at which seawalls or levees are overtopped?)

  There are two main ways to choose scenarios from which to evaluate sea level rise: by sea level rise amount or by time-period. Tools that provide maps by sea level rise amount can then be linked to the relevant time period, as shown below in the *Our Coast Our Future* example. There is not one accepted sea level rise mapping methodology for the

[29] The *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris *et* al. 2012) establishes 6.6 ft (2 m) as the highest global sea level rise scenario for Year 2100.

state of California. Local governments can choose whether to use existing sea level rise tools or to develop their own scenarios and maps. See below for information on scenarios and modeling outputs generated by existing sea level rise modeling tools.

Examples of Choosing Scenarios with Existing Sea Level Rise Modeling Tools

For California, there are two primary methods for identifying sea level rise scenarios, based on two of the currently available SLR mapping tools: CoSMoS (Our Coast Our Future) and Coastal Resilience Ventura (The Nature Conservancy). The type of tool available for sea level rise mapping in a planning area can be a deciding factor for which scenarios to use in the analysis. The Coastal Commission recommends using as many scenarios as necessary to fully analyze the potential impacts to coastal resources, human health and safety rather than a specific tool or number of scenarios. Examples for choosing scenarios based on the tools available are described below.

Example 1: Identify SLR amounts, then relate to likely time period(s) of occurrence

This method involves first examining different amounts of sea level rise and storm events, and second, looking at the NRC projections to determine the range of years during which those impacts could potentially occur. For example, the Our Coast Our Future CoSMoS-based tool provides sea level rise maps for 9 different amounts in 25 cm (0.8 ft) intervals, three different storm scenarios (annual, 20-year, and 100-year), and a king tide scenario. With this tool, users can first evaluate different amounts of sea level rise and storms, determine how different amounts of sea level rise and storm situations affect the planning area, and then can determine when the increased water level is likely to occur based on the NRC report projections. The CosMoS tool is currently available for Marin, Sonoma, and San Mateo Counties, and preliminary data will be available from Point Conception to the Mexico Border in Fall of 2015. The NOAA Sea Level Rise and Coastal Flooding Impacts viewer similarly provides maps for different amounts of sea level rise (in this case, in 1-ft increments), but does not include impacts from storms, erosion or waves. A methodology for adding in these additional impacts is described in Appendix B.

Example 2: Choose applicable years, then identify high, intermediate, and low scenarios

For this method, planners pick specific years, determine the range of sea level rise amounts that could occur by that year, and examine the consequences of three or more sea level rise amounts within that range. For example, the Coastal Resilience Ventura Tool (The Nature Conservancy) provides maps showing inundation, flooding, wave impact zone, and erosion risk zones with low, medium, and high sea level rise scenarios for the years 2030, 2060, and 2100. For local governments within Ventura County, planners may choose to evaluate scenarios according to the 2030, 2060, and 2100 time periods. The model provides maps for both flooding and erosion.

Expected outcomes from Step 1: *Upon completing this step, a range of regionally- or locally-relevant sea level rise projections for the time periods of concern should be established. Based on the range of projections, planners will have identified a low, high, and one or more intermediate projections. These projections are the sea level rise scenarios that will be carried through the rest of the planning process.*

Step 2 – Identify potential physical sea level rise impacts in LCP planning area/segment

The next step is to identify the physical hazards and impacts (referred to comprehensively as sea level rise impacts) associated with current and future sea level. As described in Section C of Chapter 3 of this Guidance, broad categories of sea level rise impacts may include inundation, flooding, wave impacts, erosion, and saltwater intrusion. In this step, planners should analyze these physical impacts and their various sub-components in order to understand current and future local hazard conditions. The analysis should answer the following basic questions:

- What are the existing hazard conditions that threaten the planning area?
- What is the projected change in hazard conditions due to locally appropriate sea level rise projections and planning horizons of concern?

This analysis should include the following topics, as applicable:

- Local Water Conditions (See Appendix B for a detailed methodology)
  - Current tidal datum[30] and future inundation
  - Water level changes from storm surge, atmospheric pressure, the Pacific Decadal Oscillation (PDO), the El Niño Southern Oscillation (ENSO), and/or other basin-wide phenomena
  - Wave impacts and wave runup, including wave runup from a 100-year storm, and based on tides, other water level changes, and future beach and bluff erosion
  - Flooding from extreme events such as storms with intervals greater than 100 years, tsunamis, *etc.*
- Shoreline change (See Appendix B for more information)
  - Current shoreline erosion rates. For future cliff and dune erosion rates, modify historic erosion rates, to account for the influence of sea level rise (*e.g.*, work by the Pacific Institute – Heberger *et al*. 2009; Revell *et al*. 2011). If possible, modify long-term beach erosion rates to account for changes in El Niño frequency, storm intensity, sediment supply or changing transport conditions. Analyzing wetland responses to sea level rise may require site-specific analyses of various physical and biological factors as described in Heberger *et al.* 2009.
  - Sedimentation rates
- Water quality
  - Current and future saltwater intrusion areas

[30] Tidal datums are based on the latest National Tidal Datum Epoch (NTDE) published by NOAA and are the mean of the observed sea levels over a 19-year period. The latest published epoch is 1983-2001. This tidal epoch can be considered equivalent to the year 2000 baseline for the NRC projections.

- Current and potential future coastal water pollution issues due to inundation of toxic soils, rising water tables, and increases in nonpoint source pollution

Use existing models, tools, reports, historic records, and other materials (Table 5) to develop or double check the identified hazard areas. Document the current and future hazard areas in the Land Use Plan using maps, GIS products, graphics, tables, charts, figures, descriptions, or other means. This process should be repeated for each planning horizon and/or sea level rise scenario defined in Step 1.

Expected outcomes from Step 2: *Upon completing this step, the potential current and future impacts to the planning area from sea level rise hazards should be identified based on sea level rise projections. These should include impacts from the high, low, and intermediate sea level rise scenarios for the planning horizon(s) of concern. Maps, GIS layers, graphics, figures, charts, tables, descriptions, or another system should be developed to communicate the impacts of current and future hazards.*

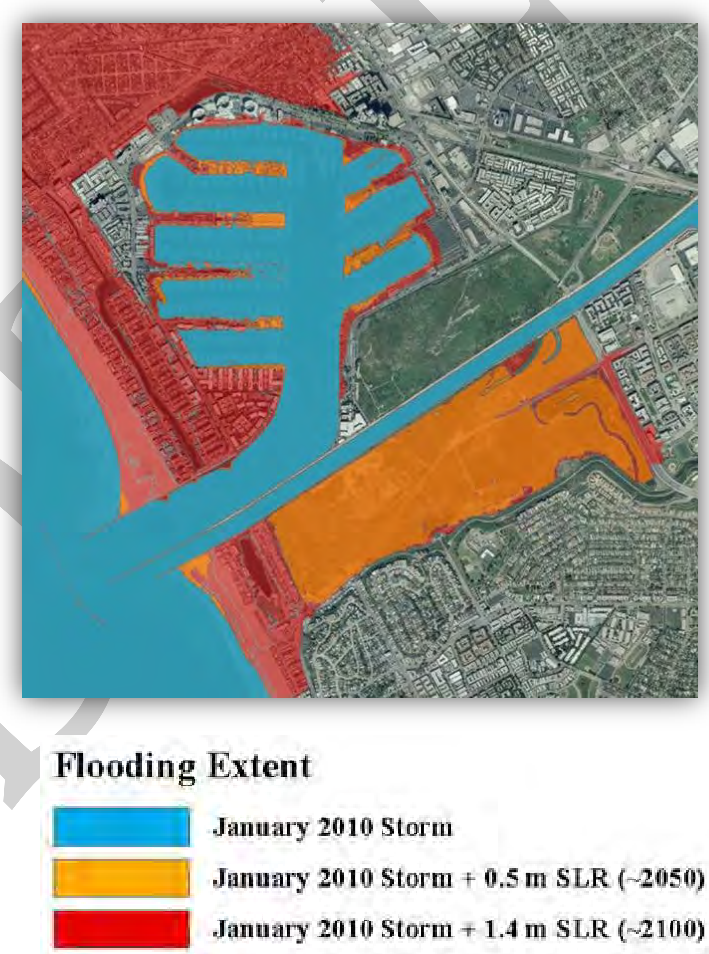

Figure 11. Example of analysis of SLR impacts. Flooding hazards predicted from the CoSMoS hindcast of the January 2010 storm, with and without sea level rise (SLR) scenarios, in the region of Venice and Marina del Rey, CA. (*Source*: Barnard *et al.* 2014).

Resources for Sea Level Rise Mapping

Table 5 includes a list of sea level rise mapping tools. The tools vary in their complexity: some are considered "bathtub models," because they show future inundation with simple rise in sea level (and no changes to the shoreline caused by other forces). Others include factors like erosion, storms, and fluvial inputs. These tools provide a useful first look at possible sea level rise impacts, but may need to be supplemented with additional, site- or topic-specific analyses, depending on the region. See Appendix B for additional information on determining hazard impacts and tools for mapping sea level rise.

Table 5. Sea Level Rise Mapping Tools

Tool	Description	Link
Statewide		
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels with a slider bar. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	NOAA Office for Coastal Management, http://coast.noaa.gov/digitalcoast/tools/slr
Cal-Adapt – Exploring California's Climate	Shows coastal areas that may be threatened by flooding from a 4.6 ft (1.4 m) rise in sea level and a 100-year flood event. Maps were developed using the Pacific Institute SLR Maps (see below) and do not currently include any influence of beach or dune erosion or existing protective structures.	http://cal-adapt.org/sealevel/
Pacific Institute Sea Level Rise Maps	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise, population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report *The Impacts of Sea-Level Rise on the California Coast* visit: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

Climate Central Surging Seas	Overlays sea level rise data with socio-economic information and ability to analyze property values, population, socio-economic status, ethnicity, and income or areas at risk. Can compare exposure across the state or a county.	http://sealevel.climatecentral.org/ssrf/california
North Coast		
Humboldt Bay Sea Level Rise Adaptation Project	This project is a multi-phased, regional collaboration. Phase I produced the *Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment* which describes current shoreline conditions and vulnerabilities under the current tidal regime. Phase II included hydrodynamic modeling to develop vulnerability maps of areas surrounding Humboldt Bay vulnerable to inundation from existing and future sea levels. Phase II produced the *Humboldt Bay Sea Level Rise Modeling Inundation Mapping Report* and the *Humboldt Bay Sea Level Rise Conceptual Groundwater Model*.	All reports are available at: http://humboldtbay.org/humboldt-bay-sea-level-rise-adaptation-planning-project
North Central Coast		
Our Coast Our Future Project (Bodega Head to Half Moon Bay), including the Coastal Storm Modeling System (CoSMoS)	Provides online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms, including seamless Digital Elevation Model (DEM) at 6.6 ft (2 m) horizontal resolution; 9.8 in (25 cm) increment sea level rise projections between 0-6.6 ft (0-2 m) with a 16.4 ft (5 m) extreme; storm scenarios using the Coastal Storm Modeling System (CoSMoS); and interactive maps overlaying infrastructure and ecosystem vulnerabilities.	http://data.prbo.org/apps/ocof/

Southern Coast		
Coastal Resilience Ventura	A partnership to provide science and decision-support tools to aid conservation and planning projects and policymaking to address conditions brought about by climate change within the County of Ventura. The primary goals of Coastal Resilience Ventura are assessing the vulnerabilities of human and natural resources, and identifying nature-based solutions.	http://coastalresilience.org/geographies/ventura-county
Southern California Coastal Impacts Project, including the Coastal Storm Modeling System (CoSMoS)	A numerical modeling system to predict coastal flooding due to both sea level rise and storms driven by climate change; conditions will be specifically selected for and downscaled to the southern California region (from Point Conception to the US-Mexico border, including the Channel Islands and coastal embayments). This version will take into account shoreline change and fluvial inputs; additionally, even more robust modeling of coastal erosion and shoreline change will be provided for the Los Angeles region.	http://walrus.wr.usgs.gov/coastal_processes/cosmos/

Step 3 – Assess potential risks from sea level rise to coastal resources and development in LCP planning area/segment

After sea level rise impacts are identified and mapped in Step 2, the next Step is to determine whether sea level rise poses any risks, or potential problems, for coastal resources and development in the LCP planning area (refer to Chapter 4 for a description of the potential consequences of sea level rise for coastal resources). Next, assess whether the LCP planning area's current and planned land uses are appropriate or consistent with Coastal Act or LCP policies given those impacts, or if those land uses should be revised. This step requires an understanding of several characteristics of the coastal resources and development typically found within various land use types. (Much of this information can be produced in a vulnerability assessment, an analysis that is commonly conducted in the planning and climate change adaptation field. See Appendix C for a list of recent sea level rise vulnerability assessments.) Consider coastal development and resources, including but not limited to:

- Existing and planned development
- Coastal-dependent development and uses such as harbors, wharfs, ports, marinas, and commercial and recreational fishing areas and facilities
- Critical infrastructure such as wastewater treatment plants, transportation infrastructure, and power plants and energy transmission infrastructure
- Public accessways, beaches and other recreation areas, and the California Coastal Trail
- State Highway 1, 101, and other state and local roads that provide access to the coast
- Wetlands, environmentally sensitive habitat area (ESHA), and other coastal habitats and sensitive species
- Agricultural areas
- Cultural sites and archaeological or paleontological resources
- Visitor-serving development and uses

Conduct the following tasks for each planning horizon (*e.g.*, the years 2030, 2050, and 2100, or other planning horizons):

1. For the planning horizon of interest, determine what development and coastal resources may be subjected to the sea level rise impacts expected for that time period. Map the coastal resources and development that lie within the sea level rise impact areas for the given time period. (Remember to address the wide range of resources listed above, including both natural resources and development.)

2. Determine if sea level rise impacts are a problem or benefit for each resource, and if so, when and to what degree the resource will be impacted. In some instances, sea level rise may result in the creation of new habitat areas that could help to alleviate impacts from the loss of similar habitat in other locations. However, it is more likely, especially in

heavily urbanized areas, that sea level rise will result in a net loss of habitat unless steps are taken to preserve these systems.

To accomplish this, consider a wide range of characteristics of each resource, including the following. The questions listed under each characteristic might help guide the consideration of each of these characteristics. These questions are meant to be suggestions rather than a standardized approach, and planners may use scientific literature, best professional judgment, or a variety of other resources to gain a conceptual understanding of the important resources and vulnerabilities in their jurisdictions.

a. **Exposure.** Will sea level rise impacts affect the resource/development at all?
    i. Are coastal resources and community assets exposed to sea level rise impacts?
    ii. Is the resource already exposed to hazards such as waves, flooding, erosion, or saltwater intrusion? If it is, will sea level rise increase hazard exposure?

b. **Sensitivity.** If resources are exposed, to what degree will coastal resources/development be affected by sea level rise impacts? A simple way to think about this concept is to consider *how easily affected* the resource or development is in regard to sea level rise impacts.
    i. How quickly will the resource respond to the impact from sea level rise?
    ii. Will the resource/development be harmed if environmental conditions change just a small amount? What are the physical characteristics of resource/asset (*e.g.*, geology, soil characteristics, hydrology, coastal geomorphology, topography, bathymetry, land cover, land use)? Do any of those characteristics make the resource especially sensitive?
    iii. Are there thresholds or tipping points beyond which sensitivity to sea level rise increases?

c. **Adaptive Capacity.** How easily can the resource successfully adapt to sea level rise impacts?
    i. How well can the resource/development accommodate changes in sea level?
    ii. Is rate of change faster than the ability of the resource/development to adapt?
    iii. How easily can development be modified to cope with flooding, inundation, and/or erosion? Can structures be elevated or relocated?
    iv. Are there adaptation efforts already underway? Are there any factors that limit the success of adaptation efforts?

v. Do beaches, wetlands and other coastal habitats have room to migrate inland? What is the overall health of existing wetlands and coastal habitats?

vi. Are there any other climate change-related impacts to consider? Are there any non-climate stressors that could impair ability to adapt to sea level rise?

vii. Is there potential for habitat creation as a result of sea level rise?

viii. What are the options to protect, redesign (*e.g.*, elevate), or relocate inland any existing public accessways, recreational beaches, and segments of the Coastal Trail to cope with rising sea levels? Is lateral access compromised with sea level rise?

d. **Consequences.** When sea level rise and/or sea level rise adaptation measures have impact(s) upon a resource, what are the economic, ecological, social, cultural, and legal consequences?

i. How severely could each resource be affected? At what scale?

ii. Are there cumulative consequences?

iii. Are there ripple effects, or secondary consequences to consider?

iv. Will human responses cause further adverse impacts?

e. **Land Use Constraints.** Given the location of sea level rise impacts and the resources currently located in those areas, should the types and intensities of land use be altered to minimize hazards and protect coastal resources?

i. What is the current pattern of development? Is the area largely developed or does it have significant areas of undeveloped land?

ii. Is the area served by infrastructure that is vulnerable to sea level rise impacts?

iii. Are large areas of land under common ownership or is land mostly subdivided into smaller lots in separate ownership?

iv. What conditions does the land use type, development, or resource require to either exist or fulfill its intended purpose?

v. Is it a coastal-dependent use? What is its ideal proximity to the coast?

vi. For new development, what is the expected lifespan? Is it economically feasible to locate it in a sea level rise impact area for a certain period of time before it is removed or relocated?

vii. For existing development, what are the options available to minimize hazards to the development and protect coastal resources? Note that in certain situations, the Coastal Act allows existing structures to be protected (Coastal Act Section 30235). What are the coastal resource impacts of such protection, and are there feasible alternatives that avoid shoreline armoring, such as options to provide incentives to property owners to relocate or remove at-risk structures?

viii. For a natural resource or habitat, what conditions does it require to persist?

ix. Where would resources/development ideally be located after sea level rise causes environmental conditions to shift?

x. What changes to existing LCP requirements or other land use restrictions are necessary to maximize opportunities for avoiding hazards or relocating threatened existing development?

After going through the questions listed above, and others that may be relevant to the planning exercise, synthesize the information and determine where sea level rise impacts currently pose problems for coastal resources, what problems may develop over time as sea level rises, and how urgent the problems are. Create maps illustrating the location and extent of vulnerable land uses, such as critical facilities, wastewater infrastructure, and State Highway 1 and other coastal access roadways. This information can also be summarized in narrative form. The analysis should identify resources and development likely to be impacted by sea level rise at various periods in the future, and thus the issues that need to be resolved in the LCP planning process.

Remember that these assessments are not static; existing risks will change and new risks will arise with changes in a community, the emergence of new threats, new information, and the implementation of adaptation actions. For this reason, the analysis should be updated as needed to reflect changes in sea level rise projections, changes in land use patterns, or new threats.

Expected outcomes from Step 3*: Descriptions of the characteristics that influence risk, including exposure, sensitivity, and adaptive capacity of each coastal resource to sea level rise impacts under each sea level rise scenario identified in Step 1 at the selected planning horizons, along with the expected consequences of those impacts for the resource and broader community. Maps of resources and/or land uses at risk could be produced.*

Example for Step 3

To illustrate the process described in Step 3, consider a hypothetical planning area that includes multiple coastal resources and land use types, including a coastal wetland, bluff-top residential development with a fronting beach, and a wastewater treatment facility, that need to be addressed in the planning process. After Steps 1 and 2, portions of the planning area are found to be subject to current and future sea level rise impacts.

Step 3.1: Map the coastal resources (in this case the wetland, development, and wastewater treatment facility) for the range of time periods and sea level rise projections.

Step 3.2

a. **Exposure**

- *Wetland:* The wetland is highly exposed to flooding and inundation from sea level rise. By the year 2030, portions of the wetland will trap sediment at a rate such that the elevation keeps pace with sea level rise. By 2050, a portion of the wetland will become inundated and converted to open water, and by 2100 the entire area will be converted to open water. The wetland will be completely lost by this time period if it is not able to move inland.
- *Bluff-top Residential Development:* Houses in the residential development are not exposed to sea level rise impacts in 2030. However, a high rate of retreat along the fronting beach and bluff will put front-line houses in danger of being undermined by the year 2050, and the entire development may be lost by 2100.
- *Wastewater Treatment Facility:* Given that the wastewater treatment plant is set back somewhat from the water, it will not be exposed to impacts from sea level rise until 2050. By 2050, however, portions of the infrastructure will be exposed to impacts from elevated water levels due to 100-year storm events and El Niño occurrences. By 2100, significant portions of the facility will be exposed to flooding as the surrounding area is eroded and inundated.

b. **Sensitivity**

- *Wetland:* The wetland has high sensitivity to changes in sea level because its functioning is highly-dependent on local physical parameters such as water flow, tidal fluctuation, sediment supply, and water quality. Although it currently has good sediment supply, good water quality, and a number of other characteristics, small changes in sea level rise by 2050 may alter the function of the wetland. In addition, there are concerns that beyond 2050 the wetland will not be able to keep up with accelerated sea level rise, thus increasing sensitivity to further changes in sea level.
- *Bluff-top Residential Development:* The residential development has moderate to high sensitivity to longer-term sea level rise changes. By 2050, the front-line houses will no longer be safe enough for occupancy. Moreover, infrastructure such as roads, sewage systems, and power networks may be damaged as the bluff-face erodes.
- *Wastewater Treatment Facility:* The facility is moderately sensitive to sea level rise. Flooding and erosion from sea level rise could cause damage of the facility, pumps and

other equipment, but the facility was initially built to withstand a high degree of storm and related impacts.

c. **Adaptive Capacity**

- *Wetland:* Unlike many wetlands in the State of California, this particular wetland has a moderate-high adaptive capacity because it has the ability to both accumulate sediment and grow upwards, and, given that the land upland of the wetland is preserved as open space, it can migrate inland. However, by 2050, a part or all of the existing wetland area could be converted to open water if the wetland is not able to migrate inland or accumulate sediment at a rate that keeps pace with sea level rise. In this case, for example, a public trail will need to be relocated to allow inland migration of the new intertidal zone. Additionally, adaptive capacity may be reduced if pollution increases (*e.g.*, as a result of damage to adjacent development) and disrupts the normal functioning of the wetland.
- *Bluff-top Residential Development:* The residential development has a moderate adaptive capacity. As houses become threatened over time, a scenario of managed retreat would allow houses to be removed incrementally and eventually be relocated to safer areas. The feasibility of managed retreat can depend upon lot sizes, ownership patterns, land use restrictions in the safer areas, and the availability of public or private financing. In addition, a protective structure such as a seawall would minimize threats to the residence due to erosion, though if the development is protected by shoreline structures, the fronting beach will eventually be lost.
- *Wastewater Treatment Facility:* The wastewater treatment facility has a very low adaptive capacity. It is large and has expensive infrastructure so it cannot be elevated, and relocation is costly and difficult. In order to be protected in its current location, new structures will need to be built.

d. **Consequences**

- *Wetland:* In many situations, the loss of wetland area is a high risk since wetlands provide flood protection, water quality enhancement, and essential habitat for fish and bird species. However, in this case, wetland migration is not restricted by inland development, so the risks for this wetland are slight to moderate, depending upon the suitability of the inland area for establishment of wetland plants and potential changes in water temperature and water quality. In the short term, the wetland will likely continue to function at normal levels. However, if it eventually can't keep up with sea level rise or if there are barriers to migration, loss of the habitat will result in a loss of important ecosystem services.
- *Bluff-top Residential Development:* The housing development has medium to high risk through 2100. The option to either relocate houses or protect them with a seawall means that they could continue to exist. Importantly, a system of managed retreat will allow for the continued existence of the fronting beach and all of its social, economic, and environmental benefits, whereas the construction of a seawall will result in the loss of the beach and these benefits.

- *Wastewater Treatment Facility:* Given its low adaptive capacity and high sensitivity to higher levels of sea level rise, the wastewater treatment facility is at high risk. Loss or damage to the facility could result in serious social, economic, and environmental consequences. Flooding of the facility and surrounding areas will cause damage to infrastructure and loss of facility function. This could lead to discharge of untreated sewage, which would have adverse impacts to water quality and could impair the health of nearshore ecosystems. Sea level rise could also cause outflow pipes to back up with seawater, leading to inland flooding and additional water quality problems. However, efforts to protect the structure may have unintended consequences including loss of surrounding habitat areas.

e. **Land Use Constraints (discussed further in Step 4)**

- *Wetland:* The high adaptive capacity of the wetland means that minimizing risk to this resource may be accomplished by ensuring that there is space available for it to move into. Land use policies designed to protect areas inland of the current wetland area will be necessary.
- *Bluff-top Residential Development:* The area in question will eventually become incompatible with the current use. Development will not begin to be exposed to sea level rise impacts until 2050, but it is important to start planning now about how best to address the risks to the houses. Managed retreat would necessitate identifying feasible locations into which houses could be moved or a plan to abandon and remove houses. Such a plan might include a Transfer of Development Rights program in which homes are encouraged in less hazardous areas. If a managed retreat strategy is not in place, existing structures may qualify for shoreline protection. Shoreline protection would likely exacerbate beach erosion, degrade public access, impair shoreline habitat, and alter visual character.
- *Wastewater Treatment Facility:* The biggest risk in this scenario is to the wastewater treatment facility. It should be determined how likely it is that the facility will be able to be protected throughout the rest of its expected lifespan under even the highest sea level rise scenarios. It may be that the wastewater treatment facility becomes an incompatible use under future conditions. If so, plans should be made to relocate at-risk portions of the facility, as feasible, or to phase out the facility.

Note that this is a simplified example used to demonstrate the process described in Step 3. Decisions about how to address various challenges presented by sea level rise will be more complex than that illustrated above and may require prioritizing the different resources based on Coastal Act requirements taking into account the goals and circumstances of the community and the various characteristics of each resource. An understanding of the exposure, sensitivity, adaptive capacity, consequences, and land use constraints for the particular resources and scenarios will need to be kept in mind as planners move into Step 4 to identify possible adaptation strategies. Updated LCP policies and ordinances should be considered to support strategy implementation over the long term.

Step 4 – Identify LCP adaptation strategies to minimize risks

Whether as part of a new LCP or as part of an amendment to update an existing LCP, coastal planners should work with the Coastal Commission and relevant stakeholders at all steps, but particularly to evaluate potential options and adaptation strategies to address the sea level rise impacts identified in Step 2 and the risks to coastal resources identified in Step 3. Managers will then develop new or revised land use designations, policies, standards, or ordinances to implement the adaptation strategies in the LCP.

An LCP as certified by the Commission should already have land use policies, standards, and ordinances to implement Coastal Act Chapter 3 policies, including policies to avoid and mitigate hazards, and to protect coastal resources. However, in older LCPs, many of these policies may not address changing conditions adequately enough to protect coastal resources over time as sea level rises. Similarly, policies to protect resources and address coastal hazards may not reflect new techniques that can be utilized to adaptively manage coastal resources in a dynamic environment. As such, the LCP should be evaluated to identify the land use designations, policies, or ordinances that need to be amended. An LCP update may need to include a variety of adaptation measures depending on the nature and location of the vulnerability. In addition, local governments may need to add new "programmatic" changes to address sea level rise, such as transfer of development credit programs, regional sediment management programs, or a land acquisition program.

In Steps 1-3, planners will have analyzed several possible sea level rise scenarios, and this analysis will have revealed valuable information about areas and specific coastal resources that are especially vulnerable to sea level rise hazards under possible scenarios. The results should show areas that are particularly resilient to future change and trigger points at which sea level hazards will become particularly relevant to certain areas. Step 3d (identifying the *Consequences* of sea level rise impacts) and Step 3e (considering the *Land use constraints*) will be particularly useful in thinking through what resources are particularly vulnerable and what the local priorities may be.

In Step 4, planners should weigh information from the previous steps, keeping in mind the hazard avoidance and resource protection policies of the Coastal Act, and begin identifying, choosing, and/or developing adaptation strategies to be included in a new or updated LCP. The options available to minimize risks from sea level rise are dependent upon the specifics of the local community, and will vary widely depending on whether the area is an urban, fully-developed waterfront, or a rural, undeveloped coastline. In undeveloped areas, the options may be clear: strictly limit new development in sea level rise hazard zones.

However, in urban areas, sea level rise can present unprecedented challenges, and the options are less clear. The Coastal Act allows for protection of certain existing structures. However, armoring can pose significant impacts to coastal resources. To minimize impacts, innovative, cutting-edge solutions will be needed, such as the use of living shorelines to protect existing infrastructure, restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at risk areas to open space, or transfer of development rights programs. Strategies will need to be tailored to the specific needs of each community based on the resources at risk, should be evaluated for resulting impacts to coastal resources, and should be developed through a public process, in close consultation with the Coastal Commission and in line with the Coastal Act.

Adaptation strategies should be selected based upon the local conditions, the results of the scenario-based analysis, and Coastal Act requirements, taking into account the particular goals of the local community. If certain adaptation strategies should be implemented when conditions reach pre-identified trigger points, those caveats should be included in the LCP. Similarly, LCP adaptation policies should be developed and implemented in such a way as to be flexible and adaptive enough that they can be changed or updated as conditions change or if sea level rise impacts are significantly different than anticipated. Additionally, many adaptation strategies should be implemented in a coordinated way through both the LCP and individual CDPs. For example, current land uses that will conflict with future conditions may be amended through updated zoning designations in an LCP. In turn, zoning designations could carry out specific policies or requirements regarding new development or redevelopment that need to be addressed in a CDP to ensure that projects are resilient over time. Planners are encouraged to work with Coastal Commission staff to ensure compliance with the Coastal Act and to coordinate and share information with other local partners including those in charge of emergency management, law enforcement, and related services, and those identified in Figure 10 as applicable and feasible.

A key issue that should be addressed in the LCP is the evaluation of strategies to minimize hazards related to existing development. Under the Coastal Act, certain improvements and repairs to existing development are exempt from CDP requirements. Non-exempt improvements and any repairs that involve the replacement of 50% or more of a structure, however, generally require a CDP and must conform to the standards of the relevant Local Coastal Program or Coastal Act.[31] Redevelopment, therefore, should minimize hazards from sea level rise. For existing structures currently sited in at-risk locations, the process of redeveloping the structure may require the structure to be moved or modified to ensure that the structure and coastal resources are not at risk due to impacts from sea level rise. As described in Guiding Principle 6, sequential renovation or replacement of small portions of existing development should be considered in total. LCPs should include policies that specify that multiple smaller renovations that amount to alteration of 50% or more of the original structure should require a Coastal Development Permit, and require that the entire structure to be brought into conformance with the standards of the Local Coastal Program or Coastal Act.[32]

[31] Section § 13252(b) of the Commission's regulations states that "unless destroyed by natural disaster, the replacement of 50 percent or more of a single family residence, seawall, revetment, bluff retaining wall, breakwater, groin or any other structure is not repair and maintenance under Coastal Act Section 30610(d) but instead constitutes a replacement structure requiring a Coastal Development Permit."

[32] In addition, for existing structures located between the first public road and the sea or within 300 feet of the inland extent of a beach, improvements that increase the height or internal floor area by more than 10% normally require a CDP. (Cal. Code Regs., tit. 14, §§13250(b)(4), 13253(b)(4).) Depending upon the location of the structure, smaller improvements may also require a CDP. (Cal. Code Regs., tit. 14, §§ 13250(b), 13253(b).)

General Adaptation Strategies:

Chapter 7 describes a number of adaptation policies and strategies and is organized by resource type to allow users to easily identify the types of policies that may be relevant to local resource vulnerabilities. However, there are a number of adaption strategies or related actions that apply to a variety of resources or that may be generally useful when adopting or updating an LCP. Some of these adaptation strategies and actions are broadly described below.

- **Update resource inventory and maps**: An important first step for addressing sea level rise hazards and vulnerabilities in a new or updated LCP will be to compile a set of maps that clearly show the current locations of the range of coastal resources present in an LCP jurisdiction (*e.g.*, beaches and public accessways; agricultural land, wetlands, ESHA, and other coastal habitats; energy, wastewater, transportation, and other critical infrastructure; and archaeological and paleontological resources), as well as existing land use designations, and hazard areas. It may also be helpful to map possible future conditions based on the analysis done in Steps 1-3. Doing so will help planners begin to identify possible land use and zoning changes and other adaptation strategies that will be necessary to meet hazard avoidance and resources protection goals.
- **Update land use designations and zoning ordinances**: One of the most common methods of regulating land use is through zoning designations and ordinances, and updating these policies is one of the most fundamental ways of responding to sea level rise impacts. Planners may address particular vulnerabilities and local priorities by updating land use designations and zoning ordinances to protect specific areas and/or resources. For example, areas that are particularly vulnerable to sea level rise impacts can be designated as hazard zones and specific regulations can be used to limit new development and/or encourage removal of existing development in such zones. Similarly, open areas can be designated as conservation zones in order to protect and provide upland areas for wetland and habitat migration or for additional agricultural land.
- **Update siting and design standards**: Updated siting and design standards may go hand in hand with updated land use designations and zoning ordinances in that specific standards may be required for development or projects in certain zones. For example, development in hazard zones may require additional setbacks, limits for first floor habitable space, innovative stormwater management systems, special flood protection measures, mitigation measures for unavoidable impacts, relocation and removal triggers and methodologies, and so on.
- **Establish methods to monitor local changes from sea level rise**: Add policies that establish actions to conduct long-term sea level rise monitoring and research on areas of key uncertainties, areas sensitive to small changes in sea level rise, or areas with high sea level rise risk.
- **Research and data collection**: Support research to address key data gaps and better utilize existing information. Local governments may find it useful to collaborate with local, regional, and state partners to pursue new research to better understand the factors controlling sea level rise, baseline shoreline conditions, ecosystem responses to sea level rise, potential impacts and vulnerabilities, and the efficacy of adaptation tools. Related efforts may include monitoring programs designed to track trends in local shoreline

change, flooding extent and frequency, or water quality. Monitoring of the results of various adaptation strategies and protective structures could be included as part of a Coastal Development Permit for projects in hazard zones.

- **Outreach and education**: Education and outreach efforts involve formal instruction and provision of information to stakeholders, and can help generate for planning and action implementation. It is important to coordinate with partners and include all relevant stakeholders in these processes. For many people, sea level rise is a new issue. Information on sea level rise science and potential consequences may motivate stakeholders to take an active role in updating the LCP for sea level rise issues, or in the vulnerability and risk assessment efforts. Additionally, education efforts regarding the risks of sea level rise as well as possible adaptation strategies may encourage people to take proactive steps to retrofit their homes to be more resilient or to choose to build in less hazardous areas.

As stated above, a more extensive and detailed list of possible adaptation strategies can be found in Chapter 7. The list should neither be considered a checklist from which all options need to be added to an LCP, nor is it an exhaustive list of all possible adaptation strategies. Sea level rise adaptation is still an evolving field and decision makers will need to be innovative and flexible to respond to changing conditions, new science, and new adaptation opportunities. The important point is to analyze current and future risks from sea level rise, determine local priorities and goals for protection of coastal resources and development, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals within the context of the Coastal Act.

Expected outcomes from Step 4*: Identified sections of the LCP that need to be updated, a list of adaptation measures applicable to the LCP, and new policies and ordinances to implement the adaptation measures.*

Step 5 – Draft updated or new LCP for certification with the Coastal Commission

Once potential adaptation strategies have been identified, LCP policies that address sea level rise should be incorporated into a new LCP or LCP amendment. For jurisdictions with a certified LCP, adaptation measures will be implemented through development of amendments to the certified LCPs. For jurisdictions that currently do not have a certified LCP, the sea level rise policies will be part of the development of a new LCP. In areas without a certified LCP, the Coastal Commission generally retains permitting authority, and the standard of review for development is generally Chapter 3 of the California Coastal Act.

As noted in Step 4, sea level rise has the potential to affect many types of coastal resources in an LCP planning area/segment, and it is likely that policies throughout the LCP will need to be revised or developed to address impacts from sea level rise. Two major types of updates to the LCP will likely be needed to address sea level rise:

1. New or revised policies/ordinances that apply to all development in the planning area. For example, policies such as "All new development shall be sited and designed to minimize risks from sea level rise over the life of the structure."
2. Updated land use and zoning designations, as well as programs to facilitate adaptive community responses, to reduce risks to specific coastal resources. For example, the LCP could modify the zoning of undeveloped land located upland of wetlands from residential to open space in order to provide the opportunity for wetlands to migrate inland, and protect wetlands for the future.

Local government staff should work closely with Coastal Commission staff and relevant stakeholders, including ensuring there is opportunity for public input, to develop the new LCP or LCP amendments. Once the updates and plans are complete, local governments will submit to the Commission for certification. The Commission may either certify or deny the LCP or LCP amendment as submitted, or it may suggest modifications. If the Commission adopts suggested modifications, the local government may adopt the modifications for certification or refuse the modifications and resubmit a revised LCP for additional Commission review. For more information on updating LCPs, see http://www.coastal.ca.gov/la/lcp.html.

***Expected outcomes from Step 5**: Certified/updated LCP with policies and land use designations that address sea level rise and related hazards and ensure protection of coastal resources to the maximum extent feasible.*

Step 6 – Implement LCP and monitor and revise as needed

Upon certification of the updated LCP, sea level rise adaptation strategies will be implemented through the certified implementing ordinances and related processes and actions (*e.g.*, local review of CDPs, proactive action plans). Additionally, an important component of successful adaptation is to secure funds for implementation, regularly monitor progress and results, and update any policies and approaches as needed. Sea level rise projections should be evaluated at least every five years.

- **Secure resources for implementation:** There are a number of different sources of funds available to help local governments implement adaptation strategies. For example, the Coastal Commission, the Ocean Protection Council, and the Coastal Conservancy have grant programs designed to support local adaptation efforts (see Chapter 1 for additional details on each of these programs).

  As described previously there may also be overlap between LCP planning and Local Hazard Mitigation planning. FEMA's Hazard Mitigation Assistance (HMA) grant programs provide significant opportunities to reduce or eliminate potential losses to State, Indian Tribal government, and local assets through hazard mitigation planning and project grant funding. Currently, there are three programs: the Hazard Mitigation Grant Program (HMGP); Pre-Disaster Mitigation (PDM); and Flood Mitigation Assistance

(FMA)[33]. Cal OES administers the HMA and FMA programs. More information can be found at http://hazardmitigation.calema.ca.gov/grants or the FEMA HMA Web site at https://www.fema.gov/hazard-mitigation-assistance.

For a list of additional funding options for hazard mitigation compiled by Cal OES, see Appendix E.

- **Identify key resources to monitor:** Certain species can be indicators of whether sea level rise is affecting an ecosystem. For instance, the presence of certain plant species can indicate the salinity of soils. Also, monitoring plans should reflect the outcome of the scenario-based analysis of sea level rise. Some adaptation measures might be earmarked for implementation when a certain amount of sea level rise (or a particular sea level rise impact) occurs. Monitoring programs should ensure that these triggers are recognized and responded to at the appropriate time.

- **Periodically Update LCPs:** Local governments should try to review their vulnerability and risk assessments on a regular basis as significant new scientific information becomes available and propose amendments as appropriate. Given the evolving nature of sea level rise science, policies may need to be updated as major scientific advancements are made, changing what is considered the best available science. Modify the current and future hazard areas on a five to ten year basis or as necessary to allow for the incorporation of new sea level rise science, monitoring results, and information on coastal conditions. Regular evaluation of LCPs is important to make sure policies and adaptation strategies are effective in reducing impacts from sea level rise.

Expected outcomes from Step 6*: Plan to monitor the LCP planning area for sea level rise and other impacts and for effectiveness of various adaptation strategies that are implemented; plan to revise the LCP when conditions change or science is updated.*

This six-step process discussed in this chapter is illustrated in the flowchart below (Figure 12). Notice that the process is circular. Because sea level rise science will be refined and updated in the future, planners should periodically repeat this six-step process to update and improve their LCPs.

For additional resources and examples of ways to incorporate sea level rise into the LCP, see Appendix C.

[33] Each HMA program was authorized by separate legislative action, and as such, each program differs slightly in scope and intent.

Planning Process for Local Coastal Programs and Other Plans

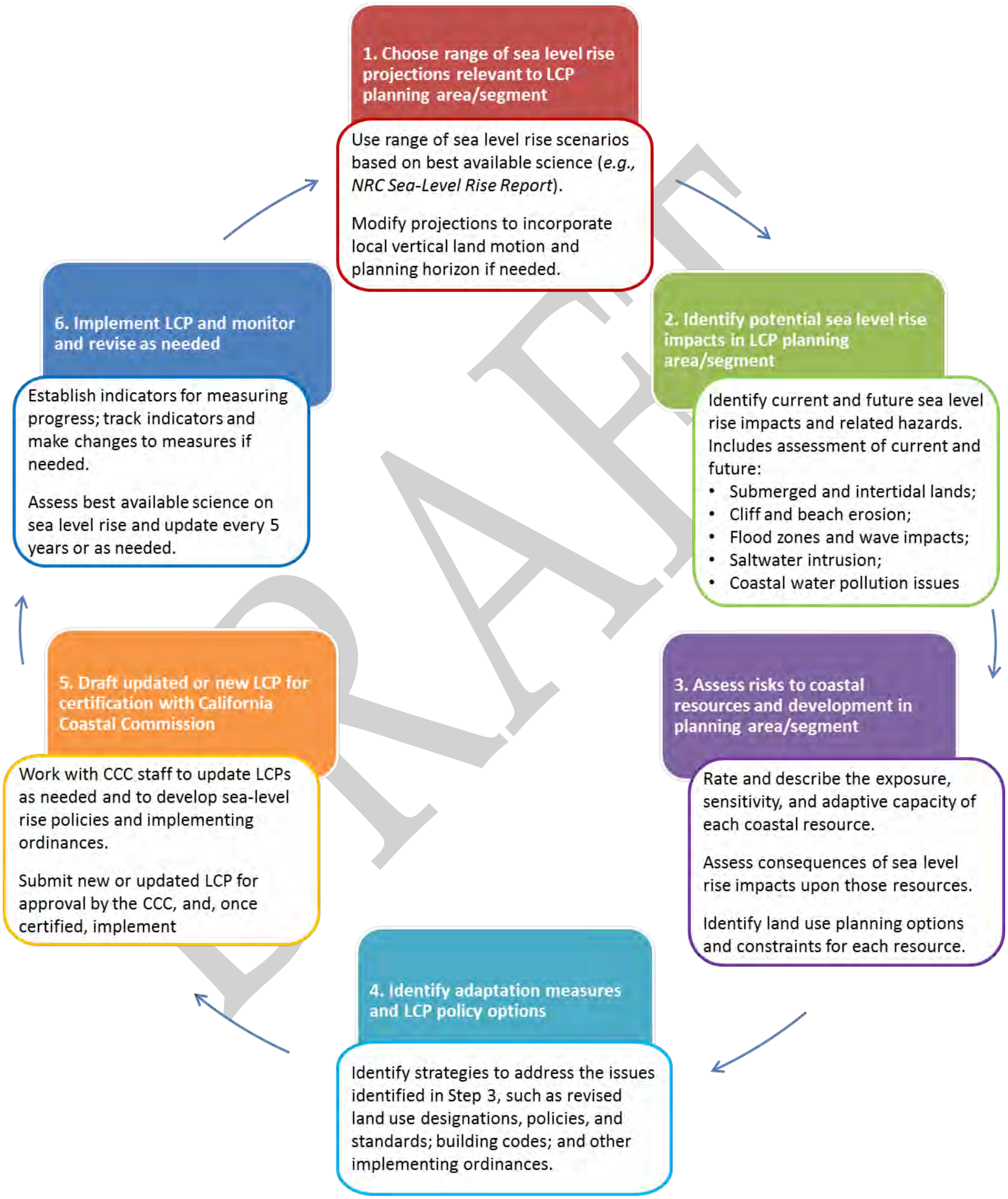

Figure 12. Flowchart for addressing sea level rise in Local Coastal Programs and other plans

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Chapter 6

Addressing Sea Level Rise in Coastal Development Permits

Development in the coastal zone generally requires a Coastal Development Permit (CDP).[34] In areas of retained jurisdiction and areas without a certified Local Coastal Program (LCP), the Commission is generally responsible for reviewing the consistency of CDP applications with the policies of Chapter 3 of the Coastal Act (Public Resources Code Sections 30200-30265.5).[35] In areas with a certified LCP, the local government is responsible for reviewing the compliance of CDP applications with the requirements of the certified LCP and, where applicable, the public access and recreation policies of the Coastal Act. Certain local government actions on CDP applications are appealable to the Commission. On appeal, the Commission also applies the policies of the certified LCP and applicable public access and recreation policies of the Coastal Act.[36] The Commission and local governments may require changes to the project or other mitigation measures in order to assure compliance with Coastal Act policies or LCP requirements by both minimizing risks to the development from coastal hazards and avoiding impacts to coastal resources.

The Coastal Act, the LCP, and the CDP Application cover the broad range of information and analyses that must be addressed in a CDP application. This CDP guidance focuses only on sea level rise and those conditions or circumstances that might change as a result of changing sea level. It does not address other Coastal Act or LCP requirements.

Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where close review of sea level rise concerns is necessary and where it is not. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate.

Sea level rise will be important for some, but not all, of the projects reviewed through the CDP process. Locations currently subject to inundation, flooding, wave impacts, erosion, or saltwater intrusion will be exposed to increased risks from these coastal hazards with rising sea level and will require review for sea level rise effects. Locations close to or hydraulically connected to these at-risk locations, will themselves be at risk as sea level rises and increases the inland extent

[34] Coastal Act Section 30106 defines "Development" to be, "on land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 (commencing with Section 4511)."

[35] The Commission retains CDP jurisdiction below mean high tide and on public trust lands.

[36] Local governments may assume permitting authority even without a fully certified LCP (*see* Public Resources Code, §§ 30600(b), 30600.5), but only the City of Los Angeles has done so. Any action on a CDP application by a local government without a fully certified LCP may be appealed to the Commission. (Public Resources Code, § 30602.)

of these hazards. The following box provides some of the general situations for which sea level rise will need to be included in the project analysis.

General Situations when sea level rise should be considered in the project analysis include when the project or planning site is:

- Currently in or adjacent to an identified floodplain
- Currently or has been exposed to flooding or erosion from waves or tides
- Currently in a location protected by constructed dikes, levees, bulkheads, or other flood-control or protective structures
- On or close to a beach, estuary, lagoon, or wetland
- On a coastal bluff with historic evidence of erosion
- Reliant upon shallow wells for water supply

Many of the projects reviewed through the CDP application process already examine sea level rise as part of the hazards analysis. Such examination will need to continue, and these guidelines offer direction and support for thorough examination of sea level rise and its associated impacts based on current climate science, coastal responses to changing sea level, and consequences of future changes.

To comply with Coastal Act Section 30253 or the equivalent LCP section, projects will need to be planned, located, designed, and engineered for the changing water levels and associated impacts that might occur over the life of the development. In addition, project planning should anticipate the migration and natural adaptation of coastal resources (beaches, access, wetlands, *etc.*) due to future sea level rise conditions in order to avoid future impacts to those resources from the new development. As LCPs are updated to reflect changing conditions and to implement sea level rise adaptation strategies, it will be important that CDPs are also conditioned and approved in ways that similarly emphasize an adaptive approach to addressing sea level rise hazards. Such coordination between LCP and CDP adaptation policies and strategies will help ensure that coastal development and resources are resilient over time.

Steps for Addressing Sea Level Rise in Coastal Development Permits

The steps presented in Figure 13 and described in more detail below, provide general guidance for addressing sea level rise in the project design and permitting process for those projects where sea level rise may be contribute to or exacerbate hazards or impact coastal resources.

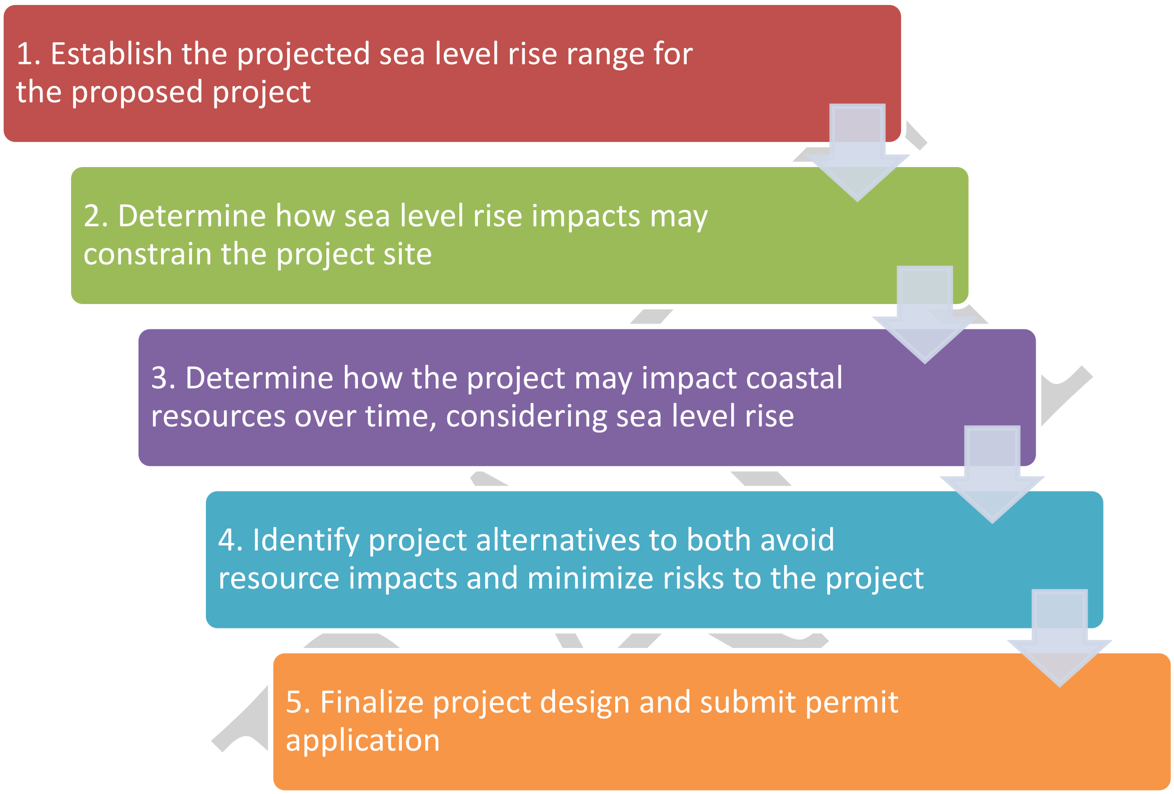

Figure 13. Process for addressing sea level rise in Coastal Development Permits

The goal of these steps is to ensure that projects are designed and built in a way that minimizes risks to the development and avoids impacts to coastal resources in light of current conditions and the changes that may arise over the life of the project. Many project sites and proposed projects may raise issues not specifically contemplated by the following guidance steps or the permit filing checklist at the end of this section. It remains the responsibility of the project applicant to adequately address these situations so that consistency with the Coastal Act and/or LCP may be fully evaluated. There are many ways to evaluate and minimize the risks associated with sea level rise, and the Commission understands that different types of analyses and actions will be appropriate depending on the type of project or planning effort.

Throughout the CDP analysis, applicants are advised to contact planning staff (either at the Commission or the local government, whichever is appropriate) to discuss the proposed project, project site, and possible resource or hazard concerns. The extent and frequency of staff coordination may vary with the scale of the proposed project and the constraints of the proposed project site. Larger projects and more constrained sites will likely necessitate greater coordination with local government and Commission staff.

Use scenario-based analysis

This process recommends using various sea level rise scenarios for the analysis of possible resource changes and site risks associated with sea level rise. Given the uncertainty about the magnitude and timing of future sea level rise, a scenario-based analysis will examine the consequences of a range of situations rather than basing project planning and design upon one sea level rise projection.

One approach for scenario-based analysis is to start with the highest possible sea level rise. If a developable area can be identified that has no long-term resource impacts, and is at no or low-risk from inundation, flooding, and erosion, then there may be no benefit to undertaking additional analysis for sea level rise and the project can continue with the rest of the analyses that are part of the Coastal Act or LCP (such as impacts to coastal habitats, public access, and scenic and visual qualities, and other issues unrelated to sea level rise).

If the site is constrained under a high sea level rise scenario, analysis of other, lower sea level rise amounts can help determine thresholds for varying impacts to coastal resources and types and extent of site constraints that need to be considered during project planning. The analysis of lower and intermediate sea level rise projections are used to better understand the timing and probability of the constraints. For further description of scenario-based analysis, see Chapter 3 of this Guidance.

Step 1 – Establish the projected sea level rise range for the proposed project

A projected sea level rise range should be obtained from the best available science, such as the 2012 National Research Council (NRC) report or an equivalent resource. These projections should cover the expected life of the proposed project, as the ultimate objective will be to assure that the project is safe from coastal hazards, without the need for shoreline protection or other detrimental hazard mitigation measures, as long as it exists.

- **Define Expected Project Life**: The expected project life will help determine the amount of sea level rise to which the project site could be exposed while the development is in place. Importantly, the point of this step is not to specify exactly how long a project will exist (and be permitted for), but rather to identify a project life time frame that is typical for the type of development in question so that the hazard analyses performed in subsequent steps will adequately consider the impacts that may occur over the entire life of the development.

  Some LCPs include a specified design life for new development. If no specified time frame is provided, a more general range may be chosen based on the type of development. For example, temporary structures, ancillary development, amenity structures, or moveable or expendable construction may identify a relatively short expected life such as 25 years or less. Residential or commercial structures will likely be around for some time, so a time frame of 75 to 100 may be appropriate. A longer time frame of 100 years or more should be considered for critical infrastructure like bridges or industrial facilities. Resource protection or enhancement projects such as coastal habitat conservation or restoration projects should also consider longer time frames of 100 years or more, as these types of projects are typically meant to last in perpetuity.[37]

- **Determine Sea Level Rise Range:** Using the typical project life identified above, the project analysis should identify a range of sea level rise projections based on the best available science that may occur over the life of the project. At present, the 2012 NRC report is considered to be the best available science (Table 6)[38], though an equivalent resource may be used provided that it is peer-reviewed, widely accepted within the scientific community, and locally relevant. Appendix B provides information on how to determine sea level rise amounts for years that are not included in the NRC report and, if needed, how to modify the NRC sea level rise projections to account for local vertical land motion. At a minimum, one high sea level rise projection for the proposed life of the project should be used for project analysis and evaluation. If constraints are identified with the high sea level rise scenario, a low sea level rise scenario and/or one or more intermediate rise scenarios should also be used. For critical infrastructure, development with a very long project life, or for projects with the potential to have severe impacts to Coastal Act resources, the analysis may also consider higher scenarios (such as a 2-m (6.6-ft) scenario[39]). These values should each be carried forward through the rest of the steps in this chapter.

Table 6. Sea Level Rise Projections for California (NRC 2012)

TIME PERIOD*	NORTH OF CAPE MENDOCINO	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

[37] Determining an anticipated life for restoration activities or other related projects is somewhat more complex than for typical development projects because these activities are typically meant to exist in perpetuity. As such, assessing sea level rise impacts may necessitate analyzing multiple different time frames, including the present, near future, and very long term depending on the overall goals of the project. For restoration projects that are implemented as mitigation for development projects, an expected project life that is at least as long as the expected life of the corresponding development project should be considered.

[38] The NRC Committee divided the Pacific coast for California, Oregon and Washington into two regions, north and south of Cape Mendocino, due to differences in tectonics that occur at this point. North of Cape Mendocino, land is rising as ocean plates descend below the North American plate at the Cascadia Subduction Zone. South of Cape Mendocino, the coast is sinking (NRC 2012, p. 3). Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary.

[39] The Global Sea Level Rise Scenarios for the United States National Climate Assessment 2012 established 6.6 ft (2 m) as the highest global sea level rise scenario for 2100.

Note that for project locations in the vicinity of Humboldt Bay and the Eel River estuary, the regional NRC sea level rise projections will need to be modified to adjust for localized vertical land motion.[40] Adjustments for vertical land motion are not necessary for other locations, though they may be done if desired and if locally relevant data are available.[41] If sea level rise projections are modified for areas other than the Humboldt Bay region, at least one scenario for the analysis of impacts should use the high value from the unmodified NRC projections in order to assess a worst case scenario possibility.

***Expected outcomes from Step 1**: A proposed or expected project life and corresponding range of sea level projections—including the high, the low, and one or more intermediate sea level rise projections—that will be used in the following analytic steps.*

Step 2 – Determine how physical impacts from sea level rise may constrain the project site

The Coastal Act requires that development minimize risks from coastal hazards. Sea level rise can both present new hazards and exacerbate hazards that are typically analyzed in CDP applications. In this step, project applicants determine the types and extent of sea level rise impacts that may occur now and into the future.

As described in Chapter 3 of the Guidance, impacts associated with sea level rise generally include erosion, inundation, flooding, wave impacts, and saltwater intrusion. An assessment of these impacts is often required as part of a routine hazards assessment or the safety element of the LCP. Therefore, information in the local LCP can provide an initial determination of potential hazards for the project in question, if available. However, proposed development will often need a second, site-specific analysis of hazards to augment the more general LCP information.

Analyze relevant sea level rise impacts for each sea level rise scenario.

A CDP application for new development in a hazardous area should include reports analyzing the anticipated impacts to a project site associated with each sea level rise scenario identified in Step 1. Generally, the analyses pertinent to sea level rise include geologic stability, erosion, flooding/inundation, wave runup, and wave impacts, and these analyses are described in detail below. Depending on the site, however, different analyses may be required. Applicants should work with planning staff (Coastal Commission or local government staff) to perform a pre-application submittal consultation to determine what analyses are required for their particular

[40] Please see Appendix B and *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on VLM and sea level rise projections for the Humboldt Bay region.

[41] A three-member subcommittee of the OPC Science Advisory Team (OPC-SAT) advised using the NRC projections, without modification, for all California locations except between Humboldt Bay and Crescent City. The OPC-SAT subcommittee stated, “We do not believe that there is enough certainty in the sea level rise projections nor is there a strong scientific rationale for specifying specific sea level rise values at individual locations along California’s coastline.” (OPC 2013, p. 10)

project. Analysis of those hazards that will not be altered by sea level rise (such as the location of faults, fire zones, *etc.*) should be undertaken at the same time as the assessment of sea level rise affected hazards so a complete understanding of hazard constraints can be used for identification of safe or low-hazard building areas. After the submission of the CDP application, any additional analyses that are required will be listed in an application filing status review letter.

The professionals who are responsible for technical studies of geologic stability, erosion, flooding/inundation, wave runup, and wave impacts should be familiar with the methodologies for examining the respective impacts. However, the methodologies do not always adequately examine potential impacts under rising sea level conditions, as established by best available science. Appendix B goes through the various steps for incorporating the best available science on sea level rise into the more routine analyses, which are summarized below. The analyses should be undertaken for each of the sea level rise scenarios identified in Step 1.

- **Geologic Stability:** The CDP should analyze site-specific stability and structural integrity without reliance upon existing or new protective devices (including cliff-retaining structures, seawalls, revetments, groins, buried retaining walls, and caisson foundations) that would substantially alter natural landforms along bluffs and cliffs. Geologic stability can include, among others, concerns such as landslides, slope failure, liquefiable soils, and seismic activity. In most situations, the analyses of these concerns will be combined with the erosion analysis (below) to fully establish the safe developable area.
- **Erosion:** Both bluff erosion and long-term shoreline change will increase as the time period increases. Thus, some estimate of project life is needed to determine expected bluff and shoreline change, and to fully assess the viability of a proposed site for long-term development. The CDP application should include an erosion analysis that establishes the extent of erosion that could occur from current processes, as well as future erosion hazards associated with the identified sea level rise scenarios over the life of the project. If possible, these erosion conditions should be shown on a site map, and the erosion zone, combined with the geologic stability concerns, can be used to help establish locations on the parcel or parcels that can be developed without reliance upon existing or new protective devices (including cliff-retaining structures, seawalls, revetments, groins, buried retaining walls, and caissons) that would substantially alter natural landforms along bluffs and cliffs.
- **Flooding and Inundation:** The CDP application should identify the current tidal datum and include analysis of the extent of flooding or inundation that potentially could occur from the identified sea level rise scenarios, and under a range of conditions that could include high tide, storm surge, water elevation due to El Niños, Pacific Decadal Oscillations, a 100-year storm event, and the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting flood zones should be shown on a site map.
    - **Flood Elevation Certificate**: If a site is within a FEMA-mapped 100-year flood zone, building regulations, in implementing the federal flood protection program, require new residences to have a finished floor elevation above Base Flood

Elevation (BFE; generally 1 ft).[42] The CDP application should include a flood elevation certificate prepared by a registered land surveyor, engineer, or architect, demonstrating that the finished floor foundation of the new structure will comply with the minimum FEMA guidelines and building standards. However, at this time, the Flood Certificate does not address sea level rise related flooding. In addition, designing to meet FEMA requirements may be in conflict other resource constraints, such as protection of visual resources, community character, and public access and recreation. Thus, in general, a certificate is not adequate to address Coastal Act and LCP standards for demonstrating that future flood risk or other impacts to coastal resources have been minimized.

- **Wave Runup and Wave Impacts:** Building upon the analysis for flooding, the CDP application should include analysis of the wave runup and impacts that potentially could occur over the anticipated life of the project from a 100-year storm event, combined with the identified sea level rise scenarios, and under a range of conditions that could include high tide, storm surge, water elevation due to El Niño events, Pacific Decadal Oscillations, and the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting wave runup zones should be shown on a site map or site profile.
- **Other Impacts**: Any additional sea level rise related impacts that could be expected to occur over the life of the project, such as saltwater intrusion should be evaluated. This may be especially significant for areas with a high groundwater table such as wetlands or coastal resources that might rely upon groundwater, such as agricultural uses.

Expected outcomes from Step 2*: Detailed information about the sea level rise related impacts that can occur on the site and changes that will occur over time under various sea level rise scenarios. High risk and low risk areas of the site should be identified. The scenario-based analyses should also provide information on the potential effects of sea level rise, such as coastal erosion, that could occur over the proposed development life, without relying upon existing or new protective devices.*

[42] FEMA's proposed "Revised Guidelines for Implementing Executive Order 11988, Floodplain Management" (released for public review and comment on January 30, 2015) will modify the Federal Flood Risk Management Standard, in compliance with EO 13960, to address the need for federal agencies to include climate change considerations in floodplain management. It recommends that the elevation and flood hazard area be established by (i) using climate-informed science, (ii) adding 2 feet (for non-critical actions) or 3 feet (for critical actions) of freeboard to the Base Flood Elevation, or (iii) including the area subject to the 0.2% annual chance of flood. These Revised Guidelines could lead to future changes in the elevation required for Flood Elevation Certificates for new development.

Step 3 – Determine how the project may impact coastal resources, considering the influence of sea level rise upon the landscape over time

The Coastal Act requires that development avoid impacts to coastal resources. Sea level rise will likely cause some coastal resources to change over time, as described in Chapters 3 and 4. Therefore, in this step, applicants should analyze how sea level rise will affect coastal resources now and in the future so that alternatives can be developed in Step 4 to minimize the project's impacts to coastal resources throughout its lifetime.

This section discusses only those resources that might change due to rising sea level or possible responses to rising sea levels. As in Step 2, each sea level rise scenario (high, low, and intermediate values) should be carried through this step. A complete CDP application will need to assess possible impacts to all coastal resources – including public access and recreation, water quality, natural resources (such as ESHA and wetlands), agricultural resources, natural landforms, scenic resources, and archaeological and paleontological resources. Analysis of those resources that will not be affected by sea level rise should be undertaken at the same time as the assessment of the sea level rise affected resources so a complete map of resource constraints can be used for identification of a resource-protective building area.

3.1 Analyze coastal resource impacts and hazard risks for each sea level rise scenario

Analysis of resource impacts will require information about the type and location of the resources on or in proximity to the proposed project site and the way in which the proposed project will affect such resources initially and over time. The following discussion of each resource will help identify the key impacts to each that might result from either sea level rise or the proposed development. If coastal resources will be affected by sea level rise, such as changes to the area and extent of a wetland or riparian buffer, these changes must be considered in the analysis. Much of the following discussion recommends analysis of impacts from current and future inundation, flooding, erosion, and from the ways in which the project proposes to address such impacts. Appendix B provides guidance on how to undertake this analysis and includes lists of suggested resources that can provide data, tools, or other resources to help with these analyses. This analysis should be repeated for each sea level rise scenario identified in Step 1. Also, it may be important for local planners to coordinate and share information with other local partners – including those in charge of emergency management, law enforcement, and related services – in order to identify risks and vulnerabilities. Information on the following coastal resources is included. To skip to a section, click on the links below:

- New Development (addressed in Step 2, above)
- Public Access and Recreation
- Coastal Habitats
- Natural Land Forms
- Agricultural Resources
- Water Quality and Groundwater
- Scenic Resources

Public Access and Recreation: Public access and recreation resources include lateral and vertical public accessways, public access easements, beaches, recreation areas, public trust lands,[43] and trails, including the California Coastal Trail. These areas may become hazardous or unusable during the project life due to sea level rise and/or due to the proposed project. Approaches to identify potential risks to public access and recreation include:

- Identify all public access locations on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project. The analysis should also identify existing public trust areas in relation to the proposed project
- Determine whether any access locations or public trust lands will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation, or shoreline erosion, or from proposed project elements. At a minimum, establish the extent of likely and/or possible changes to public access and recreation and to public trust lands.
- If any access locations will be altered by sea level rise and/or the proposed project, map or otherwise identify the potential changes to the location of these access resources for the identified sea level rise scenarios.
- Identify whether there are locations on the proposed project site that can support development without encroachment onto the existing or future locations of these access locations, and without impacts otherwise to public access and recreation. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Coastal Habitats (ESHA, wetlands, *etc.*): Coastal habitats, especially those that have a connection to water, such as beaches, intertidal areas, and wetlands, can be highly sensitive to changes in sea level. Ways to identify potential resource impacts associated with the project include:

- Identify all coastal habitats and species of special biological or economic significance on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project.
- Determine whether any coastal habitats will be altered or affected by sea level rise and/or the proposed project over the proposed life of the project. Such impacts could result from flooding, inundation, shoreline erosion, or changes to surface or groundwater conditions (see discussion below on water quality). At a minimum, use the identified sea level rise scenarios to establish the extent of likely and/or possible changes to coastal habitats.
- If any coastal habitats will be altered by sea level rise and/or the proposed project, map or otherwise identify potential changes to the location of these coastal resources for the identified sea level rise scenarios.
- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these coastal habitats, and without

[43] The State Lands Commission has oversight of all public trust lands and many local governments are trustees of granted tidelands. The State Lands Commission or other appropriate trustee should be contacted if there is any possibility that public trust lands might be involved in the proposed project. As a general guide, public trust lands include tide and submerged lands as well as artificially filled tide and submerged lands.

other impacts to coastal habitats. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Natural Landforms: Natural landforms can include coastal caves, rock formations, bluffs, terraces, ridges, and cliffs. Steps to identify natural landforms at risk include:

- Identify all natural landforms on or near the proposed project site and, if possible map these resources in relation to the location of the proposed project.
- Determine whether any natural landforms will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation or shoreline erosion. At a minimum, use the identified sea level rise scenarios to establish the zone of likely and/or possible changes to natural landforms.
- If any natural landforms will be altered by sea level rise and/or the proposed project, map or otherwise identify the likely changes to location of these coastal resources for the identified sea level rise scenarios.
- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these natural landforms and without other impacts to such landforms. Bluffs and cliffs can often require additional analysis for slope stability to determine the setback from the eroded bluff face that can safely support development. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Agricultural Resources: Agricultural resources may be affected by sea level rise through changes to surface drainage and the groundwater table. Other changes can result from flooding, inundation or saltwater intrusion. If agricultural lands are protected by levees or dikes, they can be affected by changes to the stability or effectiveness of these structures. Steps to identify risks to agricultural resources include:

- Identify whether the proposed project site is used for or zoned for agricultural uses, contains agricultural soils, or is in the vicinity of or upstream of lands in agricultural use.
- Identify surface water drainage patterns across the site or from the site to the agricultural use site.
- If any drainage patterns are closely linked to and potentially influenced by the elevation of sea level, examine changes in drainage patterns with rising sea level on the proposed site or the agricultural use site.

Water Quality and Groundwater: Sea level rise may cause drainages with a low elevation discharge to have water back-ups. It may also cause a rise in the groundwater table. Both of these changes could alter on-site drainage and limit future drainage options. If the proposed site must support an on-site wastewater treatment system, or if drainage and on-site water retention will be a concern, consider the following, as appropriate:

- Identify surface water drainage patterns across the site.

- Examine changes with rising sea level of any drainage patterns that are closely linked to and likely influenced by the elevation of sea level. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to drainage patterns.
- Identify the elevation of the groundwater table. Since groundwater can fluctuate during periods of rain and drought, attempt to identify the groundwater zone.
- Estimate the likely future elevation of the groundwater zone, due to sea level rise. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to groundwater.
- Evaluate whether changes in groundwater will alter the proposed site conditions.

Scenic Resources: Visual and scenic resources include views to and along the ocean and scenic coastal areas. Development modifications to minimize risks from sea level rise could have negative consequences for scenic resources, including creating a structure that is out of character with the surrounding area, blocks a scenic view, or alters natural landforms. Steps to identify impacts to scenic resources, including any impacts from possible adaptation measures, include:

- Identify all scenic views to and through the proposed project site from public vantage points such as overlooks, access locations, beaches, trails, the Coastal Trail, public roads, parks, and if possible, map these views and view lines in relation to the location and maximum allowable elevation of the proposed project.
- Identify locations of the proposed project site that can support development and avoid or minimize impacts to scenic views from current and future vantage points. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

3.2 Synthesize and assess development and resource constraints

After completing the detailed analysis of each coastal resource, the applicant should summarize the potential resource impacts under each sea level rise scenario identified in Step 1. This set of results, when combined with potential impacts to those coastal resources not affected by sea level rise, should give the applicant valuable information about the degree of risk posed to each coastal resource and to the development itself. If practical, for each sea level rise scenario, applicants should produce a constraints map illustrating the location and the extent of resource impacts that could occur over the life of the development. Based on the analysis of resource impacts and potential hazard risks over the life of the development, the applicant should develop an overlay identifying the development and resource constraints.

3.3 Identify areas suitable for development

The final part of this step is to identify the locations of the project site that could support some level of development without impacts to coastal resources and without putting the development at risk.

***Expected outcomes from Step 3**: Upon completing this step, the applicant should have detailed information about the types of coastal resources on the project site and the level of risk that sea level rise poses to each resource under each sea level rise scenario, including resource locations and the extent of resource impacts that could occur over the life of the proposed project. This step should also provide an overlay of all development and resource constraints, and clearly identify the locations on the proposed project site that could support some level of development without impacts to coastal resources and without putting the development at risk.*

Step 4 – Identify project alternatives that avoid resource impacts and minimize risks to the project

By this step, applicants should have developed a set of factors based on the sea level rise hazards identified in Step 2, potential resource impacts identified in Step 3, and other site conditions (such as archaeological resources or fault lines) to identify the buildable areas that avoid both risk from coastal hazards and impacts to coastal resources. Hazard and resource avoidance is usually the preferred option, and, in many cases, applicants may find that the site is safe from sea level rise hazards for all the identified sea level rise scenarios and no further identification of project alternatives would be necessary in order to address sea level rise concerns.

For some cases, the site constraints may require consideration of project alternatives that fit with the available buildable area, without the use of protective structures. In these cases, one of the alternatives may replace what was initially being considered for the site. In other cases, development that is safe from hazards and is resource protective may be possible if certain adaptation strategies are used to modify the project over time and as the potential hazard areas increase or move closer to the project. For these cases, the possible adaptation measures would be included as part of the proposed project, along with necessary monitoring and triggers for implementing the adaptation options. In still other cases, hazard minimization may be the only feasible option for development on hazard constrained-sites. In all cases, projects must be sited and designed to address all applicable Coastal Act and LCP requirements, including any new requirements within LCPs that have been updated to adapt to sea level rise.

The results from the analysis of sea level rise scenarios should factor into the decisions made in this step. In particular, after looking at the results from Steps 2 and 3 as a whole, applicants can better decide the project changes, types of adaptation strategies, and design alternatives that would be most appropriate given the degree of risk posed by possible sea level rise and how long the development might be free from risk. The applicant also might identify triggers (*e.g.*, a certain amount of sea level rise) when certain adaptation measures should be implemented to reduce risk and/or impacts to coastal resources.

Importantly, land divisions and lot line adjustments in high hazard areas can change hazard exposure and should therefore be undertaken only when they can be shown to not worsen or create new vulnerability. In particular, no new lots or reconfigured lots with new development potential should be created if they cannot be developed without additional shoreline hazard risks.

Strategies to Avoid Resource Impacts and Minimize Risks

The best way to minimize risks to development and coastal resources is to avoid areas that are or will become hazardous as identified by the sea level rise scenarios analysis in the previous steps. Such avoidance often includes changes to the proposed project to bring the size and scale of the proposed development in line with the capacity of the project site. However, if it is not feasible to site or design a structure to completely avoid sea level rise impacts, the applicant may need to modify or relocate the development to prevent risks to the development or to coastal resources. Some changes, such as the use of setbacks, may be necessary at the outset of the project. Other changes, such as managed retreat or added floodproofing, may be useful as adaptive strategies that can be used after the initial project completion. Considerations involved in choosing and designing an appropriate adaptation strategy may include those listed below. See Chapter 7 for more information on specific adaptation measures. For a list of guidebooks, online clearinghouses, and other sea level rise adaptation resources, see Appendix C.

- **Assess Design Constraints:** Determine whether there are any significant site or design constraints that might prevent future implementation of possible sea level rise adaptation measures. Some project locations may be constrained due to lot size, sea level related hazards, steep slopes, fault lines, the presence of wetlands or other ESHA, or other constraints such that no safe development area exists on the parcel. Ideally, such parcels would be identified during the LCP vulnerability analysis, and the land use and zoning designations would appropriately reflect the constraints of the site. However, in some cases development may need to be permitted even if it cannot avoid all potential hazards. As stated above, care should be taken in these cases to avoid resource impacts and minimize risks as much as possible by developing and implementing a sea level rise adaptation plan for the proposed development. In creating this plan, it is important to identify any design constraints that will limit the ability to implement adaptation strategies in the future, as described below.

- **Identify Adaptation Options:** Identify possible adaptation strategies (such as those found in Chapter 7) for the proposed project, and evaluate each adaptation option for efficacy in protecting the development. Also, evaluate the consequences from each proposed adaptation measure to ensure it will not have adverse impacts on coastal and sensitive environmental resources, including visual impacts and public access.

  For example, an option that is often considered for sea level rise is to elevate the development or the structures that are providing flood protection. However, elevated structures will change the scenic quality and visual character of the area. Also, elevation of the main development may be of little long-term utility to the property owner if the supporting infrastructure, such as the driveways, roads, utilities or septic systems are not also elevated or otherwise protected. Elevation of existing levees or dikes can provide flood protection for an area of land and all the development therein. However, the foundation of the levee or dike must have been designed to support the additional height or else it may have to be expanded and the increased footprint of the foundation could have impacts on intertidal area, wetlands, or other natural resources. Thus, the long-term options for adaptation should be considered as part of any permit action, to ensure that current development decisions are not predetermining resource impacts in the future.

- **Ensure Sea Level Rise Design Flexibility:** If the likelihood of impacts is expected to increase with rising sea level, it may be necessary to design the initial project for some amount of sea level rise but to also include design flexibility that will allow future project changes or modifications to prevent impacts if the amount of sea level rise is more than anticipated in the initial design. Changes and modifications could include the use of foundation elements that will allow for building relocations or removal of portions of a building as it is threatened or reserving space to move on-site waste treatment systems away from eroding areas or areas that will be susceptible to a rising water table or increased flooding.

- **Develop Project Modifications**: Highly constrained sites may not be able to support the amount of development that an applicant initially plans for the site. Even a small building footprint may be at risk from flooding or erosion under high sea level rise scenarios. In such cases, it will be important to work closely with the appropriate planning staff to develop a project option that can minimize hazards from the identified sea level rise scenarios for as long as possible, and then incrementally retreat once certain triggers are met. Some examples of triggers could be that erosion is within some distance of the foundation, or monthly high tides are within some distance of the finished floor elevation. The time period for relocation or removing the structure would be determined by changing site conditions but relocation would most likely occur prior to the time period used in Step 1 to determine long-term site constraints.

- **Plan for Monitoring:** Develop a monitoring program or links to other monitoring efforts to ensure that the proposed adaptation measures will be implemented in a timely manner. Following a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time can help to identify the triggers that would lead to revising project life, other project modifications or additional adaptation efforts.

Expected outcomes from Step 4*: This step may involve an iterative process of project modifications and reexamination of impacts, leading to one or more alternatives for the project site. The alternative that will minimize risks from coastal hazards and avoid or minimize impacts to coastal resources should be identified. Possible adaptation options could be identified and analyzed, if appropriate. If the site is very constrained, modifications to the expected project life might be suggested.*

Step 5 – Finalize project design and submit CDP application

After Step 4, the applicant should have developed one or more project alternatives and identified a preferred alternative. The alternatives should include adaptation strategies to minimize impacts if hazards cannot be avoided entirely. The CDP application step involves the following:

1. **Work with the planning staff to complete the CDP application**. Depending upon the proposed project and extent of prior interactions with the planning staff, the initial submittal may be the first time the planner has been provided with information about the general project or the preferred alternative. Once a proposed project is submitted, the coastal planner will need to become familiar with the project location, area around the project site, the proposed actions and the studies and analyses that have been undertaken in support of the application. The planner will review the application for completeness to ensure that there is sufficient information to analyze the project for all appropriate LCP or Coastal Act Chapter 3 policies. If analysis for sea level rise concerns is needed, the planner will also check that analyses for sea level rise risks have been included in the submittal. Much of the information developed in Steps 1-4 will be useful for the application process. The Suggested Filing Checklist for CDP Applications (located at the end of this chapter) covers the typical information that might be included in a CDP application necessary for planning review of the sea level rise aspects of the proposed project. Applicants who are unfamiliar with the permit process should consult the local government website, Coastal Commission website, or contact the appropriate district office for instructions on how to complete a CDP application.

   The review of an application might involve an iterative process, wherein planning staff requests more information about the proposed project, project alternatives, analysis of the hazards or identification of potential resource impacts to help in the review for compliance with the LCP or the Coastal Act. At the same time, planning staff may request that some of the technical staff review the submitted material to ensure that there is sufficient information in all technical information and analyses to support a decision on the proposed project. This process may be repeated until the application provides the studies, analysis and project review necessary for planning review.

2. **Submit a complete CDP application.** Once a complete application has been accepted, the planning staff will do a more thorough review and analysis of the potential hazards and resource impacts associated with the proposed project. Ideally, the planner will have requested all necessary project information at the filing stage. In some instances, additional information may be needed after the application has been accepted. This is normally limited to clarifications of some of the information or further details about some of the possible, but not preferred alternatives. During this stage in the CDP application process, the planner may identify necessary project modifications that were not part of the initial application, or identify various conditions that will be needed if the project is to be approved. Chapter 7 includes many of the possible project modifications and permit conditions that might be used to address sea level rise concerns and potential resource impacts.

   During the project analysis, the planning staff will review all submitted material, discussing the proposed project with other staff members, and obtaining further technical review. Working with their supervisors and managers, they will also develop a staff recommendation and prepare a staff report that supports the proposed recommendation, the planning staff will then review the permit, and if necessary request additional information or modifications to the project. Please consult the Coastal Commission website (http://www.coastal.ca.gov/cdp/cdp-forms.html) or contact your district office for instructions on how to complete a CDP application.

3. **Permit action.** Once the proposed project has been through planning review and a staff recommendation has been prepared, the proposed project will be brought to hearing before either the local planning commission or the California Coastal Commission. The outcome of the hearing process will be project approval, approval with conditions, or denial. Based on the regulatory decision, the project may be constructed, or additional modifications and condition requirements may have to be met.

4. **Monitor and revise.** CDP approvals may include conditions that require monitoring. Applicants should monitor the physical impacts of sea level rise on the project site, provide reports and updates to planning staff and introduce adaptive changes to the project in accordance with the permit and permit conditions.

Expected outcomes from Step 5*: This step, combined with supporting documentation from the previous steps, should provide a basis for evaluating the proposed project's hazard risks and impacts that can result from sea level rise. Such an analysis will provide one of the bases for project evaluation and complements the other resource evaluations and analyses that are part of a complete CDP application.*

Planning Process for Coastal Development Permits

1. Establish the projected sea level rise range for the proposed project

- Determine time period of concern using expected project life.
- Use range of sea level rise scenarios based on best available science (*e.g., NRC Sea-Level Rise Report*).
- Modify projections to incorporate local vertical land motion and planning horizon if needed.

2. Determine how sea level rise impacts may constrain the project site

Using locally-relevant sea level rise projections, determine site- or project-specific hazards or impacts for the time period of concern, including current and future hazard impacts. Consider:

- Geologic Stability and Erosion
- Flooding and Inundation
- Wave Impacts
- Other Impacts

3. Determine how the project may impact coastal resources over time, considering sea level rise

Determine how the project may impact coastal resources (below) considering how sea level rise may alter the resources over the expected lifetime of the project.

- Public Access and Recreation
- Coastal Habitats
- Agriculture
- Water Quality
- Archaeological/Paleontological resources
- Scenic Resources

4. Identify project alternatives to both avoid resource impacts and minimize risks to the project

- Ideally, locate the project in a site that avoids conflicts with natural resources and sea level impacts
- Alternatively, minimize the likelihood that the project will come into contact with hazards, and design an adaptation strategy for unavoidable impacts.
- Modify project if impacts cannot be avoided
- Summarize these alternatives

5. Finalize project design and submit permit application

Complete the CDP application. Submit the application. Receive permit action. Monitor and revise project as needed.

Figure 14. Flowchart for steps to address sea level rise in Coastal Development Permits

Suggested Filing Checklist for Sea Level Rise Analysis

- Proposed/Expected Project Life
- Sea Level Rise Projections used in Impacts Analyses
- Impacts Analyses (possibly from Vulnerability Assessment)
    - Structural and Geologic Stability
        - Identify current tidal datum
        - Perform Geotechnical Report and Erosion Analysis
        - Identify blufftop setback and safe building area
        - Show setback, safe building area and proposed project footprint (site maps)
    - Erosion Amount over Expected Project Life
        - Perform Coastal Processes Study and Erosion Analysis
        - Quantify total erosion amount for proposed project site
        - Show retreat along with proposed project footprint (site maps)
    - Flooding and Inundation Risks
        - Perform Coastal Processes Study and Wave Runup Analysis
        - Quantify flood elevation and flooding extent
        - Show flood extent with proposed project footprint (site map)
        - Show flood elevation on site profile, with proposed project elevation
        - Provide Flood Certificate if in FEMA designated 100-year Flood Zone
    - Tipping points for sea level rise impacts, specific to proposed project site
- Impacts to coastal resources (possibly from Environmental Assessment) for current conditions and changes due to sea level rise and related impacts
    - Public Access and Recreation
        - Show access resources and future changes (site maps)
    - Water Quality, surface and groundwater
        - Provide surface drainage patterns and runoff and future changes (site maps)
        - Provide zone of groundwater elevation
    - Coastal Habitats
        - Provide wetland delineation, ESHA determination, if appropriate
        - Provide boundary determinations or State Lands review, if appropriate
        - Show all coastal habitats and future changes (site maps)
    - Agricultural Resources
        - Show agricultural resources and future changes (site maps)
    - Natural Landforms
        - Show all natural landforms and future changes (site maps)
    - Scenic Resources
        - Show views from public access and future changes due to access changes
    - Overlay all coastal resources to establish areas suitable for development (site maps)
- Analysis of Proposed Project and Alternatives
    - Provide amount(s) of sea level rise used in project planning and design
    - Provide analysis of the proposed project and alternatives
    - Identify proposed current and future adaptation strategies
    - Show avoidance efforts (site map)
    - Identify hazard minimization efforts that avoid resource impacts (site maps)

Example for Addressing Sea Level Rise in Coastal Development Permits

To illustrate the process described in this chapter for how to address sea level rise in the CDP process, consider three example projects: a wetland restoration project, a new bluff-top residential development with a fronting beach, and a new wastewater treatment facility. These three examples will follow each of the recommended CDP steps, showing how the guidance could be applied in specific situations. Note that these are simplified examples used to demonstrate the process described in this chapter. Decisions about how to address various challenges presented by sea level rise will be more complex than those illustrated below, and the Coastal Commission encourages applicants to coordinate with staff as necessary and feasible throughout the process.

Step 1: Establish the projected sea level rise range for the proposed project

- *Wetland Restoration Project:* Sea level rise projection ranges should be chosen based on the goals of the project. For example, if wetland restoration efforts are intended as mitigation for a development project, the lifetime for the wetland restoration should be, at a minimum, the lifetime of the development project. For wetland restoration projects in which the desired outcome is the protection of the wetland in perpetuity, sea level rise ranges should be projected over a minimum of 100 years, with consideration of the intervening years as well as the even longer term for ongoing adaptive management.
- *Bluff-top Residential Development:* The lifetime of the project is assumed to be at least 75 years, unless the LCP specifies a different time period. High, low, and intermediate sea level rise projection ranges are established, appropriate for the proposed area over the assumed 75-year project life.
- *Wastewater Treatment Facility:* Wastewater treatment facilities are normally critical infrastructure. For this example, a minimum life of 100 years is assumed, unless the LCP specifies a different time period. High, low, and intermediate sea level rise projections ranges are established, appropriate for the proposed area over the assumed 100-year or longer project life.

Step 2: Determine how impacts from sea level rise may constrain the project site

- *Wetland Restoration Project:* Current topography of the wetland area is mapped, current barriers to inland migration are identified, and an analysis of erosion and flooding potential (and subsequent effects to wetland extent) is performed for various sea level rise scenarios. Potential changes to groundwater are evaluated. Potential changes in sediment flows or other physical properties as a result of changing conditions are examined. It is determined that in this case, open space exists behind the wetland to allow for inland migration over time.
- *Bluff-top Residential Development:* The average long-term beach and bluff retreat rate, erosion rate due to various sea level rise scenarios, and erosion potential from 100-year storms and other extreme events are determined. Beach and bluff erosion will vary with sea level rise rates. The geologic stability of the bluff over the life of the development is analyzed assuming that no protective structure (such as a seawall) either exists or will be built.

- *Wastewater Treatment Facility:* Erosion and flooding potential over the lifetime of the facility under both a low and a worst-case scenario sea level rise projection are analyzed, as are current and future wave runup and storm impacts for 100-year storms. The geologic stability of the site over the life of the facility is analyzed assuming that no protective structure either exists or will be built. Potential damage to infrastructure (for example corrosion due to salt water intrusion) is examined.

Step 3: Determine how the project may impact coastal resources, considering the influence of sea level rise upon the landscape over time

- *Wetland Restoration Project:* Coastal resources present in the proposed project site are mapped and sea level rise impacts to these resources are analyzed over the lifetime of the project. It is unlikely that the project will have any adverse impact on coastal resources. Barriers to wetland migration are examined and it is determined in this case that enough open space currently exists to allow for the wetland to migrate inland over time. The few barriers that exist can be modified in the future, if necessary. This will allow for continued maintenance of habitat area and ecosystem services.
- *Bluff-top Residential Development:* Maps are developed that identify scenic viewsheds, the bluff extent, and adjacent coastal habitats including the fronting beach, and descriptions of each are provided. Opportunities for public access are identified. Impacts to each of these resources as a result of sea level rise are analyzed, as are impacts that would result from the development project. It is determined that the development has the potential to result in the loss of a fronting beach if a protective structure is installed. However, development setbacks are designed to ensure that no such structure is planned over the lifetime of the development under any sea level rise scenario.
- *Wastewater Treatment Facility:* Maps are developed that identify coastal resources in the area and impacts to these resources resulting from sea level rise are analyzed. As with the bluff-top development, any protective structure would have detrimental effects to the fronting beach, but no such structure is determined to be necessary. Any potential impacts to adjacent habitat areas or to water quality as a result of damage to infrastructure (for example sewage outflow or backup of seawater into the system) are examined under the range of sea level rise projections for the life of the facility.

Step 4: Identify project design alternatives that avoid resource impacts and minimize risks to the project

- *Wetland Restoration Project:* In this example, there are no concerns related to detrimental impacts to coastal resources as a result of this project. Natural barriers will be removed through grading and contouring of the land to ensure that the wetland has the ability to migrate inland with sea level rise and that hydrologic function will be maintained. Inland areas are protected into the future to ensure the space will be open for migration. Additionally, a plan is included to monitor changes in sea level, sediment dynamics, and overall health of the wetland so that adaptive management options can be applied as needed.

- *Bluff-top Residential Development:* The optimal site for a bluff-top residential development is one that avoids the hazards identified in Step 2 and impacts to coastal resources identified in Step 3 over the life-time of the project. If the proposed site does not avoid risks, alternative locations on the project sites should be identified and examined. If no such location exists, efforts should be made to minimize hazards and impacts to resources, or the project should be denied. Minimization efforts may include: building with an extra setback from the bluff-face, developing a managed retreat plan, and designing buildings to be easily relocated. If the safe building envelope will not be sufficient for a reasonable-sized building, local governments could consider allowing reduced setbacks on portions of the site located away from the bluff face (*e.g.*, side or front yard setbacks), reduced off-street parking, additional height on safe portions of the site, or other development that doesn't require shore protection. No seawall is planned as such a device would result in the loss of the fronting beach. A plan to monitor rates of erosion at various places along the bluff as well as any impacts to adjacent resources is developed, and erosion rates/scenarios that would trigger the need for retreat are identified.
- *Wastewater Treatment Facility:* The optimal site for a wastewater treatment facility is one that avoids the hazards identified in Step 2 and impacts to coastal resources identified in Step 3 over the life-time of the project. If the proposed site does not avoid risks, alternative sites should be identified and examined. If no such site exists, efforts should be made to minimize hazards and impacts to resources. Minimization efforts may include: building the facility further back from the beach, elevating outflow pipes, and adding one-way valves to prevent backflow of sea-water into the system. A plan to monitor erosion rates along the beach as well as wave and storm impacts and any impacts to coastal resources caused by the facility is developed.

Step 5: Finalize project design and submit CDP application

- *Wetland Restoration Project:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes likely options for adaptive management to maintain wetlands and key monitoring needed to examine ongoing wetland function.
- *Bluff-top Residential Development:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazard and resource risks and any plans for adaptive project designs and proposed monitoring.
- *Wastewater Treatment Facility:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazards and resource risk and plans for site monitoring.

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Chapter 7

Adaptation Strategies

Chapters 5 and 6 provide guidance on the sequential processes for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). This chapter describes some of the specific adaptation strategies to consider in these planning and development review processes. Given the range of impacts that could occur as a result of sea level rise, and the uncertainties surrounding projections of sea level rise over the lifetimes of many coastal projects, communities, planners, coastal managers and project applicants will need to use adaptation strategies to effectively address coastal hazard risks, and protect coastal resources, over time.

As described in Chapters 5 and 6, adaptation strategies should be chosen based on the specific risks and vulnerabilities of a region or project site, and the applicable Coastal Act and LCP requirements, with due consideration of local priorities and goals. Adaptation strategies may involve modifications to land use plans, regulatory changes, project modifications, or permit conditions that focus on avoidance or minimization of risks and the protection of coastal resources.

Some adaptation strategies may require land use plans or proposed projects to anticipate longer-run impacts now, such as assuring that critical infrastructure is built to last a long time without being put in danger, or rezoning hazardous areas as open space. Other adaptation strategies may build adaptive capacity into the plan or project itself, so that future changes in hazard risks can be effectively addressed while ensuring long-term resource protection. In most cases, especially for LCP land use and implementation plans, multiple adaptation strategies will need to be employed. For projects, adaptation strategies may be addressed through initial siting and design and through conditions that provide for specific adaptation over time.

The next sections provide an overview of the general categories of adaptation options; followed by a description of various specific adaptation strategies organized by type of coastal resource, as outlined in Chapter 3 of the California Coastal Act.

The adaptation options described in this chapter are intended to provide guidance for potential LCP and permitting strategies. Not all strategies listed here will be appropriate for every jurisdiction, nor is this an exhaustive list of options. However, as described in Chapters 5 and 6, all local governments and all project applicants should analyze the possible effects of sea level rise and evaluate how the strategies in this chapter can be implemented in LCPs or CDPs to minimize the adverse effects of sea level rise.

General Adaptation Categories

There are a number of options for how to address the risks and impacts associated with sea level rise. Choosing to “do nothing” or following a policy of “non-intervention” may be considered an adaptive response, but in most cases, the strategies for addressing sea level rise hazards will require proactive planning to ensure protection of coastal resources and development. Such proactive adaptation strategies generally fall into three main categories: protect, accommodate, and retreat.

For purposes of implementing the Coastal Act, no single category or even specific strategy should be considered the “best” option as a rule. Different types of strategies will be appropriate in different locations and for different hazard management and resource protection goals. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time. As discussed later in the document, the legal context and options will also need to be considered in each situation and ultimately, adaptive responses will need to be consistent with the Coastal Act. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the consideration of land use planning and regulatory options in specific communities and places along the coast.

Protect: Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into "hard" and "soft" defensive measures or armoring. "Hard" armoring refers to engineered structures such as seawalls, revetments and bulkheads to defend against coastal hazards like wave impacts, erosion, and flooding. Such armoring is a fairly common response to coastal hazards, but it can result in serious negative impacts to coastal resources, particularly as sea level rises. Most significant, hard structures form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise. This process is commonly referred to as "passive erosion" which is the narrowing of beaches due to the fact that the back of the beach on an eroding shoreline has been fixed in place (Flick *et al*. 2012). Other detrimental impacts may include negative visual impacts or interference with other ecosystem services.

Figure 15. Photo depicting passive erosion. (*Left*) Passive erosion in front of a revetment at Fort Ord, illustrating the loss of beach where the development prevents the shoreline from migrating landward. The beach continues to migrate inland on either side of the revetment. (*Right*) Recovery of the beach following removal of the revetment and blufftop structure. (*Source: California Coastal Records Project*).

"Soft" armoring refers to the use of natural or "green" infrastructure like beaches, dune systems, wetlands and other systems to buffer coastal areas. Strategies like beach nourishment, dune management, or the construction of "living shorelines" capitalize on the natural ability of these systems to protect coastlines from coastal hazards while also providing benefits such as habitat, recreation area, more pleasing visual impacts, and the continuation or enhancement of ecosystem services. The engineering of green infrastructure is a somewhat newer concept in some cases and because of this, the effectiveness of different strategies in different types of environments is not necessarily well-known or tested. In cases in which natural infrastructure might not be completely effective or may not be preferred, a hybrid approach using both hard and natural infrastructure could be considered. As described in Principle 10 of this guidance and in the *Safeguarding California* plan (CNRA 2014), priority should be given to options that protect, enhance, and maximize coastal resources and access, including giving full consideration to innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. Although the Coastal Act clearly provides for potential protection strategies for "existing development", it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline.

Accommodate: Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of sea level rise. On an individual project scale, these accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or using extra setbacks. On a community-scale, accommodation strategies include any of the land use designations, zoning ordinances, or other measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas even as development is protected. As with protection strategies, some accommodation strategies could result in negative impacts to coastal resources. Elevated structures may block coastal views or detract from community character; pile supported structures may, through erosion, develop into a form of shore protection that interferes with coastal processes, blocks access and, at the extreme, results in structures looming over or directly on top of the beach.

Figure 16. Photo depicting "managed retreat" and restoration. Surfers' Point Managed Shoreline Retreat project in which the parking lot was moved back and beach area was restored. (*Aerial composite by Rick Wilborne (February 28, 2013); photo courtesy of Surfrider Foundation*)

Retreat: Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include land use designations and zoning ordinances that encourage building in more resilient areas or gradually removing and relocating existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures where the right to protection was waived (*i.e.*, via permit condition) are examples of strategies designed to encourage managed retreat.

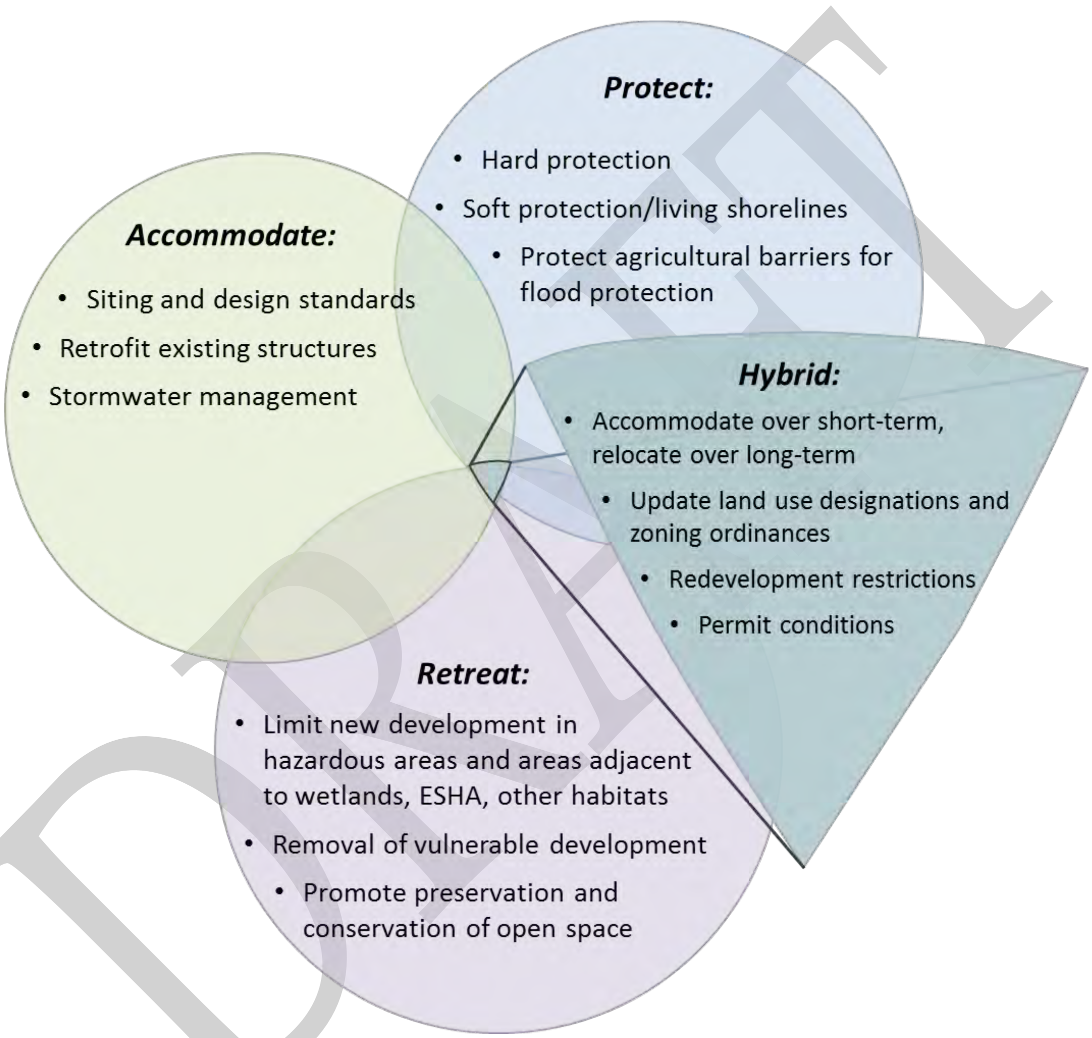

Figure 17. Examples of general adaptation strategies

SPECIFIC ADAPTATION STRATEGIES

The following sections, organized by category of coastal resource, present measures that local governments and coastal planners should consider including in their LCPs or individual CDPs. The purpose of this organization is to allow coastal managers and project applicants to easily find strategies that will help address the specific resource vulnerabilities identified in Steps 1-3 of the LCP and CDP processes laid out in Chapters 5 and 6. In the development of LCP policies, local governments should use adaptation measures that best implement the statewide resource protection and hazard policies of the Coastal Act at the local level given the diverse geography and conditions of different areas.

As part of identifying adaptation strategies, local governments should carefully examine the potential impacts to coastal resources that could occur from various adaptation strategies. Some adaptation strategies will need to be implemented incrementally over time as conditions change, and many strategies will need to be implemented through both the LCP and CDP to be effective. For each issue area, there is a description of potential impacts that could occur due to sea level rise and a list of adaptation tools or actions to minimize impacts. To skip to a topic, click on the links below.

The lists in these sections should neither be considered checklists from which all options need to be used, nor are they exhaustive lists of all possible adaptation strategies. Sea level rise adaptation is an evolving field, and policy language, cost considerations, effectiveness of various strategies, and other topics are continuing to be developed. Planners, applicants, and partners will need to think creatively and adaptively respond to changing conditions, new science, and new adaptation opportunities, and the Coastal Commission will continue to support and collaborate on these efforts.

Additionally, sea level rise planning may involve a number of trade-offs among various competing interests, and no single adaptation strategy will be able to accomplish all planning objectives. Economic and social implications of various adaptation options will likely play into the planning process at the local level. The important point is to analyze current and future risks from sea level rise, determine local priorities and goals for protection of coastal resources and development in light of Coastal Act requirements, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals.

A. Coastal Development and Hazards

The Coastal Act requires that new development be sited and designed to be safe from hazards and to not adversely impact coastal resources (Coastal Act Sections 30235 and 30253). The main goals that relate to hazards and coastal development are:

- Update land use designations, zoning maps, and ordinances to account for changing hazard zones
- Include sea level rise in hazard analyses and policies
- Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources
- Incorporate sea level rise adaptation into redevelopment policies
- Encourage the removal of development that is threatened by sea level rise
- Use "soft" or "natural" solutions as a preferred alternative for protection of existing endangered structures
- Limit bluff and shoreline protective devices to protect existing endangered structures
- Require special considerations for critical infrastructure and facilities
- Protect transportation infrastructure

Chapter 3 of the Guidance covers the impacts to coastal development that might result from sea level rise. Certified LCPs should already have policies and standards to assure that coastal development is safe over its anticipated lifetime and that it does not adversely impact other coastal resources. However, LCP policies and standards may need to be updated in light of new knowledge and to consider sea level rise hazards. Adaptation options have been developed to support the development goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Update land use designations, zoning maps, and ordinances to account for changing hazard zones

A.1 Establish mapped hazard zones or overlays: Update land uses and zoning requirements to minimize risks from sea level rise in identified hazard zones or overlay areas. For example, limit new development in current and future sea level hazard zones and encourage removal of existing development when threatened.

A.1a **Identify zones that require a more rigorous sea level rise hazards analysis**: Specify areas where a closer analysis of sea level rise is necessary at the permit application stage to avoid or minimize coastal hazards and impacts to coastal resources. Ensure that the most up-to-date information on sea level rise is incorporated in such analyses.

Goal: Include sea level rise in hazard analyses and policies

A.2 Update policies to require sea level rise to be included in hazard analyses and management plans: LCP policies should include requirements to analyze projected sea level rise. Consider specific projection scenarios to be analyzed (see Chapter 3 of the Guidance for a description of scenario planning). LCPs could also specify which analyses are required for various types of projects/development (see Step 2 of Chapters 5 and 6 or Appendix B for suggested analyses).

A.2a **Site-specific evaluation of sea level rise**: Update policies, ordinances, and permit application requirements to include a required site-specific evaluation of coastal hazards due to sea level rise over the full projected life of any proposed development. Analyses should be conducted by a certified Civil Engineer with expertise in coastal processes.

A.2b **Incorporate wave runup zones and sea level rise in coastal flood hazard maps:** Develop coastal flood maps that include areas that will be subject to wave action and flooding due to sea level rise. These maps may be able to rely upon existing flood maps, such as the FEMA Flood Insurance Rate Maps, for current flood areas and base conditions, but should be augmented to include future conditions, including sea level rise, likely to occur through the life of proposed new development.

A.2c **Incorporate sea level rise into calculations of the Geologic Setback Line**: Update geotechnical report requirements for establishing the Geologic Setback Line (bluff setback) to include consideration of bluff retreat due to sea level rise, in addition to historic bluff retreat data, future increase in storm or El Niño events, and any known site-specific conditions. The report should be completed by a licensed Geotechnical Engineer or an Engineering Geologist.

A.2d **Include sea level rise in wave runup, storm surge, and tsunami hazard assessments**[44]: Sea level rise should be included in wave runup analyses, including storm event and tsunami hazard assessments. This should include evaluating tsunami loads/currents on maritime facilities and coastal structures. Since tsunami wave runup can be quite large, sea level rise projections of only a few inches may not have a large impact on these assessments. However, for time periods or scenarios where sea level rise projections are large (perhaps 1 ft or more), it would be appropriate to include sea level rise because it could change the results to a significant degree.

[44] Tsunami evacuation maps are based upon current sea level conditions and they will need to be updated with changes in sea level.

A.3 Establish shoreline management plans to address long-term shoreline change due to sea level rise: Create policies that require a management plan for priority areas that are subject to sea level rise hazards, and incorporate the plan into the larger LCP if applicable. Similar to an LCP, shoreline management plans generally include the short and long term goals for the specified area, the management actions and policies necessary for reaching those goals, and any necessary monitoring to ensure effectiveness and success. Incorporate strategies necessary to manage and adapt to changes in wave, flooding, and erosion hazards due to sea level rise.

Goal: Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources

A.4 Limit new development in hazardous areas: Restrict or limit construction of new development in zones or overlay areas that have been identified or designated as hazardous areas to avoid or minimize impacts to coastal resources and property from sea level rise impacts.

A.5 Cluster development away from hazard areas: Concentrate development away from hazardous areas. Update any existing policies that cluster development to reflect additional hazard zones due to sea level rise.

A.5a **Concentration of development/smart growth**: Require development to concentrate in areas that can accommodate it without significant adverse effects on coastal resources. This strategy is applicable for community wide planning through an LCP, but may also apply to CDPs for subdivisions or for larger developments involving large or multiple lots.

A.5b **Transfer of Development Rights programs (TDR)**: Restrict development in one area ("sending area") and allow for the transfer of development rights to another area more appropriate for intense use ("receiving area"). LCPs can establish policies to implement a TDR program to restrict development in areas vulnerable to sea level rise and allow for transfer of development rights to parcels with less vulnerability to hazards. A TDR program can encourage the relocation of development away from at-risk locations, and may be used in combination with a buy-out program.

A.6 Develop adequate setbacks for new development: Ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced erosion) over the life of the structure, *without the use of a shoreline protective device*. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Establish general guidance and criteria for setbacks in LCPs that consider changes in retreat due to sea level rise. Require detailed, site-specific analyses through LCPs and CDPs to determine the size of the setback taking into consideration sea level rise and establish the expected life of the structure (for example, the time period over which the setback should be effective).

Figure 18. Photo depicting a development setback in Pismo Beach. (*Source:* California Coastal Records Project)

A.7 **Limit subdivisions in areas vulnerable to sea level rise**: Prohibit any new land divisions, including subdivisions, lot splits, lot line adjustments, and/or certificates of compliance that create new beachfront or blufftop lots unless the lots can meet specific criteria that ensure that when the lots are developed, the development will not be exposed to hazards or pose any risks to protection of coastal resources.

A.8 **Update development siting and design standards to avoid, minimize, and reduce risks from coastal hazards and extreme events**: Establish and implement standards for building siting and construction that avoid or minimize risks from flooding and erosion and increase resilience to extreme events within sea level rise hazard zones. Such standards should be included in LCPs as additional development controls in areas that are identified in the LCP as hazard areas, and applied in specific projects through a CDP.

A.8a **Update flood protection measures to incorporate both FEMA and Coastal Act requirements:** Require new development located in areas subject to current or future flood/wave action to be sited and designed to be capable of withstanding such impacts in compliance with both FEMA and Coastal Act requirements. For example, LCP provisions should ensure that implementation of any measures suggested by FEMA, such as elevation of habitable areas, break-away walls, etc. will not conflict with LCP provisions designed to protect public views and other coastal resources.

A.8b **Limit basements and first floor habitable space**: Where applicable, in areas likely to be subject to current or future flood/wave action, revise residential building standards to prohibit habitable space at elevations subject to wave/flood risk. Specifically address potential impacts of basements on long-range adaptation options such as landward relocation or removal.

A.8c **Evaluate impacts from flood protection measures:** Require new development that must be located in areas likely subject to current or future flood/wave action or elevated groundwater to evaluate potential impacts to adjacent or nearby properties from all proposed structural flood protection measures to ensure that these measures will not create adverse direct and/or cumulative impacts either on-site or off-site.

A.9 Analyze options for removal when planning and designing new development: Design options should not place an undue burden on future property owners or coastal resources. For new development in high hazard areas or resource-constrained areas where managed retreat might be an appropriate option at some time in the future, ensure that foundation designs or other aspects of the development will not preclude future incremental relocation or managed retreat. Foundation and building elements, such as deepened perimeter foundations, caissons or basements, may be difficult to remove in the future, or their removal may put adjacent properties at risk. Alternative design options should be considered, and employed if site conditions allow.

A.9a **Develop a plan to remove or relocate structures that become threatened:** Require new development authorized through a CDP that is subject to wave action, erosion, or other hazards to be removed or relocated if it becomes threatened in the future.

A.9b **Identify triggers for incremental removal of structures on constrained lots**: When a lot is not large enough to accommodate development that avoids coastal hazards for the expected life of the development, develop a project option that minimizes hazards from the identified sea level rise scenarios for as long as possible, and then requires incremental retreat once certain triggers are met.

Triggers for relocation or removal of the structure would be determined by changing site conditions such as when erosion is within a certain distance of the foundation; when monthly high tides are within a certain distance of the finished floor elevation; when building officials prohibit occupancy; or when the wetland buffer area decreases to a certain width.

A.9c **Avoid shoreline protection for new development:** Require CDPs for new development in hazardous locations to include as a condition of approval a waiver of rights to future shoreline protection that would substantially alter natural landforms or cause other adverse coastal resource impacts.

A.9d **Limit the use of foundations or basements that can interfere with coastal processes:** In locations where foundation or building elements, such as deepened perimeter foundations, caissons or basements may be exposed to wave action through rising sea level or erosion, require analysis of less extensive foundation or building options.

A.9e **Develop triggers for foundation and structure removal:** If no less damaging foundation alternatives are possible, insure that the foundation design allows for incremental removal as the foundation elements become exposed, and develop pre-established triggers, for example when the bluff edge or shoreline comes within a certain distance of the foundation, for incremental or complete removal that will avoid future resource impacts.

Figure 19. Photo depicting eroding bluff and exposed caissons in Encinitas, CA. (*Photograph by Lesley Ewing*)

A.10 Ensure that current and future risks are assumed by the property owner: New development should be undertaken in such a way that the consequences from development in high hazard areas will not be passed on to public or coastal resources. Recognize that over time, sea level rise will cause the public trust boundary to move inland. Establish standards, permit conditions, and deed restrictions that ensure that current and future risks are assumed by the property owner. Consider policies that would encourage or require property owners to set aside money, such as in the form of a bond, as a contingency if it becomes necessary to modify, relocate, or remove development that becomes threatened in the future.

A.11 Real estate disclosure: Require sellers of real estate to disclose permit conditions related to coastal hazards, or property defects or vulnerabilities, including information about known current and potential future vulnerabilities to sea level rise, to prospective buyers prior to closing escrow.

Goal: Incorporate sea level rise adaptation into redevelopment policies

A.12 Avoid the expansion or perpetuation of existing structures in at-risk locations: On an eroding shoreline, the seaward portions of an existing structure may become threatened as the setback or buffer zone between the structure and the mean high tide line or bluff edge is reduced due to erosion of the beach or bluff. When the seaward portion of the structure no longer meets the standards or setback that would be required for new development, it becomes a "non-conforming" structure for purposes of redevelopment policies and regulations. The following should be considered to address existing non-conforming development to avoid the need for shoreline or bluff protective devices and associated impacts to coastal resources.

A.12a **Update non-conforming structure policies and definitions**: Develop policies and regulations to define non-conforming development in hazard zones and avoid perpetuating development that may become at risk and require a new protective device or extend the need for an existing protective device.

A.12b **Limit redevelopment or upgrades to existing structures in at risk locations**: Use redevelopment policies or regulations to limit expansions, additions, or substantial renovations of existing structures in danger from erosion. Require removal of non-conforming portions of the existing structure, when possible, when a remodel or renovation is proposed.

A.12c **Limit foundation work within the geologic setback area:** Use LCP regulations and CDPs to limit new foundation or improvements to the existing foundation when located seaward of the Geologic Setback line. Approve significant new foundation work only when it is located inland of the setback line for new development and when it will not interfere with coastal processes in the future.

A.12d **Limit increases to existing non-conformities:** Use LCP regulations and CDPs to allow only repair and maintenance and modifications that do not increase the size or degree of non-conformity. For shoreline or blufftop development, any decrease in the existing non-conforming setback would increase the degree of non-conformity.

A.12e **Limit additions to non-conforming structures:** Use LCP regulations and CDPs to require that additions to an existing structure conform to the standards for new development. Consider limitations on the size of additions unless non-conforming portions of the structure are removed.

A.12f **Address existing protection of non-conforming structures:** Use LCP regulations and CDP conditions to put current and future property owners on notice that if there is currently shoreline or bluff protection for an existing structure, the structure is likely at-risk and improvements to that structure in its current location may be limited. Also, consider acknowledging that any rights to retain the existing protective device(s) apply only to the structure that existed at the time the protective device was constructed or permitted.

A.13 Clearly define "redevelopment" in the LCP: Define "redevelopment" as, at a minimum, replacement of 50% or more of an existing structure. Other options that may be used to define what constitutes redevelopment or a replacement structure could include 1) limits on the extent of replacement of major structural components such as the foundation or exterior walls, or 2) improvements costing more than 50% of the assessed value of the existing structure. The definition should take into consideration existing conditions and pattern of non-conforming structures to which the regulations may apply and potential impacts to coastal resources and the need for shoreline protection if the structure remains in its non-conforming location.

A.13a **Require redevelopment to meet the standards for new development:** Use LCPs and CDPs to require that renovations meeting the threshold for redevelopment should not be approved unless the entire structure meets the standards for new development, including but not limited to a waiver of right to protection. Specify that if any existing non-conforming elements are permitted to remain, those non-conforming elements are not subject to rights to protection pursuant to Coastal Act Section 30235.

A.13b **Include cumulative improvement or additions to existing structures in the definition of redevelopment:** Use LCP regulations to acknowledge that demolition, renovation, or replacement of less than 50% (or less) of an existing structure constitutes redevelopment when the proposed improvements would result cumulatively in replacement of more than 50% of the existing structure from an established date, such as certification of the LUP.

A.14 Remove existing shoreline protective devices: On properties with existing shoreline protective devices, use regulations to require removal of the protective device when the structure requiring protection is redeveloped or removed. If removal is not possible, require a waiver of any rights to retain the protective device to protect any structure other than the one that existed at the time the protective device was constructed or permitted.

Goal: Encourage the removal of development that is threatened by sea level rise

A.15 Use Rolling Easements: The term "rolling easement" refers to the policy or policies intended to allow coastal lands and habitats including beaches and wetlands to migrate landward over time as the mean high tide line and public trust boundary moves inland with sea level rise. Such policies often restrict the use of shoreline protective structures (such as the "no future seawall" limitation sometimes used by the Commission), limit new development, and encourage the removal of structures that are seaward (or become seaward over time) of a designated boundary. This boundary may be designated based on such variables as the mean high tide line, dune vegetation line, or other dynamic line or legal requirement. Despite the term "rolling easements," not all of the strategies related to rolling easements actually involve the use of recorded easements.

A.16 Develop an incentive program to relocate existing development at risk: Provide incentives to relocate development out of hazardous areas and to acquire oceanfront properties damaged by storms, where relocation is not feasible. Consider creating a relocation fund through increased development fees, *in lieu* fees, or other funding mechanisms.

A.17 Transfer of Development Rights programs (TDR): See Strategy A.5b above.

A.18 Acquisition and buyout programs: Acquisition includes the acquiring of land from the individual landowner(s). Structures are typically demolished or relocated, the property is restored, and future development on the land is restricted. Such a program is often used in combination with a TDR program that can provide incentives for relocation. Undeveloped lands are conserved as open space or public parks. LCPs can include policies to encourage the local government to establish an acquisition plan or buyout program to acquire property at risk from flooding or other hazards.

Goal: Use "soft" or "natural" solutions as a preferred alternative for protection of existing endangered structures

A.19 Require the use of green infrastructure as a preferred alternative: Under appropriate shoreline conditions, require or encourage development to use "soft" or "natural" solutions or "living shorelines" as an alternative to the placement of hard shoreline protection in order to protect development or other resources and to enhance natural resource areas. Examples of soft solutions include vegetative planting, dune restoration, and sand nourishment.

A.19a **Establish a beach nourishment program and protocols**: New policies may be needed to address increased demand or need for beach nourishment with sea level rise. Policies within an LCP may identify locations where nourishment may be appropriate; establish a beach nourishment program and protocols for conducting beach nourishment; establish criteria for the design, construction, and management of the nourishment area; and/or establish measures to minimize adverse biological resource impacts from deposition of material, such as sand compatibility specifications, timing or seasonal restrictions, and identification of environmentally preferred locations for deposits. Beach nourishment programs should also consider how nourishment options may need to change over time as sea level rises.

A.19b **Dune management**: Establish management actions to maintain and restore dunes and natural dune processes. Dunes provide buffers against erosion and flooding by trapping windblown sand, storing excess beach sand, and protecting inland areas, and they also provide habitat. This is likely most effective for areas with some existing dune habitat and where there is sufficient space to expand a foredune beach for sand exchange between the more active (beach) and stable (dune) parts of the ecosystem. LCPs can identify existing dune systems and develop or encourage management plans to enhance and restore these areas, including consideration of ways that the system will change with rising sea level. CDPs for dune management plans may need to include periodic reviews so the permitted plans can be updated to address increased erosion from sea level rise, and the need for increased sand retention and replenishment.

Figure 20. Photo depicting dune restoration at Surfer's Point, Ventura. (*Photograph courtesy of Surfrider Foundation*)

A.19c **Regional Sediment Management (RSM) programs**: Develop a Regional Sediment Management (RSM) program including strategies designed to allow the use of natural processes to solve engineering problems. To be most effective, RSM programs include the entire watershed, account for effects of human activities on sediment, protect and enhance coastal ecosystems and maintain safe access to beaches for recreational purposes. LCPs can support development of an RSM program and its implementation and the program should be periodically updated to address on-going changes from sea level rise. Natural boundaries for RSM may overlap within several LCPs, so regional cooperation may be needed for best implementation. Individual actions such as a beach nourishment project would be accomplished through a CDP. Many coastal RSM programs have already been developed and can be used as a resource. See the *Coastal Sediment Management Workgroup* website (and Appendix C) for more information.

A.19d **Maintenance or restoration of natural sand supply**: Adjustment of the sediment supply has been one of the ways natural systems have accommodated changes from sea level. Maintenance or restoration of sediment involves identifying natural sediment supplies and removing and/or modifying existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply.

Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

A.19e **Beneficial reuse of sediment through dredging management**: Dredging involves the removal of sediment from harbor areas to facilitate boat and ship traffic or from wetland areas for restoration. Dredging management actions and plans may need to be updated to account for elevated water levels. Policies can be developed with an LCP and/or carried out through a CDP to facilitate delivery of clean sediment extracted from dredging to nearby beaches where needed. Beneficial reuse of sediment in this way can be coordinated through a Regional Sediment Management (RSM) program and/or through coordination with other jurisdictions.

Goal: Allow bluff and shoreline protective devices only to protect existing endangered structures

A.20 Use hard protection only if allowable and if no feasible less damaging alternative exists: "Hard" coastal protection is a broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. In some cases, caissons and pilings may also be considered hard shoreline protective devices. Due to adverse effects on shoreline sand supply and beach area available for public use, such protective devices should be avoided when feasible. Under current law, shoreline protection for existing structures in danger from erosion may be allowed if coastal resource impacts are avoided or minimized and fully mitigated where unavoidable.

A.20a **Retention of existing shoreline protection**: On intensely developed, urbanized shorelines, if the removal of armoring would put existing development at risk and not otherwise result in significant protection or enhancement of coastal resources, it may be appropriate to allow properly designed shoreline armoring to remain for the foreseeable future, subject to conditions that provide for potential future removal in coordination with surrounding development. However, the proper short term responses and longer term adaptation measures and mitigation of on-going resource impacts should be determined through updated context-specific LCP planning and consideration of the existing rights and responsibilities of development in the area (see strategies A.21 – A.25).

A.21 Require monitoring of the structure: Require periodic monitoring of the shore protection structure to examine for structural damage, excessive scour, or other impacts from coastal hazards and sea level rise. Ensure that the structures remain within the initial footprint and that they retain functional stability.

A.22 Conditional approval of shoreline protection structures: Use LCP regulations and permit conditions to require monitoring of impacts to shoreline processes and beach width and provide for such actions as removal or modification of armoring in the future if no longer needed for protection or site conditions change.

A.22a **Limit the authorization of shoreline protective devices to the development being protected:** Use LCP regulations and CDP conditions to require permits for bluff and shoreline protective devices to expire when the currently existing structure requiring protection is redeveloped, is no longer present, or no longer requires a protective device, whichever occurs first. Prior to expiration of the permit, the property owner should apply for a Coastal Development Permit to remove the protective device, or to modify or retain it if removal is not feasible at that time.

A.22b **Require assessment of impacts from existing pre-Coastal Act or permitted shoreline armoring:** Use LCP regulations and permit conditions to specify that expansion and/or alteration of a pre-Coastal Act or legally permitted bluff or shoreline protective device requires a new CDP and the review should include an assessment of changes to geologic site and beach conditions including but not limited to, changes in beach width relative to sea level rise, implementation of any long-term, large scale sand replenishment or shoreline restoration programs, and any ongoing impacts to public access and recreation from the existing device.

A.22c **Reassess impacts and need for existing armoring over time:** Use LCP regulations and CDPs to provide for reassessment of the impacts from protective devices at specific trigger points, including when substantial improvement or redevelopment of the structure requiring protection is proposed, or when existing armoring is being modified or expanded. Reassessment should consider the effect any significant improvement to a structure requiring protection will have on the length of time the protective device will remain, and if the existing armoring is still required, acknowledge that it is authorized to protect the existing structure only. The CDP review should assess existing site conditions and evaluate options to modify, replace, or remove the existing device in a manner that would eliminate or mitigate any identified impacts that may be occurring on public access and recreation, scenic views, sand supply and other coastal resources, if feasible.

A.23 Require mitigation for impacts of shoreline protective devices: For unavoidable public resource impacts from shoreline structures permitted under the Coastal Act, require mitigation of resource impacts over the life of the structure as a condition of approval for the development permit. For example, require landowners to pay mitigation fees and/or complete other mitigation actions for the loss of sandy beach and other adverse impacts on public access and recreation due to shoreline protection devices. Importantly, mitigation measures should be planned in such a way that sea level rise will not impair their efficacy over time. Other mitigation measures could include acquisition of other shoreline property for public recreational purposes or construction of public access and recreational improvements along the shoreline.

A.23a **Reassess mitigation over time as necessary:** Impacts of shoreline structures, including to shoreline and sand supply, public access and recreation, ecosystem values, and other relevant coastal resources, should be fully mitigated. Where reassessment of an approved structure is authorized, phasing of necessary mitigation may be appropriate.

A.24 **Limit retention of existing shore protection:** On lots with existing pre-Coastal Act or permitted armoring, consider requiring a waiver of rights to retain such protection for any structures other than the structure that existed at the time the armoring was constructed or permitted.

A.25 **Removal of shoreline protection structures**: The removal of shoreline protection structures can open beach or wetland areas to natural processes and provide for natural responses to sea level rise. LCPs can specify priority areas where shoreline protection structures should be removed if they are no longer needed or in a state of great disrepair, including areas where structures threaten the survival of wetlands and other habitat, beaches, trails, and other recreational areas. Once these priority areas have been identified, assessment of potential re-siting of structures and removal of armoring could be required by a CDP as redevelopment occurs.

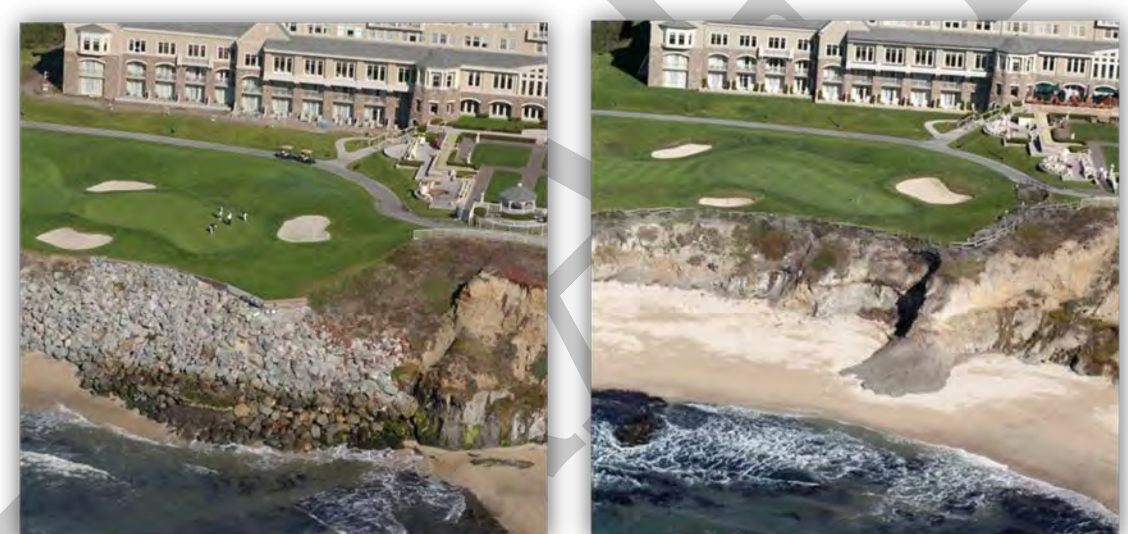

Figure 21. Photo depicting removal of shoreline protective structure. Removal of rock revetment restores access and allows natural bluff erosion at the Ritz Carlton in Half Moon Bay. (*Source:* California Coastal Records Project)

A.25a **Remove shoreline protective structures located on public lands:** Over time, sea level rise will cause the public trust boundary to move inland. If the structures as originally approved were located on uplands but that land becomes subject to the public trust in the future, the State Lands Commission or any local government or other entity acting as trustee for public trust lands could require the structures to be removed. The Commission or local governments could approve permit conditions to ensure permittees obtain authorization to retain or remove structures if they ever become located on public trust lands. Removal might also be accomplished through non-regulatory means such as by offering incentives for removal to property owners or by incorporating removal of public structures into Capital Improvement Plans.

Goal: Require special considerations for critical infrastructure and facilities

A.26 Plan ahead to preserve function of critical facilities: Addressing sea level rise impacts to critical facilities and infrastructure will likely be more complex than for other resources and may require greater amounts of planning time, impacts analyses, public input, and funding. To address these complexities, establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Programs and measures within an LCP could include identification of critical infrastructure that is vulnerable to SLR hazards, establishment of a plan for managed relocation of at-risk facilities, and/or other measures to ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms. Repair and maintenance, elevation or spot-repair of key components, or fortification of structures where consistent with the Coastal Act may be implemented through CDPs.

A.26a **Develop or update a long-term public works plan for critical facilities to address sea level rise**: Develop a long-term management plan to address the complexities of planning for sea level rise that incorporates any potential maintenance, relocation, or retrofits and structural changes to critical facilities to accommodate changes in sea level, and obtain Coastal Commission certification.

A.27 Apply high sea level rise projections for siting and design of critical facilities: Given the planning complexities, high costs, and potential impacts resulting from damage, there is reason to be particularly cautious when planning and designing new critical facilities and/or retrofitting existing facilities. Ensure that critical facilities are designed to function even if the highest projected amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts.

A.27a **Design coastal-dependent infrastructure to accommodate worst case scenario sea level rise**: Include policies that would require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation.

A.28 Site and design wastewater disposal systems to avoid risks from sea level rise: Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts.

Goal: Protect transportation infrastructure

A.29 Identify priorities for adaptation planning and response: Carry out vulnerability analyses to identify chronic problem areas that are highly subject to erosion, wave impacts, flooding, or other coastal hazards or that maybe become so in the near future. Coordinate with Caltrans and local public works/transportation agencies to address high priority areas and increase monitoring efforts of chronic problem areas.

A.30 Add policies to address impacts to transportation routes: If transportation facilities are at risk from sea level rise, coordinate with Caltrans and local public works/transportation agencies to establish new alternative transportation routes or a plan to ensure continued alternative transportation and parking is available that allows for continued access to beaches and other recreation areas.

A.30a **Integrate LCP/land use planning processes with transportation planning processes:** Updates and changes to LCPs and other land use planning efforts should be jointly planned, evaluated, and implemented with Coordinated System Management Plans, Regional Transportation Plans, and other transportation planning efforts to ensure that long-term land use and access goals and needs are aligned.

A.31 Allow for phased implementation of realignment and relocation projects: In some cases it may be necessary to make incremental changes in transportation networks so that access to and along the coast can be maintained while also addressing coastal hazards over the long-term. For example, a phased approach may allow for interim shoreline protection to maintain an existing road alignment while future realignment plans are evaluated and pursued. Such phased approaches should be coordinated with Caltrans and local public works/transportation agencies and aligned with long-term LCP planning and adaptation goals. Individual projects will be implemented through CDPs.

Figure 22. Photo depicting planned retreat for major public infrastructure. The Piedras Blancas Highway 1 Realignment will move nearly 3 miles (5km) of Highway 1 500 ft (152 m) inland. (*Source:* California Coastal Records Project)

A.32 Plan and design transportation systems to accommodate anticipated sea level rise impacts: Ensure that transportation networks are designed to function even if the highest projected sea level rise amounts occur. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, and LCP planning efforts, and individual projects will be implemented through CDPs.

A.32a **Retrofit existing transportation infrastructure as necessary:** In instances where relocation is not an option, repair damage and/or retrofit existing structures to better withstand sea level rise impacts. For example, use stronger materials, elevate bridges or sections of roadways, and build larger or additional drainage systems to address flooding concerns.

A.32b **Build redundancy into the system:** Provide alternate routes, as possible, to allow for access to and along the coast in instances in which sections of roadways may become temporarily impassible as a result of coastal hazards. Ensure that alternate route information is provided to residents and visitors to coastal areas.

B. Public Access and Recreation

One of the highest priorities in the Coastal Act is the mandate to maximize public access and recreational opportunities to and along the coast. The main goals and Coastal Act policies (Sections 30210, 30220, 30221, 30213) that relate to public access and recreation are to:

- Maximize public access and recreational use by protecting beaches and other coastal areas suitable for such use
- Protect lower cost visitor and recreational facilities and accessways

Chapter 3 of the Guidance covers the impacts to public access and recreation that might result from sea level rise or the interaction of sea level rise with development patterns. Certified LCPs should already have policies and standards to assure that existing public access and visitor serving amenities are protected and that maximum public access is both planned for and provided with new development when warranted. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the access goals of the Coastal Act through both LCP policies and CDP condition, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Maximize public access and recreational use by protecting beaches and other coastal areas

B.1 Incorporate sea level rise into a comprehensive beach management strategy: Update or develop a new comprehensive beach management strategy to address loss of beach areas, including loss of lateral access, or changes in beach management due to sea level rise. Establish a program to minimize loss of beach area through, as may be appropriate, a beach nourishment program; restoring sand and sediment supply to the littoral cell; removal, adjustments, or maintenance to shoreline protection structures; use of man-made structures such as terminal groins or artificial reefs to retain sediment; or other actions.

B.1a **Develop a sediment management and sand replenishment strategy**: Identify natural sediment supplies and remove and/or modify existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply. Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

B.2 Plan ahead to replace loss of access and recreation areas: Identify replacement opportunities or otherwise plan ahead for how to replace recreation areas and accessways that will be lost due to inundation or damage associated with sea level rise. An LCP could designate and zone lands for this through, for example, a phased overlay or other regulatory measures that ensure that access and recreational areas are available in the future. Local governments may choose to provide additional incentives to encourage creation of new recreation areas or opportunities. Such incentives could include grant for protection new recreation areas or tax breaks for recreation related businesses.

B.2a **Protect existing open space adjacent to the coast**: Plan for future coastal recreational space and parkland by protecting open space adjacent to coastal habitats so that beaches and other habitats can migrate or so that there is open space available as parkland or other areas are lost.

B.2b **Plan for removal of structures that limit inland migration of beaches**: Seawalls and other development adjacent to beaches and other coastal habitats will impede the ability of these habitats to migrate inland and will therefore result in the inundation and eventual loss of these areas. Consideration should be given to removing and relocating these structures to ensure that beaches and other habitats are able to persist over time. Additional detail on removal of structures can be found above in the "Coastal Development and Hazards" section of this chapter.

Goal: Protect lower cost visitor and recreational facilities and accessways

B.3 Site and design access sites and facilities to minimize impacts: Add policies that require public access sites, segments of the CCT, recreation and visitor-serving facilities to be sited and designed to avoid impacts from sea level rise, while maximizing public access and recreation opportunities. Examples of siting and design standards for development can be found in section A. Where facilities can be safely sited for the near term but future impacts are likely, require an adaptive management plan detailing steps for maintenance, retrofitting, and/or relocation.

B.3a **Require mitigation of any unavoidable impacts**: For unavoidable impacts to public access or recreation from shoreline armoring or other development, require mitigation of impacts through the addition of new public access, recreation opportunities, visitor-serving accommodations or Coastal Trail segments or payment of fees to fund such improvements. Importantly, mitigation measures should be planned in such a way that, if possible, sea level rise will not impair their efficacy over time.

B.4 Plan ahead to replace loss of visitor-serving and recreational facilities: Develop a plan to replace any visitor-serving facilities that are lost due to impacts from sea level rise, maximizing continued provision of affordable options, and an appropriate mix of accommodations over time. For example, an LCP could include standards to re-site existing visitor-serving and recreational facilities when they become impacted by sea level rise and/or could identify and zone for future areas to be reserved for these functions.

B.5 Add requirements for retrofit/relocation of public access and recreation sites at risk: The LCP can add policies that require all new public access and recreation areas, sections of the CCT, visitor- serving accommodations, or related recreation facilities to be retrofitted or relocated if they become threatened from erosion, flooding, or inundation. For new facilities and public access sites, the CDP conditions of approval can specify how maintenance, retrofit, or relocation will take place. Policies and plans should be designed to be adaptive so that retrofits and or/relocations are implemented as sea level rise impacts occur.

B.5a **Retrofit or relocate recreation and visitor-serving facilities**: consider options to retrofit existing recreation and visitor-serving facilities to better accommodate sea level rise impacts. Such retrofits could include use of different building materials and/or relocating facilities.

B.5b **Retrofit or relocate vertical accessways**: Consider options to retrofit existing accessways to reduce impacts from sea level rise. Such retrofits could include using different materials that can better withstand impacts, or re-orienting the layout or other features of accessways to lessen damage and other impacts. Also begin to plan for and identify triggers and options for relocating accessways over time as conditions change.

B.5c **Retrofit or relocate sections of the Coastal Trail**: Use boardwalks, bridges, and/or other design features to ensure continuity of the CCT in sections that are vulnerable to SLR hazards. Some sections may need to be relocated over time. An LCP could identify vulnerable sections of the CCT and establish a phased approach to relocate sections of the trail in such a way that is consistent with provisions of the Coastal Act and ensuring that the CCT remains within sight, sound, or smell of the sea.

Goal: Foster efforts to better understand impacts of sea level rise

B.6 Support research on impacts to recreation and public access: Changes in sea level will affect wave conditions and sediment transport, but additional research is needed to understand how these changes will affect specific conditions for surfing and other recreation activities. While such research programs may be outside the scope of individual local jurisdictions, statements of support for the local issues that need to be addressed can help guide research agendas at the regional state or federal level. Or, such needs can serve to guide grant applications to undertake the needed projects within a jurisdiction. To the extent possible, add policies to promote research on sea level rise impacts to recreational activities like surfing or other coastal recreational uses in the LCP jurisdiction.

C. Coastal Habitats, ESHA, and Wetlands

The Coastal Act provides for the protection of both land and marine habitats. It mandates that ESHA and marine resources shall be protected against significant disruption of habitat value and shall be maintained, enhanced, and restored as feasible (Sections 30230, 30233, 30240, 30240(a), 30240(b)). The main goals and Coastal Act policies that relate to coastal habitats are to:

- Protect, enhance, and restore sensitive habitats
- Avoid significant disruption to sensitive habitats
- Avoid significant impacts to habitats from adjacent development
- Manage sediment in ways that benefit habitats

Chapter 3 of the Guidance covers the impacts to coastal habitats and resources that might result from sea level rise or the interaction of sea level rise with development patterns. Certified LCPs should already have policies and standards to ensure that ESHA, wetlands, and other coastal habitats and resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the habitat protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect, enhance, and restore sensitive habitats

C.1 Open space preservation and conservation: Preserve land for its ecological or recreational value. This may involve limiting or prohibiting development and any uses that conflict with ecological preservation goals. LCPs can establish transfer of development rights programs to offset reduced development potential and can develop open space management plans that evaluate and consider the impacts of sea level rise, extreme events, and other climate change impacts. LCPs can establish open space and conservation areas through land use designations and zoning, redevelopment restrictions, acquisition and easement programs, and setback and buffer requirements.

C.1a **Update policies to provide for new or restored coastal habitat**: Update policies to require new coastal habitat to be provided or for degraded areas to be restored to account for the expected loss of existing habitat that will occur when development blocks the necessary upland migration due to sea level rise. Use an adaptive management approach where applicable. Encourage policies that provide for conservation or restoration of multiple habitat types.

C.1b **Identify areas for public acquisition**: New or updated LCPs can establish a program to partner with state, federal, and non-profit organizations to acquire and protect natural resource areas for public use, including areas that could serve as refugia for species impacted by sea level rise, or areas that could be appropriate sites for coastal habitat creation or restoration.

C.1c **Establish conservation easements or other development restrictions to protect habitat**: Establish a formalized program to identify, acquire, and manage areas appropriate for some form of conservation protection. Easements or other strategies may be used to limit or restrict development on portions of a lot parcel that are most vulnerable to SLR impacts. The program might develop standard agreements to be used for easements, and identify the entities that could hold the easements. A conservation easement program could be established on a community wide basis through an LCP and implemented on a parcel by parcel basis through individual CDPs.

C.1d **Require open space protection as a component of new development located adjacent to coastal habitats**: The LCP can require permit conditions for new development in certain areas that buffers around natural resource areas be protected through a conservation easement, deed restrictions, or other comparable mechanism.

C.1e **Use Rolling Easements**: See Strategy A.15 above.

C.1f **Transfer of Development Rights programs (TDR)**: See Strategy A.5b above.

Goal: Avoid significant disruption to habitats

C.2 Use ecological buffer zones and/or increase the size of buffers: Buffer zones are intended to protect sensitive habitats from the adverse impacts of development and human disturbance. An important aspect of buffers is that they are distinct ecologically from the habitat they are designed to protect. LCPs can establish requirements for ecological buffers and provide guidance on how to establish or adjust these buffers to accommodate sea level rise. CDPs should require buffers to be designed, where applicable, to provide "habitat migration corridors" that allow sensitive habitats and species to migrate inland or upland as sea level rises.

C.2a **Consider sea level rise buffer zones**: Update buffer zone policies to allow room for coastal habitats to migrate with changes in sea level. The size of the buffer needed to allow for migration will vary depending on the individual wetland or habitat type, as well as site-specific features such as natural or artificial topography and existing development. For instance, in flat areas, a larger buffer may be needed, but in steep areas, a smaller buffer may be acceptable.

C.3 Protect specific ESHA functions: Environmentally Sensitive Habitat Areas (ESHA) are areas that are critically important for the survival of species or valuable for maintaining biodiversity. These areas can include nursery grounds, spawning areas, or highly diverse areas. Where at risk from sea level rise, the LCP should establish measures to ensure the continued viability of the habitat areas, such as protection of migration zones, habitat corridors, and other applicable adaptation strategies, as listed below. ESHA that is not at risk from sea level rise should also be afforded special protection in the LCP to serve as refugia.

C.3a **Protect wildlife corridors, habitat linkages, and land upland of wetlands to allow habitat migration**: Preserve open areas that are adjacent to wetlands to allow for migration of these habitats as sea levels rise.

C.3b **Protect refugia areas**: Protect refugia, or areas that may be relatively unaltered by global climate change and thus can serve as a refuge for coastal species displaced from their native habitat due to sea level rise or other climate change impacts.

C.3c **Promote increased habitat connectivity to allow species movement**: Connectivity refers to the degree to which the landscape facilitates animal movement and other ecological flows. Roads, highways, median barriers, fences, walls, culverts, and other structures can inhibit movement of animals. Develop LCP policies that will enable identification of important animal movement corridors. Develop regulations to protect these corridors for present and future conditions, taking into account habitat shifts from climate change. In LCPs and through CDPs, require that new structures such as highways, medians, bridges, culverts, and other development are designed to facilitate movement of animals.

C.3d **Facilitate wetland and other habitat migration**: Reserve space for a "habitat migration corridor" or areas into which wetlands and other habitats could migrate as sea level rise induced inundation of existing wetland areas occurs. In the LCP, identify potential habitat migration corridors. These areas could be reserved for this purpose in an LCP through land acquisition, use designations, zoning buffers, setbacks, conservation easement requirements, and clustering development. LCPs should also consider developing a plan for acquisition of important habitat migration corridors.

Goal: Avoid significant impacts to habitats from adjacent development

C.4 Limit new development in areas adjacent to wetlands, ESHA, and other coastal habitats: Restrict the construction of new development in areas that are adjacent to wetlands, ESHA, and other coastal habitats in order to preserve buffers and open areas to allow for habitat migration.

C.4a **Cluster development away from coastal habitats**: Existing LCPs will likely have policies that already require clustering of development. To address sea level rise, these policies might need to be updated to include clustering development away from land where wetlands and other coastal habitats could migrate with sea level rise.

C.4b **Limit subdivisions**: Update subdivision requirements to require provision for inland migration of natural resource areas or to require lots to be configured in a way that allows such migration. Lot line adjustments may sometimes be appropriate if they facilitate locating physical development further away from hazards or sensitive resources.


Figure 23. Photo depicting the preservation and conservation of open space along an urban-rural boundary. North end of Pismo Beach from 1972 (*left*) to 2002 (*right*). (*Source:* California Coastal Records Project)

Goal: Manage sediment in ways that benefit habitats

C.5 **Identify opportunities for Regional Sediment Management**: Sediment supplies will be important for the long-term sustainability of many beaches and wetland areas. Strategies to maintain or restore natural sediment supplies and to coordinate sediment removal efforts with opportunities for reuse can provide multiple benefits to coastal ecosystems. See Strategy A.19c above for more detail on RSM programs.

C.5a **Restore natural sediment sources to wetlands**: Restoration of natural hydrodynamic systems will help to ensure the ability of wetlands to persist with sea level rise by ensuring that sediment is available for wetland accretion. Such actions may include restoring natural channels in streams and waterways that have been armored or channelized. Organizing and coordinating such efforts may be accomplished through a Regional Sediment Management Plan.

Goal: Incorporate sea level rise into habitat management actions

C.6 **Include sea level rise in site-specific evaluations**: Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise where appropriate. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion).

C.7 **Incorporate sea level rise in restoration, creation, or enhancement of coastal habitats**: Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion). Habitat restoration, creation, or enhancement projects should be designed to withstand impacts of sea level rise and adapt to future conditions. As applicable, the LCP should contain policies to ensure restoration and management techniques account for future changes in conditions. CDPs for restoration projects should incorporate sea level rise and provisions to ensure habitats can adapt with changing future conditions.

C.8 Update habitat management plans to address sea level rise: Add policies stating that the effects of sea level rise should be addressed in management plans for coastal habitats. For example, plans should evaluate the full range of sea level rise impacts to coastal habitats, and develop a strategy for managing coastal habitats given changing sea level rise conditions. Existing management plans may need to be updated to add new monitoring and restoration requirements to address sea level rise. The strategies listed below are examples of strategies that could be included in habitat management plans.

C.8a **Use an adaptive management approach in ecosystem management, restoration, or design**: Habitat management plans and/or other habitat projects should establish an adaptive management approach, with clearly defined triggers for adaptive actions. Such an approach would allow for and ensure that coastal habitats are able to migrate and transition with changes in sea level.

C.9 Pursue strategies to protect ecosystem function under a range of future sea level rise or climate change scenarios: The LCP and/or habitat management plans can recommend coastal habitat management strategies that strive to protect ecosystem function in the future. Strategies include protecting a wide range of ecosystem types, protecting refugia, protecting wildlife and habitat corridors, and establishing methods to monitor ecosystem change over time.

C.9a **Update monitoring requirements for coastal habitats**: As part of the LCP and/or habitat management plans, consider establishing a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time. Such a protocol would also help identify triggers at which additional adaptation options are necessary.

Figure 24. Photo depicting habitat protection at Salinas River State Beach. Dunes are roped off to protect Snowy Plover nesting habitat. (*Source:* California Coastal Records Project)

D. Agricultural Resources

Agriculture is a priority use within the Coastal Act, which mandates that the maximum amount of prime agricultural land shall be protected and maintained (Sections 30231, 30241, 30242). The main goals and Coastal Act policies that relate to agriculture are to:

- Protect the maximum amount of prime agricultural land
- Limit conversion of lands suitable for agriculture to non-agricultural uses
- Minimize impacts to water quality that could result from agricultural practices
- Promote water conservation efforts

Chapter 3 of the Guidance describes the impacts to agricultural resources that may result from sea level rise. Certified LCPs should already have policies and standards to ensure that agricultural resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to address sea level rise hazards. Adaptation options have been developed to support the agricultural protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect the maximum amount of prime agricultural land

D.1 Identify and designate areas suitable for agricultural production to replace agricultural production areas that could be lost to sea level rise: Identify any non-sensitive open or developed areas, both within and outside of the Coastal Zone, which could potentially be used to replace agricultural land that is lost to sea level rise. Update LCP designations and/or policies to protect these identified areas for agricultural production and, as applicable, to provide for their conversion to agricultural use.

D.1a **Establish SLR-specific agricultural protection program:** Establish a formal program to identify, acquire, incentivize, and manage areas appropriate for new/renewed agricultural use and/or for protection of current and/or future agricultural uses. Such program should target key areas and properties where agricultural conversion threats are highest, and should dovetail with existing agricultural protection programs. Easements and other legal restrictions may be used as part of such program to help limit or restrict development in areas where agricultural land and production are most vulnerable to sea level rise impacts. The program might develop standard language and/or legal documents that can be used for easements or other property restrictions. The program should be flexible enough to be able to be implemented on both a large scale (*e.g.*, though LCP policies and programs) as well as on a smaller scale (*e.g.*, through the CDP process).

D.2 Protection, maintenance, and adaptation of dikes and levees: Repairing and maintaining existing flood barriers such as dikes and levees may be a cost-effective way to continue to protect agricultural areas. While some repair and maintenance activities are exempt from the need for a CDP, the repair and maintenance exemption does not apply to repair and maintenance work that is located within an ESHA, within any sand area, within 50 feet of the edge of a coastal bluff or ESHA, or within 20 feet of coastal waters. LCPs could identify opportunities for these kinds of actions and ensure that they are appropriately permitted, with consideration to the environmental protection and restoration goals of the Coastal Act. While landowners have the right to repair and maintain existing legal levees in their current configurations, the Commission and local governments administering LCPs have the authority to regulate, via the CDP process, the proposed methods of repair and maintenance. To raise, reconfigure, enlarge, or widen levees is not repair and maintenance and requires a Coastal Development Permit. Such activities may not be consistent with the Coastal Act or certified LCP, such as in cases involving wetland fill impacts. However, where there are opportunities to restore marine resources and the biological productivity of wetlands and estuaries, it may be possible to permit a dike/levee reconstruction project that provides for substantial restoration.

Goal: Limit conversion of lands suitable for agriculture to non-agricultural uses

D.3 Limit conversion of agricultural land to other developed land uses: Develop policies to assure maximum environmentally feasible protection of rural agricultural land, open space, and other coastal resources, including areas that may be considered non-prime agricultural land at this time. Anticipate areas that could become more difficult to farm and identify strategies to avoid or mitigate the potential impacts.

Goal: Minimize impacts to water quality that could result from agricultural practices

D.4 Include sea level rise in water quality protection policies: Where needed, coordinate with regional water quality control boards to add policies to reduce water pollution from runoff should agricultural lands become flooded or inundated due to sea level rise.

D.4a **Minimize water quality impacts from flooding of agricultural lands**: Agricultural practices that are designed to minimize water quality impacts, such as those designed to minimize runoff, may need to be updated or enhanced to ensure water quality protection if sea level rise results in more frequent flooding of agricultural lands.

D.4b **Add policies to address saltwater intrusion**: Add policies to protect water supply for priority coastal agriculture, including policies to address saltwater intrusion, such as limits on groundwater withdrawal or diversification of water supplies. Strategies to pump freshwater and/or highly treated wastewater into aquifers to reduce saltwater intrusion should be minimized in areas with limited freshwater resources.

Goal: Promote water conservation efforts

D.5 **Maximize water conservation to protect priority agricultural water supplies**: Saltwater intrusion and other climate change impacts may result in reduced water availability. LCP policies should be updated to establish or enhance standards related to water conservation and/or to identify opportunities for water recycling, dual plumbing systems and the like. For more information on options such as relocating wells and reducing pumping in sensitive aquifers, see the following section on Water Quality and Water Control Management.

D.6 **Identify alternate water sources for agriculture**: Establish a program to identify alternate water sources for agriculture.

E. Water Quality and Supply

The main water quality protection policy of the Coastal Act requires minimizing the adverse effects of wastewater discharges, runoff, and groundwater depletion in order to protect the biological productivity and quality of coastal waters, as described in Section 30231. The main goals related to water quality include:

- Control runoff and stormwater pollution
- Minimize adverse effects of wastewater discharges and entrainment
- Prevent depletion of groundwater supplies from saltwater intrusion
- Improve long-term water quality through research

Chapter 3 of the Guidance covers the impacts to coastal waters from increased runoff, wastewater discharge and saltwater intrusion into groundwater sources from sea level rise. Adaptation options have been developed to limit the amount of pollutants that enter coastal waters through runoff or discharges.

Goal: Control runoff and stormwater pollution

E.1 Update water quality Best Management Practices (BMPs): Evaluate and update BMPs to account for changes in water quality and supply issues due to sea level rise, as applicable. Updates could include practices to provide greater infiltration/inflow of rainwater, increased stormwater capture and/or water recycling programs, the use of low impact development, improved maintenance procedures for public sewer mains, policies to address impaired private sewer laterals, and other proactive measures.

E.2 Include sea level rise in stormwater management plans and actions: Control the amount of pollutants, sediments, and nutrients entering water bodies through precipitation-generated runoff. LCPs should include sea level rise and extreme storms in stormwater management plans and actions. CDPs for stormwater infrastructure should consider sea level rise.

E.2a **Increase capacity of stormwater infrastructure**: Actions to reduce impacts from higher water levels could include widening drainage ditches, improving carrying and storage capacity of tidally-influenced streams, installing larger pipes and culverts, adding pumps, converting culverts to bridges, creating retention and detention basins, and developing contingency plans for extreme events. Encouraging and supporting these types of efforts upstream may also be important.

E.2b **Use green stormwater infrastructure to the maximum extent feasible**: Employ natural, on-site drainage strategies to minimize the amount of stormwater that flows into pipes or conveyance systems. These strategies include low impact development, green roofs, permeable pavements, bioretention (*e.g.*, vegetated swales, rain gardens) and cisterns. LCPs can include policies that require green infrastructure be used whenever possible *in lieu* of hard structures. Incorporate sea level rise and extreme storms into the design.

Goal: Minimize adverse effects of wastewater discharges and entrainment

E.3 Add policies to address water quality risks from wastewater treatment plants, septic systems, and ocean outfalls: Consider establishing a program to retrofit, relocate, or eliminate ocean outfalls and other wastewater infrastructure deemed at risk. Alternatives include modifications to outfall lines, the use of green infrastructure, and redesign of waste and stormwater systems.

E.3a **Update siting and design policies**: Add policies to ensure that new ocean outfalls, wastewater treatment facilities, and other facilities that could negatively impact water quality if flooded or inundated, are sited and designed to minimize impacts from sea level rise. Avoid construction of new stormwater outfalls and direct stormwater to existing facilities with appropriate treatment and filtration where feasible. Where new outfalls cannot be avoided, plan, site, and design stormwater outfalls to minimize adverse impacts on coastal resources, including consolidation of existing and new outfalls where appropriate. Consolidate new and existing outfalls where appropriate.

E.3b **Retrofit, relocate, or eliminate outfalls deemed "at risk"**: An ocean outfall is a pipeline or tunnel that discharges municipal or industrial wastewater, stormwater, combined sewer overflows, cooling water, or brine effluents from desalination plants to the sea. LCPs should identify areas where sea level rise could affect flow of wastewater from outfalls and lead to backup and inland flooding, and plans should be made to retrofit, relocate, or eliminate these outfalls to prevent damage and impacts to water quality. Additionally, CDPs for new ocean outfalls should consider sea level rise in the design.

E.3c **Reduce or find alternatives for septic systems in hazardous areas**: Flooding, inundation, and changing groundwater dynamics may result in impacts to septic systems, which rely on leach fields for dispersal of wastewater, that could cause water quality impairments. Options to reduce the potential for these impacts by redesigning or eliminating septic systems in hazardous areas should be identified. New development that will rely on septic systems should be limited in hazardous areas.

Goal: Prevent depletion of groundwater supplies from saltwater intrusion

E.4 Groundwater Management: Plan and coordinate monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of fostering long-term sustainability of the resource. The LCP can add policies that specify limits or establish other standards for the use of groundwater and sensitive aquifers.

These policies should be made in accordance with other regional water planning efforts, such as Integrated Regional Water Plans as well as relevant state water policies. CDPs involving the use of groundwater should address groundwater management issues.

E.4a **Add policies to address saltwater intrusion into aquifers**: Consider adding policies that establish a long-term strategy for addressing saltwater intrusion in aquifers, including limiting development that would use sensitive aquifers as applicable. For some areas of the state, additional information is needed on the site-specific impacts of sea level rise on aquifers. For these areas, the LCP could identify the local information needs and promote the establishment of a research program to increase understanding of the vulnerability of coastal aquifers.

E.4b **Limit groundwater extraction from shallow aquifers**: Groundwater extraction from shallow aquifers can increase susceptibility to saltwater intrusion. Regulating development to limit or prevent extraction and avoid overdraft from vulnerable aquifers can reduce the impacts of saltwater intrusion and preserve fresh groundwater supplies. LCPs or CDPs can add restrictions to the use of aquifers susceptible to saltwater intrusion and can encourage measures to recharge shallow aquifers that are depleted.

E.4c **Relocate wells and water intake facilities**: Identify opportunities to relocate wells and water intake facilities away from hazards and/or areas where saltwater intrusion may be a problem.

E.4d **Restrict development of new wells in sensitive areas**: Require new water wells to be sited away from areas where saltwater intrusion could occur.

E.4e **Limit development that relies on vulnerable water supplies**: Limit or restrict new development in areas that are dependent on water supplies that are or will become susceptible to saltwater intrusion.

E.4f **Ensure adequate long term water supplies:** When siting and designing new development, ensure that adequate and sustainable water sources are available for the lifetime of the development and suitable for the intended use of the development, considering potential impacts of sea level rise and saltwater intrusion upon groundwater supplies.

Goal: Improve long-term water quality through research

E.5 Identify research and monitoring needs to more precisely understand local issues: Research programs may be established to analyze the particular local challenges related to water quality and supply as a result of sea level rise. Opportunities for innovative solutions to these challenges should be identified.

E.5a **Clearly define areas at risk**: The LCP should include an updated inventory of potential pollutant sources due to sea level rise, including toxic waste sites, ocean outfalls and wastewater treatment facilities at risk of inundation, as well as aquifers and wells at risk of saltwater intrusion.

F. Archaeological and Paleontological Resources

The Coastal Act provides for the protection of archaeological and paleontological resources, stating in Section 30244 that:

> "Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required."

Chapter 3 of the Guidance discusses the impacts to archaeological and paleontological resources that might result from sea level rise. Certified LCPs should already have policies and standards to ensure that these resources are protected to the maximum extent feasible, however, such policies and standards may need to be updated to consider sea level rise hazards. The following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect archaeological and paleontological resources

F.1 Add policies to protect archeological and paleontological resources from sea level rise: Add policies to require site-specific evaluation of potential sea level rise impacts to archeological and paleontological resources on a development site. The LCP can also add requirements that a monitoring program and plan be established as a condition of approval for development located on a site with artifacts vulnerable to sea level rise. Adaptation or protection strategies used may depend on the significance of the archaeological resources in question.

F.1a **Consult with relevant tribes for guidance:** If resources are at risk, the appropriate entity or Native American tribe(s) should be contacted to develop a coordinated management plan for artifacts. See, for example, the *California Natural Resources Agency Final Tribal Consultation Policy* for additional guidance.

F.1b **Coordinate with the State Historic Preservation Officer (SHPO):** In line with the provisions of the Coastal Act, work with the State Historic Preservation Officer to identify actions to protect archaeological and paleontological resources.

G. Scenic and Visual Resources

The scenic value of the coast is a resource of public importance. As noted in Section 30251 of the Coastal Act, development shall be sited and designed to:

> "Protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural landforms…and to restore and enhance visual quality in visually degraded areas."

As stated in Chapter 3 of the Guidance, some options to address rising sea levels, such as elevating structures or utilizing seawalls or bluff retention devices, have the potential to alter or degrade the visual character of an area. Certified LCPs should already have policies and standards to ensure scenic and visual resources are protected to the maximum extent feasible, but these may need to be updated to consider sea level rise hazards. Coastal regions with scenic overlays or designated scenic corridors, or those areas designated as scenic in the California Coastal Preservation and Recreation Plan in particular should pay close attention to actions that could be used to minimize risks to development. The following adaptation options address some of the methods for protecting the scenic qualities of the coast.

Goal: Protect views to and along the ocean and scenic coastal areas

G.1 Establish design standards to protect visual resources: Update and/or add design standards to ensure that adaptation measures protect visual resources while minimizing hazards. Adaptation strategies such as shoreline armoring or elevation techniques should be designed such that the visuals are subordinate to, and in character with, the surrounding visual resources of an area.

G.1a **Establish standards for the use of caissons or other means of elevating structures:** Ensure that the use of caissons or other elevation techniques do not result in negative visual impacts. Develop policies regarding where elevation of structures may be allowable, and establish standards guiding the use of these techniques. Ensure that the appearance of caissons will not detract from the scenic character of an area if or when they become visible as a result of erosion or other processes.

G.1b **Maintain height limitations in scenic areas**: Avoid modifications to height limits in scenic areas and provide for options to modify roof-lines or elevate the lowest flood elevation for flood protection in a manner that is consistent with scenic character. In some cases it may be appropriate to update height limitations to allow for elevation in response to sea level rise hazards. However, such decisions will require trade-offs and will need to strike a balance in terms of adapting to sea level rise and protecting visual resources and community character in line with the requirements of the Coastal Act.

G.1c **Develop or redevelop property to be safe from hazards without impairing scenic resources**: Emphasize the use of adaptation strategies that will not impact visual resources. Such strategies may include short-term retrofits with plans for longer term relocation or removal.

G.1d **Establish new scenic communities**: Designate areas with significant visual resources that could be negatively impacted by adaptation responses (*e.g.*, due to seawalls or "spider" homes) as scenic communities with special protections. Establish standards in LCPs to specifically protect visual resources in these areas.

Figure 25. Photo depicting protection of visual resources and public access. A seawall visually blends in with the natural bluff while surfing access is also provided at Pleasure Point, Santa Cruz (2013). (*Source:* California Coastal Records Project)

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Chapter 8

Legal Context of Adaptation Planning

Land use law is dynamic and must be interpreted and applied based on case-specific factors at the time of decision. Nonetheless, sea level rise and adaptation planning raise a number of important legal issues that coastal managers should consider as they develop and apply adaptation strategies.

This section includes discussion of the legal contexts for addressing:

- Seawalls and other shoreline protective devices
- The public trust boundary
- Potential private property takings issues

SEAWALLS AND OTHER SHORELINE PROTECTIVE DEVICES

Section 30235 of the Coastal Act provides that seawalls and other forms of construction that alter natural shoreline processes "shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply." Despite other Coastal Act provisions that could often serve as the basis for denial of shoreline protective devices, the Coastal Commission has interpreted Section 30235 as an overriding policy that requires the approval of Coastal Development Permits for construction intended to protect coastal dependent uses[45] or existing structures if the other requirements of Section 30235 are also satisfied.[46]

The Coastal Act does not define what qualifies as an "existing structure" for the purposes of Section 30235. However, the Coastal Act as enacted in 1976 also includes Section 30253, which requires that "new development" ensure stability and structural integrity, and not in any way requires the construction of a protective device that would substantially alter natural bluff and cliff landforms. Thus, there is a clear distinction in the Coastal Act as enacted between the specific allowance for shoreline protection for *existing* structures and the prohibition on shoreline protection for *new* development if it would substantially alter natural landforms.

The Commission has relatively infrequently evaluated whether structures built after 1976 are entitled to shoreline protection pursuant to Section 30235. When it has, that shoreline protection has often also been required to protect adjacent pre-Coastal Act structures. In a few instances, however, the Commission has treated structures built after 1976 as existing structures entitled to shoreline protection even if no adjacent pre-Coastal Act structure also need protection. In order to limit the potential proliferation of seawalls to protect newly approved structures, the Commission has, over the last 15-20 years, generally required that applicants proposing new development in hazardous shoreline locations waive any rights under Section 30235 (or related LCP policies) to build shoreline protection for the proposed new development. No appellate

[45] Coastal-dependent uses are those that require a site on, or adjacent to, the sea to be able to function at all. (Public Resources Code, § 30101.)

[46] Some commenters argue that because shoreline armoring often conflicts with Coastal Act policies other than Section 30235, the Commission should evaluate proposed armoring under the conflict resolution provisions of the Act. (See Public Resources Code, § 30007.5, 30200(b).) Because the conflict resolution provisions require the Commission to resolve the conflict in a manner which on balance is the most protective of significant coastal resources, this approach could result in the more frequent denial of shoreline armoring, especially when it is intended to protect residential development or other uses that the Coastal Act does not identify as priority uses.

decision addresses whether the term "existing structures" in this context includes only structures built prior to the Coastal Act or instead includes structures in existence at the time the Commission acts on an application for shoreline protection.

Although the Coastal Act does not define "existing structure," local governments have sometimes specified a date by which a structure must have been constructed in order to qualify as an "existing structure" for the purpose of evaluating whether it may be eligible for shoreline protection. For example, the Marin County Local Coastal Program policy that implements Section 30235 specifies that existing structures are those that existed on the date the LCP was originally adopted (May 13, 1982).

In addition, although a public agency may not deny a Coastal Development Permit for an eligible shoreline protective device, Section 30235 does not limit the authority of public agencies to refuse to allow construction of shoreline protective devices pursuant to some authority other than the Coastal Act. For example, if a private property owner requests permission from a public agency to build a structure on that agency's property (such as a local or State park or public beach) to protect adjacent private property, the public agency would generally have the authority as the landowner not to agree to the encroachment. Similarly, agencies that are trustees of public trust lands (such as the State Lands Commission) have the authority to prohibit structures that are not consistent with public trust uses and prioritized public trust needs, values, and principles. Public trust uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration, but do not typically include non-water dependent uses such as residential or general commercial and office uses. Thus, trustee agencies have the authority to refuse to allow, or to require removal of, shoreline armoring located on public trust lands, including if that armoring unreasonably interferes with public trust uses.

Although approval of a Coastal Development Permit for shoreline armoring under Section 30235 may be unavoidable in certain circumstances, the construction of shoreline armoring will often conflict with other Coastal Act requirements. For example, as discussed above, Section 30253(b) prohibits *new development* from in any way requiring the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. Shoreline protective devices can also adversely affect a wide range of other coastal resources and uses that the Coastal Act protects. For example, they often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelands, by reducing shoreline sand supply, or by fixing the back of the beach, ultimately leading to the loss of the beach. Shoreline protection structures thus raise serious concerns regarding consistency with the public access and recreation policies of the Coastal Act. They also can fill coastal waters or tidelands and harm marine resources and biological productivity in conflict with Sections 30230, 30231, and 30233. They often degrade the scenic qualities of coastal areas and alter natural landforms in conflict with Section 30251. Finally, by halting shoreline erosion, they can prevent the inland migration of inter-tidal habitat, salt marshes, beaches, and other low-lying habitats that rising sea levels will inundate. Even when an agency approves a Coastal Development Permit for shoreline armoring, the agency has the authority to impose conditions to mitigate impacts on shoreline sand supply and to minimize adverse impacts on other coastal resources. (See *Ocean Harbor House Homeowners Assn. v. California Coastal Comm.* (2008) 163 Cal.App.4th 215, 242; Public Resources Code, § 30607.)

Any approved shoreline structure, therefore, must avoid or mitigate impacts that are inconsistent with Coastal Act policies.

Because of the wide range of adverse effects that shoreline protective devices typically have on coastal resources, this Guidance recommends avoidance of hard shoreline armoring whenever possible. This can entail denying development in hazardous locations or allowing only development that is easily removable as the shoreline erodes or requiring new development to be set back far enough from wave runup zones or eroding bluff edges so that the development will not need shoreline armoring during its anticipated lifetime. The Commission's practice when reviewing proposed development in shoreline locations that are potentially vulnerable to shoreline erosion, wave runup, or inundation has been to require applicants to waive rights to shoreline protective devices in the future, and, more recently, to require relocation and/or removal should such development become endangered in the future.

PUBLIC TRUST BOUNDARY

The State of California acquired sovereign ownership of all tidelands and submerged lands and beds of navigable waterways upon its admission to the United States in 1850. The State holds and manages these lands for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine ("public trust"). The public trust ensures that title to sovereign land is held by the State in trust for the people of the State. Public trust uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, visitor-serving facilities and environmental preservation and restoration. Non-water dependent uses such as residential and general office or commercial uses are generally inconsistent with public trust protections and do not qualify as public trust uses.

In coastal areas, the landward location and extent of the State's sovereign fee ownership of these public trust lands are generally defined by reference to the ordinary high water mark (Civil Code §670), as measured by the mean high tide line (*Borax Consolidated v. City of Los Angeles* (1935) 210 U.S. 10); these boundaries remain ambulatory, except where there has been fill or artificial accretion. More specifically, in areas unaffected by fill or artificial accretion, the ordinary high water mark and the mean high tide line will generally be the same. In areas where there has been fill or artificial accretion, the ordinary high water mark (and the state's public trust ownership) is generally defined as the location of the mean high tide line just prior to the fill or artificial influence. It is important to note that such boundaries may not be readily apparent from present day site inspections (*Carpenter v. City of Santa Monica* (1944) 63 C. A. 2nd 772, 787).

The mean high tide line is the intersection of the shoreline with the elevation of the average of all high tides calculated over an 18.6 year tidal epoch. This property line is referred to as "ambulatory" for two reasons: first, gradual changes to the shoreline due to factors such as variations in the height and width of sandy beaches, shoreline erosion or accretion, and uplift or subsidence of land can change the location of where the mean high tide line meets the shoreline. Second, the elevation of the mean high tide line itself changes over time and is likely to increase at an accelerating rate in the future due to sea level rise. Over time, sea level rise will continue to gradually cause the public trust boundary to move inland. Boundaries between publicly owned waterways and adjoining private properties (referred to as *littoral* along lakes and seas and *riparian* along rivers and streams) have always been subject to the forces of nature and property boundary law reflects these realities.

Accelerating sea level rise will likely lead to more disputes regarding the location of property boundaries along the shoreline, since lands that were previously landward of the mean high tide line have become subject to the State's ownership and protections of the public trust. These disputes, in turn, will affect determinations regarding what kinds of structures and uses may be allowed or maintained in areas that, because of sea level rise, either are already seaward of the mean high tide line, are likely to become seaward of the mean high tide line in the future, or would be seaward of the mean high tide line if it were not for artificial alterations to the shoreline.

California caselaw does not explicitly address how shoreline structures such as seawalls that artificially fix the shoreline temporarily and prevent inland movement of the mean high tide line affect property boundaries, if at all. The Ninth Circuit Court of Appeals, however, has interpreted federal common law as allowing the owner of tidelands to bring a trespass action against a neighboring upland property owner who built a revetment that prevented the natural inland movement of the mean high tide line. The court ruled that the actual property boundary was where the mean high tide line would have been if the revetment were not there and that the owner of the tidelands could require the upland owners to remove the portions of the revetment that were no longer located on the upland owners' properties. (*United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190.)

POTENTIAL PRIVATE PROPERTY TAKINGS ISSUES

The United States and California constitutions prohibit public agencies from taking private property for public use without just compensation. Section 30010 of the Coastal Act similarly prohibits public agencies implementing the Coastal Act from granting or denying a permit in a manner that takes or damages private property for public use without payment of just compensation. The classic "takings" scenario arises when a public agency acquires title to private property in order to build a public facility or otherwise devote the property to public use. In 1922, however, the United States Supreme Court ruled that regulation of private property can constitute a taking even if the regulation does not involve acquisition of title to the property. As Justice Oliver Wendell Holmes stated, "while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking," (*Pennsylvania Coal Co. v. Mahon* (1922) 260 U.S. 393, 415.)

Courts have struggled in the 90 years since then to give agencies and property owners a more definite sense of exactly when a regulation "goes too far." The Supreme Court has identified three basic categories of takings that can occur in the context of land use regulation. Different legal standards apply depending on what kind of taking is at issue. (See generally *Lingle v. Chevron USA, Inc.* (2005) 544 U.S. 528).

The most straightforward test applies to what is variously called a categorical, total, *per se,* or *"Lucas"* takings, which occurs when a regulation deprives an owner of all economically beneficial use of the property. (See *Lucas v. South Carolina Coastal Council* (1992) 505 U.S. 1003). An agency that completely deprives a property owner of all economically beneficial use of the property will likely be found liable for a taking unless background principles of nuisance or property law independently restrict the owner's intended use of the property. Courts have generally been very strict about when they apply this test. If any economically beneficial use remains after application of the regulation, even if the value of that use is a very small percentage of the value of the property absent the regulatory restriction, a *Lucas* taking has not occurred.

Where a regulation significantly reduces the value of private property but does not completely deprive the owner of all economically beneficial use, the multi-factor "*Penn-Central"* test applies (*Penn Central Transportation Co. v. City of New York* (1978) 438 U.S. 104). This test has no set formula, but the primary factors include the economic impact of the regulation, the extent to which the regulation interferes with distinct, reasonable investment-backed expectations, and the character of the governmental action. When evaluating the character of the governmental action, courts consider whether the regulation amounts to a physical invasion or instead more generally affects property interests through a program that adjusts the burdens and benefits of economic life for the common good. Whether a regulation was in effect at the time an owner acquired title is also a relevant factor, but is not by itself dispositive. (See *Palazzolo v. Rhode Island* (2001) 533 U.S. 606, 632-633 (O'Connor, J., concurring)). Because this test takes such a wide range of factors into account, caselaw does not provide clear guidance about the situations in which a regulation is likely to qualify as a "*Penn-Central"* taking. A *Penn-Central* claim is unlikely to succeed, however, unless the plaintiff can establish that the regulation very substantially reduces the value of the property.

The third category of takings claims applies to "exactions," that is, government permitting decisions that require a property owner either to convey a property interest or to pay a mitigation fee as a condition of approval. (See *Nollan v. California Coastal Comm.* (1987) 483 U.S. 825; *Dolan v. City of Tigard* (1994) 512 U.S. 374; *Koontz v. St. Johns River Water Management Dist.* (2013) 133 S.Ct. 2586). Under the *Nollan/Dolan* line of cases, the agency must establish a "nexus" between the condition requiring a property interest or payment and the effects of the project that that property interest or payment is mitigating. That property interest or payment must also be roughly proportional to the impact that it is intended to mitigate. In California, the Ocean Harbor House case is a good example of a shoreline structure impact mitigation requirement that was found by the courts to meet the relevant standards of nexus and proportionality.

Various recommendations of this Guidance may potentially give rise to takings concerns. Because the determination of whether a particular regulation may in some circumstances be applied in a way that constitutes a taking is so fact intensive and context specific, this Guidance cannot provide a simple set of parameters for when agencies should either allow exceptions to a land use regulation or consider purchasing a property interest. That said, land use restrictions that prevent all economically beneficial use of the entirety of a property[47] are vulnerable to *Lucas* takings claims unless those uses would qualify as a nuisance or are prohibited by property law

[47] What qualifies as the entirety of a property can also be the subject of dispute. The property will normally include all legal lots on which the proposed development would be located, but can also include other lots that are in common ownership and adjacent to, or in close proximity with, the lots that would be developed. (See *Norman v. United States* (Fed. Cir. 2005) 429 F.3d 1081, 1091; *District Intown Properties Limited Partnership v. District of Columbia* (D.C. Cir. 1999) 198 F.3d 874, 880.).

principles such as the public trust doctrine. Agencies can minimize the risk of these claims by allowing economically beneficial uses on some of the property and by exploring whether legal doctrines regarding nuisance, changing shoreline property lines, or the public trust independently allow for significant limitations on the use of the property. Establishing a transferrable development rights program for properties that are subject to significant development restrictions may also minimize potential exposure to takings claims.

Where a proposed development would be safe from hazards related to sea level rise in the near future, but cannot be sited so as to avoid those risks for the expected life of the structure, agencies may consider allowing the structure, but requiring removal once it is threatened. Property owners may argue that they have a right to protect threatened structures even if they have waived rights to shoreline protection under the Coastal Act, but a recent federal court of appeal ruling casts significant doubt on the existence of any common law right to attempt to fix an ambulatory shoreline boundary through artificial structures such as seawalls (see *United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190).

If an agency is contemplating requiring property owners to dedicate open space easements or other property interests or requiring the payment of fees to mitigate project impacts, the agency should be careful to adopt findings explaining how requiring the property interest or payment is both logically related to mitigating an adverse impact of the project and roughly proportional to that impact. Legislatively adopting rules that establish the exact criteria for determining when to require these exactions and, if so, their magnitude, may also reduce an agency's exposure to takings claims.[48] With respect to mitigation fees, California cities and counties should also comply with applicable requirements of the Mitigation Fee Act (Government Code, §66000 *et seq.*).

[48] The California Supreme Court has ruled that courts should be more deferential towards agencies when reviewing fees imposed pursuant to legislatively enacted rules of general applicability than when reviewing fees imposed on an ad hoc basis. (*Ehrlich v. City of Culver City* (1996) 12 Cal.4th 854, 881.) The rationale is that fees imposed pursuant to rules of general applicability that involve little discretion are less likely to impose disproportionate burdens on property owners than fees determined on an ad hoc basis.

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Chapter 9

Next Steps

CURRENT AND FUTURE COASTAL COMMISSION EFFORTS:

The Commission has a Strategic Plan for 2013-2018 (2013a) that identifies many action items that the Commission or partner organizations plan to take to address the challenges of sea level rise and climate change. The first priority in the Strategic Plan is for the Commission to adopt sea level rise policy guidance for use in Local Coastal Program (LCP) planning and project design (Action 3.1.1), and this draft guidance reflects significant progress toward accomplishing this task. The objectives and action items from the Strategic Plan related to sea level rise and climate change are presented on the following pages.

The Commission is also involved in a number of other efforts that meet the climate change planning goals laid out in the Strategic Plan. These include efforts related to the Commission's normal operating business, such as ongoing coordination with local government partners and other agencies, as well as specially funded projects designed to meet specific needs. Several of these efforts that are currently underway or that staff identified as next steps during the completion of this Guidance document are listed below. The Commission contemplates that these items will be completed over the next two to five years, in coordination with other relevant partners and research institutions, as staff capacity and funding allows.

1. **Continue an active program of public outreach on sea level rise.** The Commission will strive to provide public information about sea level rise issues through public workshops, the Commission's website, meetings, outreach and our public education program.

2. **Develop methods for quantifying impacts to coastal resources from shoreline armoring projects.** The Coastal Commission staff has initiated a Project of Special Merit (funded by NOAA) to build upon the Commission's existing efforts to mitigate for the adverse impacts of shoreline development projects to public access and recreation by working with beach ecologists and a valuation economist to develop a method to quantify impacts to biological resources and beach ecology. The final product is anticipated to be a set of guidelines to use in assessing the impacts of proposed shoreline armoring projects and a method(s) for calculating the full value of recreational and ecological loss resulting from installation of shoreline armoring projects (where they may be approved as consistent with the Coastal Act).

3. **Adopt policy guidance and model ordinance language for resilient shoreline residential development in hazardous areas affected by sea level rise.** Under another NOAA-funded Project of Special Merit, the Coastal Commission will conduct a statewide survey to characterize physical shoreline conditions for residential areas along the coast. Informed by this assessment, staff will identify and analyze policy and legal issues for development and redevelopment in hazardous areas, factoring in sea level rise projections that will change shoreline conditions over time. Working collaboratively with local governments, staff will use the policy and legal analysis to develop policy guidance and model ordinance language. The project will build upon this *Sea Level Rise Policy Guidance* and is consistent with the Coastal Commission's Strategic Plan goals.

4. **Enhance coordination and planning efforts related to developing adaptation strategies for critical infrastructure.** Addressing sea level rise impacts to critical infrastructure is particularly complex and will require greater amounts of planning time, stakeholder input,

and funding. The Commission will support planning efforts in a number of ways including, for example:

a. Providing guidance or participating in working groups that examine managed retreat of critical infrastructure, including when to consider managed retreat rather than continue with repairs and maintenance in light of sea level rise.

b. Coordinating closely with Caltrans to address transportation issues. Planning efforts may include integrating LCP planning and regional transportation planning processes; coordinating and supporting phased approaches for realignment projects; and identifying priorities for adaption response.

c. Coordinating with the State and Regional Water Quality Control Boards to consider vulnerability issues related to water supply and wastewater capacity infrastructure in California.

5. **Consider producing additional guidance documents, including**:

a. Broader climate change guidance addressing other climate change impacts to the coastal zone.

b. One-page fact sheets on some adaptation measures such as green infrastructure and conservation easements.

c. Guidance on the use of 'living shorelines', dune management, beach nourishment, and so on for California, including an assessment of areas or coastal situations where these strategies could be effective, what they need to succeed, monitoring requirements, and maintenance.

6. **Implement the Coastal Commission's responsibilities under other state efforts and legislation.**

a. Governor Brown's April 2015 Executive Order B-30-15 states that state agencies shall take climate change into account in their planning and investment decisions, and employ full life-cycle cost accounting to evaluate and compare infrastructure investments and alternatives. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas emissions, provide flexible and adaptive approaches, protect the state's most vulnerable populations, and promote natural infrastructure solutions. The Coastal Commission will continue to integrate these principles into its planning and regulatory work.

b. AB2516, authored by Assemblymember Gordon and approved in September 2014, established a Planning for Sea Level Rise Database that is anticipated to be available online in early 2016. The database will provide the public with an educational tool from which to learn about the actions taken by cities, counties, regions, and various public and private entities to address sea level rise. The Coastal Commission will contribute data to this effort, including information about grant-funded LCP updates.

c. The Coastal Commission will also particulate in the implementation of the 2014 *Safeguarding California* Plan, along with the Ocean Protection Council's 2014 Resolution on the Implementation of the Safeguarding California Plan. Key principles are and will continue to be incorporated into Coastal Commission work, including protection of California's most vulnerable populations the integration of risk reduction with emissions reductions, and the development of metrics and indicators of progress on efforts to reduce climate risk.

Coastal Commission Strategic Plan 2013-2018 Excerpts
Actions Related to Sea Level Rise and Climate Change

GOAL 1: Maximize Public Access and Recreation

Objective 1.1 – Enhance Public Access through Updated Beach Access Assessment and Constraints Analysis

Actions:

1.1.5 Identify locations where access may be limited or eliminated in the future due to sea level rise and increased storm events and begin planning for other options such as new vertical accessways to maintain maximum beach access (see also Action 3.2.1).

Objective 1.4 – Expand the California Coastal Trail System through Enhanced Planning and Implementation

Actions:

1.4.4 Identify locations of the CCT that might be at risk from rising sea level and increased storm events and begin planning for trail relocations or other alternatives to insure continued functionality of the CCT (see also Action 3.2.1).

GOAL 3: Address Climate Change through LCP Planning, Coastal Permitting, Inter-Agency Collaboration, and Public Education

Objective 3.1 – Develop Planning and Permitting Policy Guidance for Addressing the Effects of Climate Change on Coastal Resources

Actions:

3.1.2 Adopt general sea level rise (SLR) policy guidance for use in coastal permitting and LCP planning, and amendments based on best available science, including the final report from the National Research Council of the National Academy of Science entitled *Sea-Level Rise for the Coasts of California, Oregon, and Washington* (June 2012).

3.1.3 Based on the general SLR policy guidance, identify and develop specific regulatory guidance for addressing coastal hazards, including recommendations for analytic methods for accounting for SLR and increased storm events in project analysis, standards for redevelopment and development in hazard zones (*e.g.*, bluff top and flood zones), buffers for coastal wetlands, and policies for shoreline structure design and impact mitigation.

3.1.4 Develop a work program to produce policy guidance for coastal permitting and LCPs, to account for other climate change related impacts and adaptation planning including wetland, marine and terrestrial habitat protection, habitat migration, risk of wildfires, water supply and groundwater protection.

3.1.5 Provide public information and guidance through workshops, presentations to local government, *etc.* Assist local governments with interpretation of scientific or other technical information related to climate change and sea level rise that could be of use in adaptation planning.

3.1.6 Contribute to relevant state-wide efforts on climate change and adaptation as a member of the State's Climate Action Team – Coast and Ocean Working Group.

3.1.7 Coordinate with Natural Resources Agency, Office of Planning and Research, California Governor's Office of Emergency Services (Cal OES) and others to provide consistent guidance on climate change in updating general plans, hazard mitigation plans and other planning documents used by local governments.

3.1.8 Coordinate with the State Lands Commission to address sea level rise and shoreline change and implications for the management of public trust resources.

Objective 3.2 – Assess Coastal Resource Vulnerabilities to Guide Development of Priority Coastal Adaptation Planning Strategies

Actions:

3.2.1 Conduct a broad vulnerability assessment of urban and rural areas to identify priority areas for adaptation planning, such as community development, public infrastructure, public accessways, open space or public beaches at risk from sea level rise. Identify and participate in on-going vulnerability assessments and adaptation planning efforts as feasible.

3.2.2 Work with CalTrans and other public agency partners to assess and address roadway, rail, and other transportation infrastructure vulnerabilities, particularly along Highway One and other coastal roads and highways.

3.2.3 Work with the Department of Water Resources, State Water Resources Control Board, and local agencies to assess and address water and wastewater treatment plant vulnerabilities along the coast.

3.2.4 Work with the Conservancy, California Department of Fish and Game *[sic]*, US Fish and Wildlife, and other partners to assess the vulnerability of wetlands and other sensitive habitat areas. Identify habitats that are particularly vulnerable climate change and/or habitats that may be important for future habitat migration (*e.g.*, wetland transitional areas).

3.2.5 Work with the Coastal Observing Systems, researchers, and others to identify and develop baseline monitoring elements to better understand and monitor changes in coastal conditions related to sea level rise and other climate change impacts.

With the Conservancy and OPC, develop and implement a competitive grant program to provide funding to selected local governments to conduct vulnerability assessments and/or technical studies that can be used to assess a community's risks from climate change and inform updates to LCPs.

ADDITIONAL RESEARCH NEEDS

Additional research is needed to more fully understand and prepare for sea level rise. The research needs are directed toward research institutions at academic, state, federal, and local levels. The Commission will strive to collaborate with and support research related to sea level rise science and adaptation, including with the efforts and ongoing work of the California Climate Change Research Plan.

1. **Modeling.** Sea level rise science is an evolving field, and new science is expected to change and refine our understanding of the dynamics of sea level rise and its associated impacts to both natural and built environments. As such, there is a continual need for models to be developed, updated, and refined to ensure that we continue to have the best understanding of sea level rise-related impacts as possible. In some cases, the modelling capabilities already exist, but there is a need for such modelling to be applied to local areas to understand specific localized impacts. Several topics in particular that are in need of better or more refined modeling include:
    a. Fluvial dynamics as they relate to and interact with rising sea levels
    b. Habitat evolution models (*e.g.*, SLAMM) that project future locations of wetlands and other coastal habitats
    c. The interaction of other climate change related impacts with the impacts of sea level rise (*e.g.*, changing precipitation patterns, increased frequency and/or intensity of storms)

2. **Improved estimates of local vertical land motion.** Several independent processes – glacial isostatic rebound, groundwater withdrawals, plate movements and seismic activity – influence vertical land motion. Current guidance on sea level projections adjusts for large-scale vertical land motion north and south of Cape Mendocino. These adjustments do not properly address locations that are moving differently from the region, such as Humboldt Bay. A peer-reviewed methodology is needed to determine:
    a. Instances when it will be important to modify the regional sea level rise projections for local vertical land motion
    b. Types of existing information on land motion (*e.g.*, tide gauge records, satellite data, land-based GPS stations) that provide the best estimates of local land trends
    c. A procedure for adjusting state or regional sea level rise projections for sub-regional or local conditions
    d. Additional data that are needed to implement this procedure

3. **Baseline data and monitoring systems**. Baseline monitoring data are needed for coastal and nearshore waters, beaches, bluffs, dune systems, near-shore reefs, tide pools, wetlands, and other habitat areas to better understand these systems, monitor trends, and detect significant deviations from historic conditions that may be related to sea level rise and other aspects of climate change. Better storm event monitoring data are also needed to support refinements and calibration of models used to project and analyze impacts.

A system for monitoring and tracking the cumulative impacts of projects in the coastal zone, including both new development and any adaptation strategies, is needed to better understand the impacts of development in the face of sea level rise and the efficacy of various adaptation methods. Monitoring systems may be needed at a variety of scales, including at the local, regional, and state level.

4. **Methods for estimating change in erosion rates and shoreline change due to future sea level rise.** There is a need for a peer-reviewed methodology for estimating change in erosion rates due to sea level rise for bluffs, beaches, and other shorelines exposed to erosion. An improved understanding of future erosion rates is necessary to better evaluate projects affected by such erosion, including in terms of calculating an appropriate setback distance.

5. **Analysis of sea level rise impacts to coastal access and recreation.** To improve public access planning efforts, more information is needed about how sea level rise could affect public access areas and recreation throughout the state, including changes to waves and surfing, and the potential economic costs of these impacts. Many currently accessible beach areas have the potential to become inaccessible due to impacts from sea level rise. Shoreline armoring and emerging headlands could isolate connected beaches with sea level rise, which will block lateral access.

   Rising sea level will also tend to constrict beaches that are prevented from migrating landward by shoreline armoring and development. Some blufftop trails will become inaccessible as segments of trail are lost to erosion. In addition, changes in beach conditions and sediment dynamics due to sea level rise could affect waves and surfing, as can the rise itself by potentially 'drowning out' surf spots combined with the lack of space available for these spots to move (*e.g.*, where new 'tripping' elements can be encountered in the right depth of water to create surfable waves). Research on the specifics of these impacts will help the Commission and others understand the details of the potential impacts to coastal access and recreation.

6. **Methods to evaluate impacts to coastal resources from shoreline protection.** Research is needed to develop and improve methods to evaluate and mitigate for the adverse impacts to recreation, public access and beach ecology from shoreline armoring projects. This information will be used to determine a set of mitigation options that may be considered for use when evaluating individual permit applications to offset anticipated losses to beach ecology and resources caused by shoreline armoring projects. The Coastal Commission staff is currently working on developing resource valuation guidelines as part of a Project of Special Merit (see Coastal Commission Effort #2).

7. **Analysis of sea level rise impacts to wetlands and strategies for preserving wetlands throughout the state.** Additional research is needed to assess the vulnerability of wetlands and other sensitive habitat areas to climate change, and to identify adjacent areas that may be important for future habitat migration (*e.g.*, wetland transitional areas). Further work is also needed to develop management strategies that are adaptable to local wetland conditions and sea level rise impacts, such as the following:

a. Methodologies for establishing natural resource area buffer widths in light of sea level rise
b. Approaches for identifying and protecting migration corridors
c. Guidance for increasing wetland sediment supply and retention
d. Techniques for developing an adaptive wetland restoration plan
e. Monitoring criteria

8. **Assessment of coastal habitat functions in light of sea level rise and other climate change impacts.** It is necessary to develop a better understanding of the value and benefits that intact natural habitats provide, especially as they relate to increasing coastal resiliency to sea level rise. In addition, further research is needed to identify the coastal habitats that are most likely to experience adverse impacts from sea level rise and extreme storms, and what the associated loss of ecosystem services will mean for coastal populations. Research is also needed to identify strategies to ameliorate the vulnerabilities.

9. **Potential effects of sea level rise on groundwater and coastal aquifers.** Additional research is needed to quantify the potential effect of sea level rise on freshwater aquifers located along the California coast, and the degree to which sea level rise could lead to new incidences of intrusion. Research should include: (a) an evaluation of the potential incidence and severity of saltwater intrusion at the scale of individual aquifers, under various sea level rise scenarios, (b) criteria to use when deciding if saltwater intrusion requires mitigation or response and (c) identification of strategies to address the impacts rising groundwater and saltwater intrusion have on agriculture.

10. **Analysis of non-environmental factors that influence sea level rise adaptation.** As suggested in a number of places throughout this Guidance, there are factors beyond just environmental concerns that will influence sea level rise planning. Such factors include environmental justice/social equity, economic, and legal considerations, among others. Understanding how these social concerns interact with environmental vulnerabilities will be important when assessing adaptation planning opportunities and challenges.

Glossary

The following terms were collected from the 2009 *California Climate Change Adaptation Strategy*[49], the Intergovernmental Panel on Climate Change Third Assessment Report[50], the Coastal Commission's Beach Erosion and Response (BEAR) document,[51] and the California Coastal Act, unless otherwise noted. Some of these definitions are not used in the text of the report, but are included as a resource on coastal-related adaptation issues.

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Adaptive capacity: The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.[52]

Adaptive management: Involves monitoring the results of a management decision, and updating actions as needed and as based on new information and results from the monitoring.

Ambulatory (*as used in public trust boundaries*): Moveable, subject to change, or capable of alteration.[53]

Aquifer: An underground layer of porous rock, sand, or other earth material containing water, into which wells may be sunk.

Armor: To fortify a topographical feature to protect it from erosion (*e.g.*, constructing a wall to armor the base of a sea cliff), or to construct a feature (*e.g.*, a seawall, dike, or levee) to protect other resources (*e.g.*, development or agricultural land) from flooding, erosion, or other hazards.

Atmosphere-Ocean General Circulation Models (or Atmosphere-Ocean General Climate Models; ACGOM): Three-dimensional global models that dynamically link ocean density, circulation, and sea level using wind stress, heat transfer between air and sea, and freshwater fluxes as critical variables. (See also *General Circulation Models*)

Baseline (or Reference): Any datum against which change is measured. It might be a "current baseline," in which case it represents observable, present-day conditions. It might also be a "future baseline", which is a projected future set of conditions excluding the driving factor of interest (*e.g.*, how would a sector evolve without climate warming). It is critical to be aware of what change is measured against which baseline to ensure proper interpretation. Alternative interpretations of the reference conditions can give rise to multiple baselines.[54]

[49] CNRA 2009

[50] IPCC 2001

[51] Many of these definitions were extracted from: USACE 1984, Griggs and Savoy 1985 and Flick 1994.

[52] Willows and Connell 2003

[53] *West's Encyclopedia of American Law* 2008

[54] Moser 2008

Beach: The expanse of sand, gravel, cobble or other loose material that extends landward from the low water line to the place where there is distinguishable change in physiographic form, or to the line of permanent vegetation. The seaward limit of a beach (unless specified otherwise) is the mean low water line.

Beach nourishment: Placement of sand and/or sediment (*e.g.,* beneficial re-use of dredged sediment) on a beach to provide protection from storms and erosion, to create or maintain a wide(r) beach, and/or to aid shoreline dynamics throughout the littoral cell. The project may include dunes and/or hard structures as part of the design.

Bluff (or Cliff): A scarp or steep face of rock, weathered rock, sediment and/or soil resulting from erosion, faulting, folding or excavation of the land mass. The cliff or bluff may be simple planar or curved surface or it may be step-like in section. For purposes of (the Statewide Interpretive Guidelines), “cliff” or “bluff” is limited to those features having vertical relief of ten feet or more and “seacliff” is a cliff whose toe is or may be subject to marine erosion.

Bluff top retreat (or Cliff top retreat): The landward migration of the bluff or cliff edge, caused by marine erosion of the bluff or cliff toe and subaerial erosion of the bluff or cliff face.

Caisson: A supporting piling constructed by drilling a casing hole into a geologic formation and filling it with reinforcing bar and concrete; used for foundations. (See also *Piling*)

Climate change: Any long-term change in average climate conditions in a place or region, whether due to natural causes or as a result of human activity.

Climate variability: Variations in the mean state of the climate and other statistics (*e.g.*, standard deviations, the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events.

Coastal-dependent development or use: Any development or use which requires a site on, or adjacent to, the sea to be able to function at all.[55]

Coastal-related development: Any use that is dependent on a coastal-dependent development or use.[56]

Coastal resources: A general term used throughout the Guidance to refer to those resources addressed in Chapter 3 of the California Coastal Act, including beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

Development: On land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or

[55] Public Resources Code § 30101

[56] Public Resources Code § 30101.3

thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice of 1973 (commencing with Section 4511).[57]

Ecosystem-Based Management (EBM): An integrated approach to resource management that considers the entire ecosystem, including humans, and the elements that are integral to ecosystem functions.[58]

Ecosystem services: Benefits that nature provides to humans. For example, plants, animals, fungi and micro-organisms produce services or goods like food, wood and other raw materials, as well as provide essential regulating services such as pollination of crops, prevention of soil erosion and water purification, and a vast array of cultural services, like recreation and a sense of place.[59]

Emissions scenarios: Scenarios representing alternative rates of global greenhouse gas emissions growth, which are dependent on rates of economic growth, the success of emission reduction strategies, and rates of clean technology development and diffusion, among other factors.[60]

Environmentally Sensitive [Habitat] Area (ESHA): Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.[61]

Erosion: The wearing away of land by natural forces; on a beach, the carrying away of beach material by wave action, currents, or the wind. Development and other non-natural forces (*e.g.,* water leaking from pipes or scour caused by wave action against a seawall) may create or worse erosion problems.

Eustatic: Refers to worldwide changes in sea level.

[57] Public Resources Code § 30106

[58] NOC 2011

[59] Hassan *et al.* 2005

[60] Bedsworth and Hanak 2008

[61] Public Resources Code § 30107.5

Feasible (*as used in "least environmentally damaging feasible alternative"*): Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.[62]

Flood (or Flooding): Refers to normally dry land becoming temporarily covered in water, either periodically (*e.g.*, tidal flooding) or episodically (*e.g.*, storm or tsunami flooding).[63]

General Circulation Models (or General Climate Models; GCM): A global, three-dimensional computer model of the climate system which can be used to simulate human-induced climate change. GCMs are highly complex and they represent the effects of such factors as reflective and absorptive properties of atmospheric water vapor, greenhouse gas concentrations, clouds, annual and daily solar heating, ocean temperatures and ice boundaries. The most recent GCMs include global representations of the atmosphere, oceans, and land surface.[64] (See also *Atmospheric-Ocean General Circulation Models*)

Green infrastructure: Refers to the use of vegetative planting, dune management, beach nourishment or other methods that mimic natural systems to capitalize on the ability of these systems to provide flood and erosion protection, stormwater management, and other ecosystem services while also contributing to the enhancement or creation of natural habitat areas.

Greenhouse gases (GHGs): Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.[65]

Hard protection: A broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. (See also *Revetment, Seawall, Shoreline protection devices*)

Impact assessment: The practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

Inundation: The process of dry land becoming permanently drowned or submerged, such as from dam construction or from sea level rise.[66]

Local Coastal Program (LCP): A local government's (a) land use plans, (b) zoning ordinances, (c) zoning district maps, and (d) within sensitive coastal resources areas, other implementing actions, which, when taken together, meet the requirements of, and implement the provisions and policies of, this division at the local level.[67]

[62] California Coastal Act § 30108

[63] Flick *et al.* 2012

[64] NASA Earth Observatory Glossary

[65] UNFCCC 2004

[66] Flick *et al.* 2012

[67] Public Resources Code § 30108.6

Mean sea level: The average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. Relative sea level is sea level measured by a tide gauge with respect to the land upon which it is situated. (See also *Sea level change/sea level rise*)

Mitigation (*as used in climate science*): A set of policies and programs designed to reduce emissions of greenhouse gases.[68]

Mitigation (*as used in resource management*): Projects or programs intended to offset impacts to resources.

Monitoring: Systematic collection of physical, biological, chemical, or economic data or a combination of these data on a project in order to make decisions regarding project operation or to evaluate project performance.

Passive erosion: The process whereby erosion causes the shoreline to retreat and migrate landward of any hardened structures that have fixed the location of the back beach therefore resulting in the gradual loss of beach in front of the hardened structure.

Permit: Any license, certificate, approval, or other entitlement for use granted or denied by any public agency which is subject to the provisions of this division.[69]

Piling (or Pile): A long, heavy timber or section of concrete or metal driven or drilled into the earth or seabed to serve as a support or protection. (See also *Caisson*)

Potential impacts: All impacts that may occur given a projected change in climate, including impacts that may result from adaptation measures.

Public Trust Lands: All lands subject to the Common Law Public Trust for commerce, navigation, fisheries, recreation, and other public purposes. Public Trust Lands include tidelands, submerged lands, the beds of navigable lakes and rivers, and historic tidelands and submerged lands that are presently filled or reclaimed and which were subject to the Public Trust at any time.[70] (See also *Tidelands, Submerged lands*)

Radiative forcing: Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In [the IPCC] report radiative forcing values are for changes relative to preindustrial conditions defined at 1750 and are expressed in Watts per square meter (W/m^2).[71]

[68] Luers and Moser 2006

[69] Public Resources Code § 30110

[70] Public Resources Code § 13577

[71] IPCC 2007

Redevelopment: At a minimum, replacement of 50% or more of an existing structure. LCPs may also consider including limits on the extent of replacement of major structural components such as the foundation or exterior walls or improvements costing more than 50% of the assessed value of the existing structure**.**

Revetment: A sloped retaining wall; a facing of stone, concrete, blocks, rip-rap, *etc.* built to protect an embankment, bluff, or development against erosion by wave action and currents. (See also *Hard protection, Seawall, Shoreline protective devices*)

Risk: Commonly considered to be the combination of the likelihood of an event and its consequences – *i.e.*, risk equals the probability of climate hazard occurring multiplied the consequences a given system may experience.[72]

Scenario-based analysis: A tool for developing a science-based decision-making framework to address environmental uncertainty. In general, a range of plausible impacts based on multiple time scales, emissions scenarios, or other factors is developed to inform further decision making regarding the range of impacts and vulnerabilities.[73]

Sea level: The height of the ocean relative to land; tides, wind, atmospheric pressure changes, heating, cooling, and other factors cause sea level changes.

Sea level change/sea level rise: Sea level can change, both globally and locally, due to (i) changes in the shape of the ocean basins, (ii) changes in the total mass of water and (iii) changes in water density. Factors leading to sea level rise under global warming include both increases in the total mass of water from the melting of land-based snow and ice, and changes in water density from an increase in ocean water temperatures and salinity changes. Relative sea level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.[74] (See also *Mean sea level*, *Thermal expansion*)

Sea level rise impact: An effect of sea level rise on the structure or function of a system.[75]

Seawall: A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. It is usually a vertical wood or concrete wall as opposed to a sloped revetment. (See also *Hard protection, Revetment, Shoreline protective devices*)

Sediment: Grains of soil, sand, or rock that have been transported from one location and deposited at another.

[72] Burton *et al.* 2004

[73] NOAA 2010

[74] IPCC 2007

[75] PCGCC 2007

Sediment management: The system-based approach to the management of coastal, nearshore and estuarine sediments through activities that affect the transport, removal and deposition of sediment to achieve balanced and sustainable solutions to sediment related needs.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (*e.g.*, a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (*e.g.*, climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).

Shore protection: Structures or sand placed at or on the shore to reduce or eliminate upland damage from wave action or flooding during storms.

Shoreline protection devices: A broad term for constructed features such as seawalls, revetments, riprap, earthen berms, cave fills, and bulkheads that block the landward retreat of the shoreline and are used to protect structures or other features from erosion and other hazards. (See also *Hard protection, Revetment, Seawall*)

Still water level: The elevation that the surface of the water would assume if all wave action were absent.

Storm surge: A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in water level due to atmospheric pressure reduction as well as that due to wind stress.

Submerged lands: Lands which lie below the line of mean low tide.[76] (See also *Public Trust Lands*, *Tidelands*)

Subsidence: Sinking or down-warping of a part of the earth's surface; can result from seismic activity, changes in loadings on the earth's surface, fluid extraction, or soil settlement.

Tectonic: Of or relating to the structure of the earth's crust and the large-scale processes that take place within it.

Thermal expansion: An increase in water volume in response to an increase in temperature, through heat transfer.

Tidal prism: The total amount of water that flows into a harbor or estuary and out again with movement of the tide, excluding any freshwater flow.

Tidal range: The vertical difference between consecutive high and low waters. The Great Diurnal Range is the difference between mean higher high water and mean lower low water; the Mean Range of tide is the difference in height between mean high water and mean low water.[77]

[76] Public Resources Code § 13577

[77] NOAA 2013

Tidelands: Lands which are located between the lines of mean high tide and mean low tide.[78] (See also *Public Trust Lands*, *Submerged lands*)

Transfer of Development Rights (TDR): A device by which the development potential of a site is severed from its title and made available for transfer to another location. The owner of a site within a transfer area may retain property ownership, but not approval to develop. The owner of a site within a receiving area may purchase transferable development rights, allowing a receptor site to be developed at a greater density.[79]

Tsunami: A long period wave, or seismic sea wave, caused by an underwater disturbance such as an earthquake, submarine landslide, or subaerial landslide (slope failure from land into a water body). Tsunamis can cause significant flooding in low-lying coastal areas and strong currents in harbors. (Commonly misnamed a *Tidal wave*)

Vulnerability: The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity.

Vulnerability assessment: A practice that identifies who and what is exposed and sensitive to change and how able a given system is to cope with extremes and change. It considers the factors that expose and make people or the environment susceptible to harm and accesses to natural and financial resources available to cope and adapt, including the ability to self-protect, external coping mechanisms, support networks, and so on.[80]

Wave: A ridge, deformation, or undulation of the surface of a liquid. On the ocean, most waves are generated by wind and are often referred to as wind waves.

Wave height: The vertical distance from a wave trough to crest.

Wave length (or Wavelength): The horizontal distance between successive wave crests or between successive troughs of waves.

Wave period: the time for a wave crest to traverse a distance equal to one wavelength, which is the time for two successive wave crests to pass a fixed point.

Wave runup: the distance or extent that water from a breaking wave will extend up the shoreline, including up a beach, bluff, or structure.

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[78] Public Resources Code § 13577

[79] Cal OPR 1987

[80] Tompkins *et al.* 2005

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Appendices

Appendices: Table of Contents

Appendix A

Sea Level Rise Science and Projections for Future Change

DRIVERS OF SEA LEVEL RISE

The main mechanisms driving increases in *global* sea level are: 1) expansion of sea water as it gets warmer (thermal expansion) and, 2) increases in the amount of water in the ocean from melting of land-based glaciers and ice sheets as well as human-induced changes in water storage and groundwater pumping (Chao *et al.* 2008; Wada *et al.* 2010; Konikow 2011).[1] The reverse processes can cause global sea level to fall.

Sea level at the *regional and local levels* often differs from the average global sea level.[2] Regional variability in sea level results from large-scale tectonics and ocean and atmospheric circulation patterns. The primary factors influencing local sea level include tides, waves, atmospheric pressure, winds, vertical land motion and short duration changes from seismic events, storms, and tsunamis. Other determinants of local sea level include changes in the ocean floor (Smith and Sandwell 1997), confluence of fresh and saltwater, and proximity to major ice sheets (Clark *et al.* 1978; Perette *et al.* 2013).

Over the long-term, sea level trends in California have generally followed global trends (Cayan *et al.* 2009; Cayan *et al.* 2012). However, global projections do not account for California's regional water levels or land level changes. California's water levels are influenced by large-scale oceanographic phenomena such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), which can increase or decrease coastal water levels for extended periods of time. Figure A-1 shows how El Niño and La Niña events have corresponded to mean sea level in California in the past. California's land levels are also affected by plate tectonics and earthquakes. Changes to water as well as land levels are important factors in regionally down-scaled projections of future sea level. It follows that the sea level rise projections specific to California are more relevant to efforts in the coastal zone of California than projections of global mean sea level.

[1] Large movements of the tectonic plates have been a third major mechanism for changes in global sea level. The time periods for plate movements to significantly influence global sea level are beyond the time horizons used for even the most far-reaching land-use decisions. Plate dynamics will not be included in these discussions of changes to future sea level.

[2] For further discussion of regional sea level variations and regional sea level rise projections, see Yin *et al.* 2010, Slangen *et al.* 2012, and Levermann *et al.* 2013, as examples.

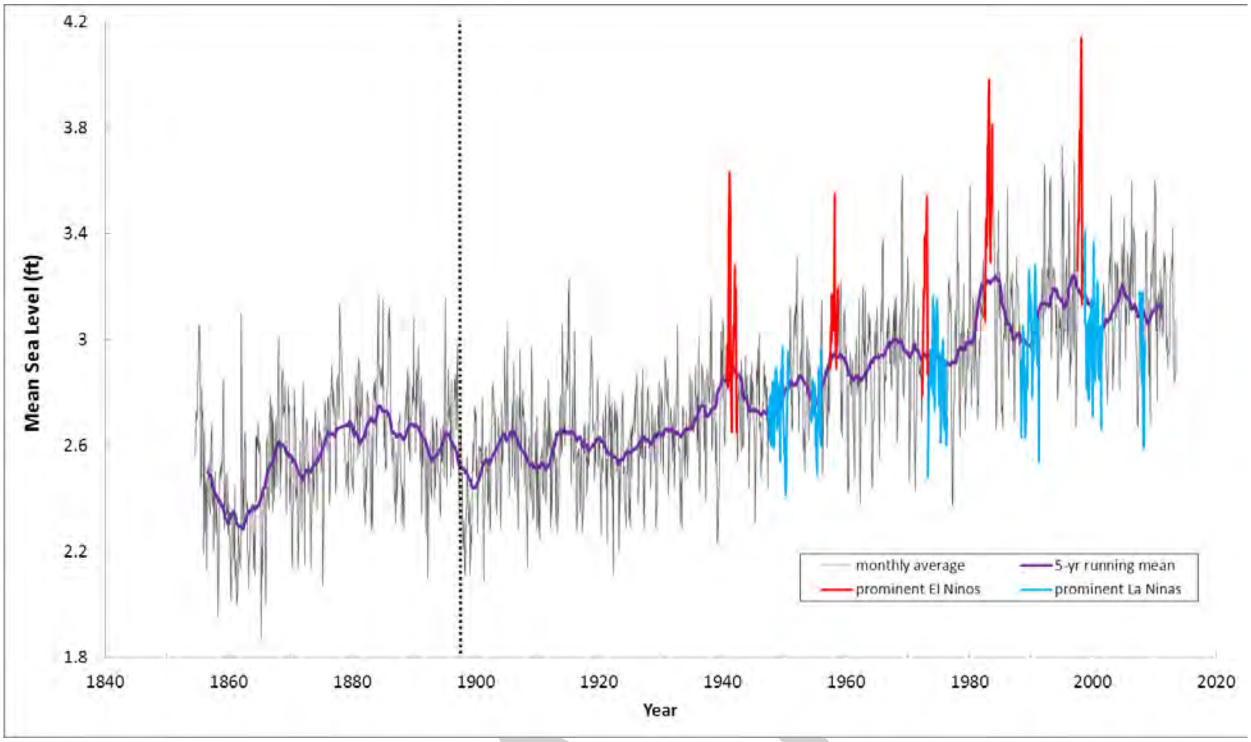

Figure A-1. Variations in monthly mean sea level at Fort Point, San Francisco, 1854 to 2013. Mean sea level heights (in ft) are relative to mean lower low water (MLLW). Purple line represents the 5-year running average. Note that the monthly mean sea level has varied greatly throughout the years and the several of the peaks occurred during strong El Niño events (red highlight). Periods of low sea level often occurred during strong La Niña events (blue highlight). The current "flat" sea level condition can also be seen in the 5-year running average. (*Sources: NOAA CO-OPS data, Station 9414290, http://tidesandcurrents.noaa.gov/ (sea level); NOAA Climate Prediction Center, http://www.elnino.noaa.gov/ (ENSO data)*)

APPROACHES FOR PROJECTING FUTURE GLOBAL SEA LEVEL RISE

This section provides an overview of some of the more well-known approaches that have been used to project sea level changes and their relevance to California. Appendix B will cover how these projections can be used to determine water conditions at the local scale.

There is no single, well-accepted technique for projecting future sea level rise. Understanding future sea level rise involves projecting future changes in glaciers, ice sheets, and ice caps, as well as future groundwater and reservoir storage. Two subjects in particular present challenges in sea level rise modeling. First, future changes to glaciers, ice sheets, and ice caps are not well understood and, due to the potential for non-linear responses from climate change, they present many difficulties for climate models (Overpeck 2006; Pfeffer *et al.* 2008; van den Broecke *et al.* 2011; Alley and Joughin 2012; Shepherd *et al.* 2012; Little *et al.* 2013). Second, the actual magnitudes of the two human-induced changes – pumping of groundwater and storage of water in reservoirs – are poorly quantified, but the effects of these activities are understood and can be modeled (Wada *et al.* 2010). Despite these challenges, sea level rise projections are needed for many coastal management efforts and scientists have employed a variety of techniques to model sea level rise, including:

1. Extrapolation of historical trends;
2. Modeling the physical conditions that cause changes in sea level;
3. Empirical or semi-empirical methods; and
4. Expert elicitations

There are strengths and weaknesses to each approach, and users of any sea level rise projections should recognize that there is no perfect approach for anticipating future conditions. This section provides users of the Guidance document with a general understanding of several of the most widely used sea level rise projection methodologies and their respective advantages and disadvantages. Figure A-2 provides a visual summary of several of the more commonly cited projections of future global and regional sea level rise.

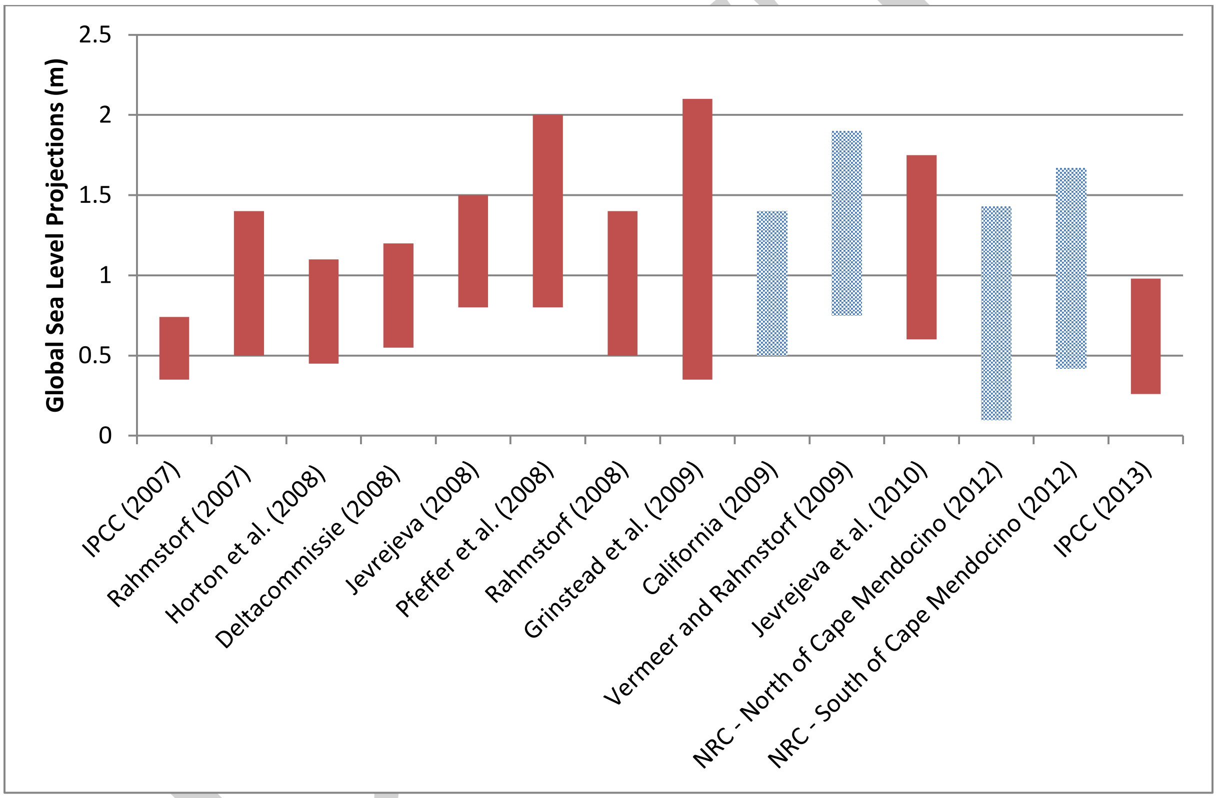

Figure A-2. Sea level rise projections for year 2100 from scientific literature. Graphic summary of the range of average sea level rise (SLR) projections by end of century (2090–2100) from the peer-reviewed literature) as compared to the recent National Research Council report for California, Oregon and Washington. The light blue shaded boxes indicate projections for California. Ranges are based on the IPCC scenarios, with the low range represented by the B1 scenario (moderate growth and reliance in the future on technological innovation and low use of fossil fuels) and the high part of the range represented by the A1FI scenario (high growth and reliance in the future on fossil fuels). Details on the methods used and assumptions are provided in the original references.

Extrapolation of Historical Trends

Extrapolation of historical trends in sea level has been used for many years to project future changes in sea level. The approach assumes that there will be no abrupt changes in the processes that drive the long-term trend, and that the driving forces will not change. However, drivers of climate change and sea level rise, such as radiative forcing, are known to be changing, and this method is no longer considered appropriate or viable in climate science.

A recent modification to the historical trend method discussed above has been to estimate rates of sea level rise during the peak of the last interglacial (LIG) period (~125,000 years before present, when some drivers of sea level rise were similar to those today)[3] and use these as proxy records to project sea level rise rates to the 21st Century. For example, Katsman *et al.* (2011) and Vellinga *et al.* (2008) used the reconstructed LIG record of sea level change (from Rohling *et al.* 2008) to reconstruct sea level rise rates during rapid climate warming, and applied these rates to estimate sea level at years 2100 and 2200. Similarly, Kopp *et al.* (2009) used sea level rise rates inferred from the LIG to estimate a range of sea level rise for Year 2100 between 1-3 ft (0.3-1 m). Compared to traditional historical trend extrapolation, this modified approach has the advantage of including the dynamic responses of ice sheets and glaciers to past global climates that were significantly warmer than the present, but is limited by the large uncertainties associated with proxy reconstructions of past sea level.

Physical Models

Physical climate models use mathematical equations that integrate the basic laws of physics, thermodynamics, and fluid dynamics with chemical reactions to represent physical processes such as atmospheric circulation, transfers of heat (thermodynamics), development of precipitation patterns, ocean warming, and other aspects of climate. Some models represent only a few processes, such as the dynamics of ice sheets or cloud cover. Other models represent larger scale atmospheric or oceanic circulation, and some of the more complex General Climate Models (GCMs) include atmospheric and oceanic interactions.

Physical models of sea level changes account for the thermal expansion of the ocean and the transfer of water currently stored on land, particularly from glaciers and ice sheets (Church *et al.* 2011). Currently, coupled Atmosphere-Ocean General Circulation Models (AOGCMs) and ice sheet models are replacing energy-balance climate models as the primary techniques supporting sea level projections (IPCC 2013). Ocean density, circulation and sea level are dynamically connected in AOGCMs as critical components of the models include surface wind stress, heat transfer between air and sea, and freshwater fluxes. AOGCM climate simulations have recently been used as input for glacier models (Marzeion *et al.* 2012) which project land-water contributions to sea level.

The Intergovernmental Panel on Climate Change (IPCC) is one of the main sources of peer-reviewed, consensus-based modeling information on climate change. The IPCC does not undertake climate modeling, but uses the outputs from a group of climate models that project

[3] During the last interglacial, global mean temperature was 1-2ºC warmer than the pre-industrial era (Levermann *et al.* 2013), while global mean sea level was likely 16.4-29.5 ft (5-9 m) above present mean sea level (Kopp *et al.* 2009; Dutton and Lambeck 2012; Levermann *et al.* 2013).

future temperature, precipitation patterns, and sea level rise, based on specific emission scenarios. Early in the 1990s, the IPCC developed basic model input conditions to ensure comparable outputs from the various models. The IPCC initially developed scenarios of future emissions, based on energy development, population and economic growth, and technological innovation. Four families of scenarios (A1, A2, B1, and B2) and subgroups (A1B, A1FI, A1T) were developed and used for climate and sea level rise projections for early IPCC reports (1990, 1995, 2001, 2007). IPCC used 4 new scenarios for the *5th Assessment Report* (AR5) in 2013, based on Representative Concentration Pathways (RCPs) that are different greenhouse gas concentration trajectories. These trajectories bear similarities to, but are not directly comparable to the earlier emission scenarios. Projections in IPCC AR5 (2013) differ from the earlier IPCC projections due to improvements in climate science, changes due to the new scenarios, and changes in the models to accommodate the new inputs, with improvements in climate science and model capabilities driving the bulk of the changes.

One finding of the earlier 2007 IPCC report called for improved modeling of ice dynamics. Focused research on ice dynamics to improve the ability of climate models to address the scale and dynamics of change to glaciers, ice sheets, and ice caps was subsequently undertaken (*e.g.*, Price *et al.* 2011; Shepherd *et al.* 2012; Winkelman *et al.* 2012; Bassis and Jacobs 2013; Little *et al.* 2013). Recent modeling results presented in the AR5 (IPCC 2013) reflect the scientific community's increased understanding in, as well as advances in modeling of the impacts of glacier melting and ocean thermal expansion on sea level change. AR5 scenarios reflect a greater range of global sea level rise (28-98 cm) based on improved modelling of land-ice contributions.

Semi-Empirical Method

The semi-empirical method for projecting sea level rise is based on developing a relationship between sea level and some factor (a proxy) – often atmospheric temperature or radiative forcing – and using this relationship to project changes to sea level. An important aspect for the proxy is that there is fairly high confidence in models of its future changes; a key assumption that is made by this method is that the historical relationship between sea level and the proxy will continue into the future. One of the first projections of this kind was based on the historical relationship between global temperature changes and sea level changes (Rahmstorf 2007). This semi-empirical approach received widespread recognition for its inclusion of sea level rise projections. These projections looked at the temperature projections for two of the previous IPCC (2007) emission scenarios that span the likely future conditions within the report's framework – B1, an optimistic, low-greenhouse gas emission future, and A1FI, a more "business-as-usual" fossil fuel intensive future.[4] The Rahmstorf 2007 sea level rise projections were used in the California 2009 *Climate Change Scenarios Assessment* (Cayan 2009).

Since the initial semi-empirical projections for future sea level rise (Rahmstorf 2007), other researchers have published different projections based on the IPCC scenarios, using different

[4] When the IPCC began examining climate change, the available models used a broad range of inputs. In an attempt to evaluate the different model outputs based on the different model characteristics rather than the inputs, the IPCC developed a number of standard greenhouse gas emission scenarios. These scenarios are described in *Response Strategies Working Group III* (IPCC 1990). In general, the B1 scenario projects the lowest temperature and sea level increases and the A1FI projects the highest increases.

data sets or best-fit relationships.[5] Notably, Vermeer and Rahmstorf (2009) prepared a more detailed methodology that includes both short-term responses and longer-term responses between sea level rise and temperature. These 2009 projections of sea level rise were used in the *Interim Guidance on Sea Level Rise* (OPC 2010) and the California 2012 *Vulnerability and Assessment Report* (Cayan 2012).

There are also several new semi-empirical sea level rise projections based on scenarios other than those developed by the IPCC. For instance, Katsman *et al.* (2011) use a "hybrid" approach that is based on the one of the newer radiative forcing scenarios and empirical relationships between temperature change and sea level. Future projections were then modified to include contributions from the melting of major ice sheets based on expert judgment[6]. This yields what they call "high end" SLR projections for Years 2100 and 2200 under several emissions scenarios.

Zecca and Chiari (2012) produced semi-empirical sea level rise projections based on their own scenarios of when fossil fuel resources would be economically exhausted. Though based on a different set of assumptions about human behavior/choices, in terms of global temperature and radiative forcing, the scenarios do not differ greatly from the IPCC scenarios. The results are identified as being "lower bound" sea level rise projections for high, medium, low fuel use scenarios, and "mitigation" (extreme and immediate action to replace fossil fuel use) scenarios. The report then provides projections for the 2000-2200 time period.

Expert Elicitation

Expert elicitation is one of the newer methods that have been used for projecting or narrowing ranges of future sea level rise. Using expert judgment has been an important aspect of scientific inquiry and the scientific method. The method of expert elicitation is a formalized use of experts in climate science and sea level change to help either narrow uncertainty for sea level projections, or to help with specifying extremes of a range. The elicitation method normally begins with experts refining model output information. One of the first attempts to use expert elicitation for sea level rise was a study by Titus and Narayanan (1996), when it was thought there was only 1% probability that sea level would exceed 3.3 ft (1 m) by Year 2100. In 2011, the Arctic Monitoring and Assessment Programme Report (AMAP 2011) surveyed the climate literature to construct a range of estimates of sea level rise by the year 2100, and then used a panel of experts to decide on a smaller, more plausible range. Not surprisingly, the projections supported by the AMAP experts fell right in the middle of the range shown in Figure A-2. Bamber and Aspinall (2013) used a statistical analysis of a large number of expert estimates to

[5] Semi-empirical projections of sea level rise using relationships between water level and radiative forcing such as those from Grinsted *et al.* (2009), Jevrejeva *et al.* (2010), Katsman *et al.* (2011), Meehl *et al.* (2012), Rahmstorf *et al.* (2012), Schaeffer *et al.* (2012), and Zecca and Chiari (2012) have shown general agreement with the projections by Vermeer and Rahmstorf (2009). The Grinsted *et al.* projections have a wider range than those of Vermeer and Rahmstorf, while the Jevrejeva *et al.* projections are slightly lower. All semi-empirical methods project that sea level in Year 2100 is likely to be much higher than linear projections of historical trends and the projections from the 2007 IPCC.

[6] Expert judgment has long been part of the scientific process. Expert elicitation, which is a formalized process for using expert judgment, has grown in importance and is discussed as a separate approach for projecting future sea level rise.

develop their projected range of future sea level, projecting sea level rise by 2100 ranging from 1–4.3 ft (0.33–1.32 m), under one of the intermediate AR5 scenarios (RCP 4.5).

Horton *et al.* (2014) surveyed experts in sea level science, based upon published papers, to develop a probabilistic assessment of long-term sea level rise (by the years 2100 and 2300), assuming two very different scenarios. Under one scenario, aggressive efforts would limit greenhouse gas concentrations that would cause global temperature to increase slightly until about 2050 when it would slowly drop (AR5's RCP 3 scenario). Under the other scenario, temperatures would continue to increase through to 2300 (AR5's RCP 8.5 scenario). Experts determined that it is likely that sea level rise could remain below 3.3 ft (1 m) for the low emission scenario (RCP 2.6), but that the likely range of future sea level rise for the high emission scenario (RCP 8.5) could be 6.6-9.8 ft (2-3 m).

Kopp *et al.* (2014) have combined detailed process modeling, community assessments and expert elicitation to assign probability distributions of local sea level rise through 2200 for identified communities around the world. Under the high concentration scenario, RCP 8.5, Kopp *et al.* find a 99.9 percentile estimate of 8.2 ft (2.5 m) for the year 2100. This study also finds that sea level rise along the Pacific Coast of the US is close to the global average, and the likely range of sea level is 2-3.3 ft (0.6-1.0 m) by the year 2100 at San Francisco, under the high concentration scenario. In contrast, in areas of high subsidence such as Galveston, Texas, the likely range of sea level in by 2100 ranges from 3.3 to 5 ft (1.0-1.5 m). And, at many of the localities that were examined, including San Francisco, the current 1-in-10 year flooding event is likely to occur every other year by 2100 (five times more frequently) due to sea level rise; the frequency of the 1-in-100 year event is expected to double by the year 2100 with sea level rise.

Coastal communities cannot ignore sea level rise in long-term planning, permitting and project design. The four different approaches to projecting future sea level rise all have varying strengths and weaknesses. As noted earlier in this section, projections, like models, will not be completely accurate, but they are important tools for evaluation nontheless[7]. The most commonly cited projections provide future sea level as a range, as a way to allow for many of the uncertainties that are part of future climate change. Often, projections of sea level rise rely upon multiple approaches. For example, the 2012 National Research Council (NRC) report, which is currently considered the best available sea level rise reference for the state of California, was developed through expert judgment that combined information from both physical models and semi-empirical projections.

[7] George E.P. Box, mathematician and statistician is quoted as saying, "Essentially all models are wrong, but some are useful."

BEST AVAILABLE SCIENCE ON SEA LEVEL RISE

Global Projections of Sea Level Rise

The best available science on *global* sea level rise projections is currently the IPCC *Fifth Assessment Report: Climate Change 2013* (AR5) released in September 2013. The new report now projects a more rapid sea level rise than the *Fourth Assessment* (AR4) released in 2007. By Year 2100, the AR5 projects global sea level to be more than 50% higher (26-98 cm) than the old projections (18-59 cm) when comparing similar emission scenarios and time periods. The increase in AR5 sea level projections results from improved modelling of land-ice contributions. Substantial progress in the assessment of extreme weather and climate events has also been made since the AR4 as models now better reproduce phenomena like the El Niño-Southern Oscillation (ENSO; IPCC 2013).

National Projections of Sea Level Rise

The third National Climate Assessment (NCA) was released in May 2014 (Melillo *et al*.), and includes the current best-available science on climate change and sea level rise *at the national scale*. The sea level rise projections in the NCA were informed by the 2012 NOAA report titled *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris *et al*.). This report provides a set of four scenarios of future global sea level rise, as well as a synthesis of the scientific literature on global sea level rise. The NOAA Climate Program Office produced the report in collaboration with twelve contributing authors.[8] The report includes the following description of the four scenarios of sea level rise by the year 2100:

- **Low scenario:** The lowest sea level change scenario (a rise of 8 in (20 cm)) is based on historical rates of observed sea level change.
- **Intermediate-low scenario:** The intermediate-low scenario (a rise of 1.6 ft (0.5 m) is based on projected ocean warming.
- **Intermediate- high scenario:** The intermediate-high scenario (a rise of 3.9 ft (1.2 m)) is based on projected ocean warming and recent ice sheet loss.
- **High scenario:** The highest sea level change scenario (a rise of 6.6 ft (2 m)) reflects ocean warming and the maximum plausible contribution of ice sheet loss and glacial melting.

The Parris *et al*. (2012) report recommends that the highest scenario be considered in situations where there is little tolerance for risk. It also provides steps for planners and local officials to modify these scenarios to account for local conditions. These steps are intended for areas where local sea level rise projections have not been developed. For California, the NRC report (below) provides scenarios that have been refined for use at the local level, and the Coastal Commission, along with the State of California Sea Level Rise Guidance, recommends using the NRC projections rather than the global or national scenarios.

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[8] Authors include NOAA, NASA, the US Geologic Survey, the Scripps Institution of Oceanography, the US Department of Defense, the US Army Corps of Engineers, Columbia University, the University of Maryland, the University of Florida, and the South Florida Water Management District.

California-Specific Projections of Sea Level Rise and Best Available Science

In 2012, the National Research Council (NRC) Committee on Sea-Level Rise in California, Oregon and Washington (NRC Committee) released a report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. This report provides an examination of global and regional sea level rise trends and projections of future sea level. It is considered the best available science on sea level rise for California.

To produce global sea level rise projections, the Committee used the basic scenarios that are the foundation of the IPCC AR4 climate projections and earlier climate studies for California. These scenarios were used to model steric changes in global sea level (thermal expansion or contraction), as well as changes in the amount of ocean water due to melting of land-based ice on Greenland, Antarctica, and other land-based glaciers and ice caps. Table A-1 shows the NRC projections for *global* sea level rise.

Table A-1. Recent Global Sea Level Rise Projections for 2000 to 2100

Time Period	NRC 2012 (English)		NRC 2012 (Metric)	
	Projection	Range	Projection	Range
2000 – 2030	5 ± 1 in	3 – 9 in	14 ± 2 cm	8 – 23 cm
2000 – 2050	11 ± 1 in	7 – 19 in	28 ± 3 cm	18 – 48 cm
2000 – 2100	33 ± 4 in	20 – 55 in	83 ± 11 cm	50 – 140 cm

Source: NRC 2012

In addition to the global sea level rise projections, the NRC Committee developed regional/West Coast projections based on the local steric and wind conditions (estimated by using down-scaled global climate models (GCMs), extrapolation of land-ice contributions, and estimates of vertical land motion. The report provides several sets of sea level rise amounts expected by the years 2030, 2050, and 2100 for several locations and regions in California. These include:

- Sea level rise "ranges" for north and south of Cape Mendocino
- Sea level rise "ranges" for San Francisco, Los Angeles, Newport, OR, and Seattle, WA
- Sea level rise "projections" for San Francisco, Los Angeles, Newport, OR, and Seattle, WA

The high and low sea level rise amounts for the "ranges" are based on the A1FI and B1 emission scenarios, respectively. The "projections" (with a standard deviation indicated) are based on the A1B emission scenario[9]. A subset of these ranges and projections is included in Table A-2. Figure A-3 displays the A1B projections for Los Angeles and San Francisco overlaid on the "ranges" for south of Cape Mendocino. The NRC Report does not provide a California community for the North of Cape Mendocino "projection" so, in addition to the range, the "projection" for Newport, Oregon is provided as a general representation for the North of Cape Mendocino region.

[9] The IPCC A1B scenario assumes similar economic and population growth patterns but with a more balanced energy approach of both fossil-intensive and non-fossil sources.

Table A-2. Regional Sea Level Rise Ranges and Projections (NRC 2012). Ranges and projections with IPCC scenario indicated.

Time Period*	North of Cape Mendocino[10]		South of Cape Mendocino	
	Range: (B1-A1FI scenario)	Projection: Newport, OR (A1B scenario)	Range: (B1-A1FI scenario)	Projection: Los Angeles, CA (A1B scenario)
by 2030	-2 – 9 in (-4 – +23 cm)	3 ± 2 in (7 ± 6 cm)	2 – 12 in (4 – 30 cm)	6 ± 2 in (15 ± 5 cm)
by 2050	-1 – 19 in (-3 – + 48 cm)	7 ± 4 in (17 ± 10 cm)	5 – 24 in (12 – 61 cm)	11 ± 4 in (29 ± 9 cm)
by 2100	4 – 56 in (10 – 143 cm)	25 ± 11 in (63 ± 28 cm)	17 – 66 in (42 – 167 cm)	37 ± 10 in (93 ± 25 cm)

* Relative to the year 2000

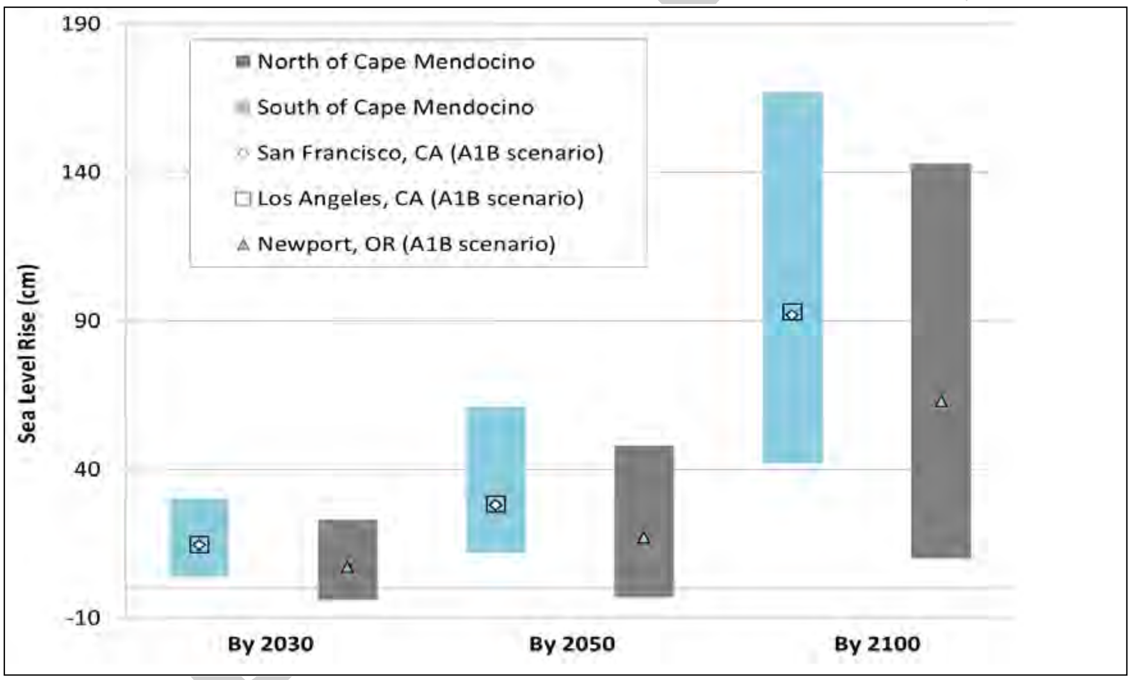

Figure A-3. NRC 2012 sea level rise ranges bounded at the low end by the B1 scenario and by the A1FI scenario at the high end. The points refer to projections based on the A1B scenario.

[10]The NRC Committee divided the Pacific into two regions, north and south of Cape Mendocino, due to differences in tectonics that occur at this point. North of Cape Mendocino, land is rising as ocean plates descend below the North American plate at the Cascadia Subduction Zone. South of Cape Mendocino, the coast is sinking (NRC 2012, p. 3). Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary.

Figure A-4. Location of Cape Mendocino

The NRC Committee gave different sea level rise ranges for north and south of Cape Mendocino because it identified distinctly different land level changes in the two regions (Figure A-4). The area north of Cape Mendocino is experiencing significant uplift of about 0.059 to 0.118 in/yr (1.5 to 3 mm/yr), which the Committee attributed to plate movement along the Cascadia Subduction Zone (NRC 2012, p. 93). In contrast, the coast south of Cape Mendocino is dropping at an average rate of about 0.039 in/yr (1 mm/yr) (NRC 2012, p. 93). The measurements of land subsidence south of Cape Mendocino vary widely, from -0.146 in/yr to +0.024 in/yr (-3.7 mm/yr to +0.6 mm/yr) (NRC 2012, p. 93), with slightly greater subsidence in southern California than in Central California.[11] The NRC Committee noted that the uplift being experienced along the Cascadia Subduction Zone may reverse during a fault rupture or earthquake of magnitude 8.0 or greater along the Cascadia Subduction Zone. The NRC report notes that during such an earthquake, coastal areas could experience sudden vertical land motion, with uplift in some locations and subsidence as much as 6.6 ft (2 m) in other locations (NRC 2012). Despite the potential for rapid reversibility of much of the coastal uplift north of Cape Mendocino, the “ranges” for north of Cape Mendocino incorporate land uplift.

In contrast to the vertical uplift occurring throughout the majority of the area north of Cape Mendocino, Humboldt Bay’s North Spit and the Eel River Estuary is subsiding and experiencing the highest rate of sea level rise in the state: a rate of 18.6 in (47 cm) over the last century (NOAA 2013). Therefore, the OPC Science Advisory Team recommends making modifications to NRC’s sea level rise projections for North of Cape Mendocino based on tide gauge readings for Crescent City and Humboldt Bay, with intermediate values for the areas between them (OPC 2013, p. 11).[12] Please see *Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.

For the area south of Cape Mendocino, the NRC report provides a range of future sea level rise for the entire region, and ranges and projections for both San Francisco and Los Angeles. The

[11] Personal Communication to staff from Anne Linn, NRC Study Director (August 1, 2012)

[12] A three-member subcommittee of the OPC Science Advisory Team (OPC-SAT) advised using the NRC projections, without modification, for all California locations except between Humboldt Bay and Crescent City (OPC 2013, p. 10).

ranges for both San Francisco and Los Angeles match ranges for the south of Cape Mendocino to within a few millimeters. Because of this close match, and because the NRC report does not indicate what portion of the coast would most appropriately use either the San Francisco or Los Angeles projections, using the city values instead of the regional values is not necessary. The Ocean Protection Council Science Advisory Team recommends using the sea level rise amount for south of Cape Mendocino for the entire region, stating, "we do not believe that there is enough certainty in the sea level rise projections nor is there a strong scientific rationale for specifying specific sea level rise values at individual locations along California's coastline" (OPC 2013, p. 10).

The Coastal Commission recommends that the high and low "ranges" for north and south of Cape Mendocino—along with one or more intermediate values—be considered in all relevant local coastal planning and coastal development permitting decisions. The NRC "projections" may serve as intermediate values where appropriate.

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Appendix B

Developing Local Hazard Conditions Based on Regional or Local Sea Level Rise Using Best Available Science

This Appendix provides technical information regarding how to determine local hazard conditions for sea level rise planning efforts. This process is described more broadly as Steps 1-3 in Chapters 5 and 6 in this document, and includes determining a range of sea level rise projections and analyzing the physical effects and possible resource impacts of sea level rise hazards.

Water level varies locally, so this analysis must be performed on a regional or site specific basis, and applicants and planners should prioritize obtaining data or conducting research at the correct geographical scale. The 2012 National Research Council (NRC) report is considered the best available science on California's regional sea level rise, and the Commission recommends using it when sea level rise projections are needed. Equivalent resources may be used by local governments and applicants provided that the resource is peer-reviewed, widely accepted within the scientific community, and locally relevant.[93]

Much of the research by the Intergovernmental Panel on Climate Change (IPCC) and others, and even the material in the 2012 NRC Report, has focused on global and regional changes to mean sea level. However, the coast is formed and changed by local water and land conditions. Local tidal range influences where beaches, wetlands and estuaries will establish; waves and currents are major drivers of shoreline change; and storms and storm waves are often the major factors causing damage to coastal development. It is local conditions that influence beach accretion and erosion, storm damage, bluff retreat, and wetland function.

Local water levels along the coast are affected by local land uplift or subsidence, tides, waves, storm waves, atmospheric forcing, surge, basin-wide oscillations, and tsunamis. Some of these factors, such as tides and waves, are ever-present and result in ever-changing shifts in the local water level. Other drivers, such as storms, tsunamis, or co-seismic uplift or subsidence, are episodic but can have important influences on water level when they occur. The following section discusses these factors in the context of sea level rise and how to incorporate them into planning and project analysis.

In most situations, high water will be the main project or planning concern. For wetlands, the intertidal zone between low and high tides will be of concern, while in some special situations, such as for intake structures, low water might be the main concern. In situations where low water is the concern, current low water is likely to be the low water planning condition and there may be no need to factor future sea level rise into those project or planning situations. In most other situations, hazards analyses will need to account for sea level rise. The following box identifies some of the key situations in which it may be important for coastal managers and applicants to consider sea level rise during project review.

[93] This appendix is written in such a way that it complements the materials from the 2012 NRC Report, which is currently considered the best available science on sea level rise in California. As new reports are issued in the future, Commission staff will assess whether they should be considered the best available science and update the approaches or terminology in this Appendix accordingly.

General situations needing sea level rise analysis include when the project or planning site is:

- Currently in or adjacent to an identified floodplain
- Currently or has been exposed to flooding or erosion from waves or tides
- Currently in a location protected from flooding by constructed dikes, levees, bulkheads, or other flood-control or protective structures
- On or close to a beach, estuary, lagoon, or wetland
- On a coastal bluff with historic evidence of erosion
- Reliant upon shallow wells for water supply

For situations where future sea level conditions will be important for the analyses of hazards or resource impacts, the following sections are provided as guidance for determining local hazards. Figure B-1 shows the general progression for going from global sea level projections to the possible consequences or impacts that can result from local water levels.

The following information provides details about how to develop sea level rise projections that can be used for specific time periods and geographic areas. It then provides guidance on using these temporally- and regionally-appropriate sea level rise projections to determine future tidal elevations and inundation, future still water, future shoreline change and erosion potential flooding, wave impacts and wave runup, and flooding from extreme events.

Most of these analyses must occur sequentially. Sea level rise is used to determine changes in tidal conditions, and tidal conditions are combined with future surge, El Niño Southern Oscillation (ENSO) events, and Pacific Decadal Oscillations (PDOs) to estimate local still water. Changes in the frequencies of still water levels will in turn affect erosion rates, and the amount of erosion will affect future wave impacts, runup and flooding.

To be consistent with other sections, these different efforts are presented as Steps, with a discussion of how to accomplish each and the expected outcome. Depending upon the planning or project concerns and required analysis, it may not be necessary to proceed step-by-step and readers should use their judgment as to which items are relevant to their concerns. For example, if the concern is about runup on a non-erosive slope due to an increase in the still water level of 5.5 ft (1.7 m), the guidance on wave runup analysis may be all that is necessary.

Step 1 – Develop temporally- and spatially-appropriate sea level rise projections
Step 2 – Determine tidal range and future inundation
Step 3 – Determine still water level changes from surge, El Niño events and PDOs
Step 4 – Estimate beach, bluff, and dune change from erosion
Step 5 – Determine wave, storm wave, wave runup, and flooding conditions
Step 6 – Examine potential flooding from extreme events

A Note on Hydrodynamic Models versus "Bathtub Fill" Models

It is important to be aware of the differences between a so-called "bathtub fill" model and hydrodynamic models, and the related pros and cons of each for analysis of sea level rise impacts. In general, "bathtub fill" refers to those models that analyze flooding or inundation based solely on elevation. In other words, if sea level is projected to rise 3 ft (1 m), thereby increasing flooding/inundation from a current elevation of +10 ft (3 m) to +13 ft (4 m), these models will, in general, flood everything below the +13 ft (4m) elevation. The modeling does not take into consideration whether the new flood areas are connected to the ocean, nor does it consider how the changes to the water level will change wave propagation or overtopping of flood barriers. This is a significant oversimplification of the processes involved in flooding, but it provides value in allowing individuals to gain a broad view of the general areas that could be impacted by sea level rise without requiring a great deal of technical information.

Conversely, hydrodynamic modeling takes into account the details of local development patterns and the characteristics of waves and storms, and can therefore provide a much better understanding of local sea level rise impacts than is possible from "bathtub fill" models. In particular, hydrodynamic models take into account factors that alter flooding and inundation patterns and impacts. Such factors may include the extent and orientation of development – for example, roadways and linear features that tend to channelize water flows, and buildings or flood barriers that can block and divert flows – as well as the conditions that contribute to flooding and inundation, such as wave conditions, flow velocities, the extent of overtopping, and so on. Although the initial development of the modeling grid that is used to depict the community development patterns can be quite time-consuming to create and the model output will change with differing grid designs (Schubert and Sanders 2012), once the grid is developed, hydrodynamic modeling can be used to better characterize areas of flooding and to distinguish areas of concentrated flooding from those areas that may experience small amounts of flooding only during peak conditions (Gallien *et al.* 2011, 2012).

Significantly, many of the analyses described in this Appendix are the kinds of analyses that go beyond "bathtub fill" modeling to include the hydrodynamic factors that help to specify the more location-specific impacts for which planners should prepare.

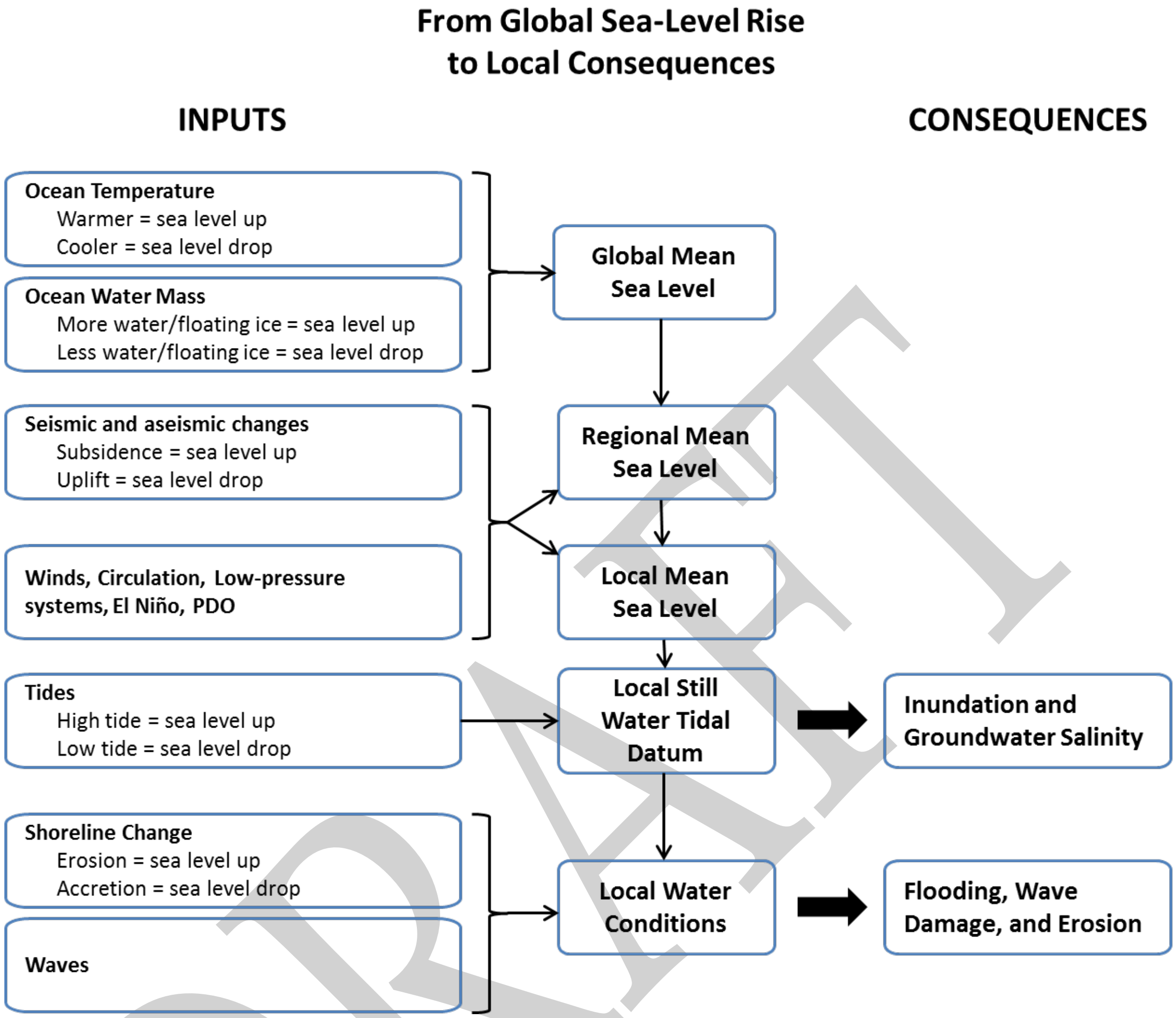

Figure B-1. General process for global sea level rise to local consequences

Step 1 – Develop temporally- and spatially-appropriate sea level rise projections

a. Determine appropriate planning horizon or expected project life

The first step in a sea level rise analysis is to determine the appropriate planning horizon based on the expected life of the project. The longer the life of a project or planning horizon, the greater the amount of sea level rise the project or planning area will experience.

Local governments should select their planning horizons to evaluate a broad range of planning concerns. Planning horizons could address the 20-year time period that is typical for *General Plan* updates as well as the long-range planning that is necessary for infrastructure and new development. The 20-year planning horizon may help identify areas within the coastal zone that are now or will soon be vulnerable to sea level rise related hazards as an aid for focusing adaptation planning on the areas of greatest need. Local Coastal Program (LCP) planning will likely use multiple planning horizons and undertake hazards analyses for multiple time periods, multiple sea level rise projections, or both.

At the project level, the LCP may provide insight into the time period that should be considered for the expected project life. At present, LCPs typically provide only a single standard (if any) for the expected life of a structure or development, such as 50, 75, or 100 years. Future LCPs and LCP Amendments (LCPAs) may find it useful to provide greater guidance on expected project life, with differentiations among major development or use classifications. For example, a general range may be chosen based on the type of development such that temporary structures, ancillary development, amenity structures, or moveable or expendable construction should identify a relatively short expected life of 25 years or less. Residential or commercial structures, which will be around longer, should choose a time frame of 75 to 100 years to consider. A longer time frame of 100 years or more should be considered for critical infrastructure like bridges or industrial facilities or for resource protection or enhancement projects that are typically meant to last in perpetuity.

For projects with long lead times, the analysis of impacts from sea level rise should use the projections for the time period when the development will be in use, rather than the current period because the trajectory of future sea level rise is not expected to be linear. For example, a project built today will experience less sea level rise over a 50-year lifetime (about 24 in (61 cm) using the higher projections for south of Cape Mendocino) than the same project if it were built in the year 2050 (about 40 in (101 cm), using the higher projections for south of Cape Mendocino). Thus, it is important to understand the anticipated project life of a structure and the associated planning horizon before starting an analysis for sea level rise concerns.

As explained in Chapters 5 and 6, the point of this step is not to specify exactly how long a project will exist (and be permitted for), but rather to identify a project life timeframe that is typical for the type of development in question so that the hazard analyses performed in subsequent steps will adequately consider the impacts that may occur over the entire life of the development.

b. Project sea level rise for years other than 2030, 2050, and 2100

At present, the 2012 NRC report provides the best available science for regional sea level rise projections from the year 2000 to 2030, 2050, and 2100. For sea level rise projections for years within a few of those used in the NRC projections, the 2030, 2050, and 2100 projections can be used. However, for years that are not close to these years, sea level rise projections should be interpolated from the projections. Two methods are recommended for establishing a projection value for a specific year: 1) conduct a linear interpolation[94], or 2) use the "best fit" equations that are provided below. At this time, both are acceptable for Coastal Commission purposes.

1. ***Linear Interpolation:*** One method for establishing a sea level rise projection for a specific year is linear interpolation between two known or given projections. The most immediate time periods before and after the desired time period should be used. For example, for a proposed project south of Cape Mendocino with an expected life until the year 2075, the upper range for the sea level rise projections closest to this time period are 24 in (61 cm) for Year 2050, and 66 in (167 cm) for Year 2100.

$$\mathrm{SLR}_{2075} = \mathrm{SLR}_{2050} + [\mathrm{SLR}_{2100} - \mathrm{SLR}_{2050}] * \frac{2075 - 2050}{2100 - 2050}$$

$$\mathrm{SLR}_{2075} = 24\text{ in} + [66\text{ in} - 24\text{ in}] * \frac{25\text{ years}}{50\text{ years}}$$

$$\mathrm{SLR}_{2075} = 45\text{ in} = 114\text{ cm}$$

2. ***"Best-Fit" Equation:*** Figure B-2 illustrates smoothed curve fits for the high and low ranges of expected sea level rise from 2012 NRC report, along with several local projections. As seen from these curves, a linear interpolation between any two points on the curves would be slightly higher than a projection that is represented by the curve itself. A second option that can be used to estimate sea level rise projections for years other than years 2030, 2050, and 2100 that avoids this slight discrepancy is to use one of the following quadratic equations that represent the "best fit" for each of the above sea level rise curves. These equations provide sea level rise in centimeters. If English units are desired, the projections will need to be converted using 1 cm = 0.0328 ft, or 1 cm = 0.394 in.

94 Linear interpolation is a method for filling in gaps in data or information that assumes that two known data points that bound the unknown point can be connected with a straight line. The missing information is estimated through reference to this line. The example in the text provides an example of the mathematical steps for linear interpolation.

Equations for Sea Level Rise Projections, based on values from the 2012 NRC Report

North of Cape Mendocino

- [*Upper Range*] Sea Level Change (cm) $= 0.0094t^2 + 0.4868t$ (Equation B1)
- [*Lower Range*] Sea Level Change (cm) $= 0.0033t^2 - 0.2257t$ (Equation B2)

South of Cape Mendocino

- [*Upper Range*] Sea Level Change (cm) $= 0.0093t^2 + 0.7457t$ (Equation B3)
- [*Lower Range*] Sea Level Change (cm) $= 0.0038t^2 + 0.039t$ (Equation B4)

Where "t" is the number of years after 2000

For example, if the proposed project were south of Cape Mendocino, with an expected life of 75 years, use Equation B3, with t = 75 (*i.e.*, Year 2075):

$$SLR_{2075} = (0.0093 \times 75^2) + (0.7457 \times 75)$$

$$SLR_{2075} = 52 + 56 = 108 \text{ cm} = 43 \text{ in}$$

The sea level projection estimated using the "best-fit" equation is slightly less than that the estimation based on linear interpolation because the NRC's sea level curves, shown in Figure B-2, are concave upward (sea level rise is expected to accelerate over the 21st Century). A line between any two points on the curve will always be slightly higher than the curve itself.

As noted previously, either of the two methods is acceptable for estimating sea level rise for a year that has not been provided in the NRC Report.

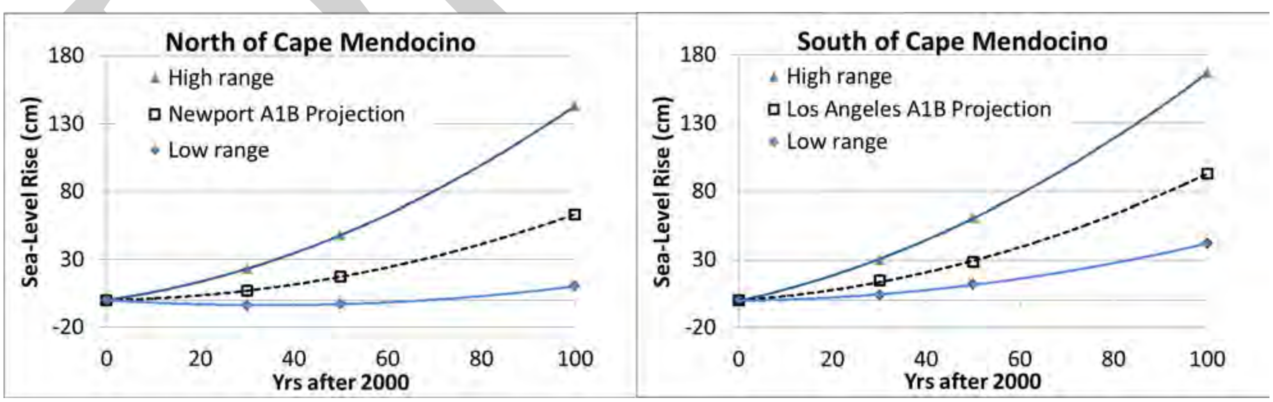

Figure B-2. Ranges of sea level rise based on 2012 NRC report. The NRC report used the IPCC (2007) A1FI scenario to represent the high range, and the B1 scenario to represent the low range. North of Cape Mendocino, Newport, OR, provides a mid-range A1B scenario projection and south of Cape Mendocino, Los Angeles, CA, provides a mid-range A1B scenario projection.

c. Ranges of sea level rise projections that do not start at the year 2000

The NRC sea level rise projections use the year 2000 as the base year. Since there has been little, if any, measureable rise in sea level since 2000 for most locations in California (Bromirski *et al.* 2011; NOAA 2013), there is little reason or justification for adjusting sea level rise projections from the year 2000 baseline to a more current date when analyzing projects with start dates prior to about Year 2015 or 2020. However, the latent sea level rise might occur quickly, providing sea level conditions consistent with the future projections. Thus, when analyzing sea level rise impacts for projects that are proposed to begin development in the near future and to exist for a limited lifetime, there is no need to adjust the 2012 NRC projections for a different project starting year or to account for the current lack of significant sea level change from the year 2000 baseline.

Conversely, if the needed sea level rise value is the range of sea level that might be experienced over a future time period, as might be used for planning a wetland restoration project, then adjustments to the starting point for sea level rise projections may be necessary. In such a case, this sea level range can be developed by interpolating the sea level projections for the starting and ending years (using the processes above for years other than 2030, 2050, and 2100), and obtaining the difference in sea level by subtracting these two. For example, if a restoration project is proposed to be designed to take into account the sea level rise that will occur from years 2040 to 2060, use Equations B1, B2, B3, or B4 to get $SLR_{t1=2040}$ and $SLR_{t2=2060}$. Then, subtract SLR_{2040} from SLR_{2060} to get the range of sea level rise that is anticipated from years 2040 to 2060.

d. Sea level rise projections beyond year 2100

Sea level rise is expected to continue well past the year 2100, despite the termination of most projections at that year in the scientific literature. However, the uncertainty associated with any projections for sea level grows significantly as the time period increases and there are large uncertainties in projections for sea level rise in the year 2100 and beyond. Despite such uncertainty, long-term planning and projects requiring long lead times or large capital expenditures need to consider conditions that might occur in the next 100 or more years in order to analyze potential hazards.

At this time, there are no studies that specifically address projections of sea level rise for California beyond the year 2100. The NRC projections stop at Year 2100 and provide no guidance for extrapolation of the range of sea level rise projections past that time. The equations provided above, while most appropriate for interpolation up to 2100, can be used to extrapolate sea level rise for a few years beyond 2100. However, for projections beyond about years 2105 or 2110, alternative methods should be considered for developing sea level rise projections. Options for developing sea level rise projections for years beyond 2100 include:

1. Use the NRC projections for 2050 and 2100 to develop a linear trend beyond Year 2100.
2. Use sea level rise rates that have been developed in recent years, some of which are provided in Table B-1.

3. Interpolate between the NRC projections, and one of the reports that provides projections of global sea level rise for years 2200 or 2300 (some of which are listed in Table B-2).

None of these options will provide sea level rise projections that have a confidence similar to the NRC projections. Eventually, there may be regionally appropriate projections for sea level into the 22nd and 23rd centuries. Until then, simplifying assumptions might be necessary for analysis that goes into these time periods. It is clear that sea level will continue to rise past 2100, and any effort to look beyond the year 2100 will be better than using projections of sea level rise for 2100 as the upper limit of what might happen beyond that time. Nonetheless, it is critical that long-range planning efforts and projects with long design lives include provisions to revisit SLR hazards periodically, and to make adjustments as new science becomes available.

Table B-1. Range of Global Sea Level Rise (*from Nicholls et al. 2011*)

Source	Methodological Approach	Sea level rise ft/century (m/century)
Rahmstorf 2007	Semi-empirical projection[a]	1.6 – 4.6 (0.5 – 1.4)
Rohling *et al.* 2008	Paleo-climate analogue	2.6 – 7.9 (0.8 – 2.4)
Vellinga *et al.* 2008	Synthesis[a]	1.8 – 3.6 (0.55 – 1.10)
Pfeffer *et al.* 2008	Physical constraints analysis[a]	2.6 – 6.6 (0.8 – 2.0)
Kopp *et al.* 2009	Paleo-climate analogue	1.8 – 3.0 (0.56 – 0.92)
Vermeer and Rahmstorf 2009	Semi-empirical projection[a]	2.5 – 6.2 (0.75 – 1.90)
Grinsted *et al.* 2009	Semi-empirical projection[a]	2.4 – 5.2 (0.72 – 1.60)[b]

[a] For the 21st Century
[b] For the best paleo-temperature record.

Table B-2. Projections of Global Sea Level Rise Beyond Year 2100

Projection Scenario[a]	Sea level rise for 2300, referenced to 2000 (Schaeffer *et al.* 2012) ft (m)	2300 Sea level rise rate (Schaeffer *et al.* 2012) in/yr (mm/yr)	Sea level rise for 2500, referenced to 2000 (Jevrejeva *et al.* 2012) ft (m)
RCP4.5	7.0 – 17.3 (2.12 – 5.27)	0.24 – 0.74 (6 - 20)	2.4 – 14.1 (0.72 – 4.3)
RCP3PD	3.9 – 10.1 (1.18 – 3.09)	0.04 – 0.35 (1 - 9)	0.4 – 5.7 (0.13 – 1.74)
RCP6			3.4 – 19.0 (1.03 – 5.79)
RCP8.5			7.4 – 37.8(2.26 – 11.51)
Stab 2°C	5.1 – 13.2 (1.56 – 4.01)	0.16 – 0.55 (4 – 14)	
Merge400	2.8 – 7.7 (0.86 – 2.36)	-0.08 – 0.12 (-2 – 3)	
Zero 2016	2.5 – 6.8 (0.76 – 2.08)	0.04 – 0.24 (1 – 6)	

[a] See referenced reports for details on projection scenarios.

Step 2 – Determine tidal range and future inundation

One of the most basic examinations of changing sea level conditions has been to determine the new intersection of mean sea level or other tidal datums[95] with the shoreline. This is a basic "bathtub" analysis since it looks only at the expansion of areas that will be inundated (*i.e.*, regularly submerged under water) or subject to tidal or wave action. For example, future subtidal levels would be the current subtidal limit plus projected regional mean sea level rise. Future intertidal zones would be bounded by the future higher high tide level (current higher high water plus projected regional sea level rise) and future lower low tide levels (current lower low water plus projected regional sea level rise).[96] For some projects, such as wetland restoration, the identification of future inundation zones may be the only sea level analysis needed for project evaluation. However, if the shoreline is eroding, the location of this elevation would need to also incorporate the rate of erosion. So, if the shoreline is expected to erode due to increased wave attack, not only will the intertidal zone move up in elevation, it will be both higher than and inland of the current zone.

Future Water *Elevation* = Current Tidal Datum + Projected Sea Level Rise

OR

Future Water *Location* = Intersection of Future Water Elevation with Future Shore Location

Future water location will extend to the new inundation elevation on the future shoreline. On beaches with a gradual slope, this can move the inundation location significantly inland, based on the geometric conditions of the beach. (This type analysis is often called the Bruun Rule). On a stable beach with a slope of 1:X (Vertical:Horizontal), every foot of vertical sea level rise will move the inundation area horizontally X feet inland. For a typical 1:60 beach, every foot of sea level would move the inundation zone inland by 60 ft. If the beach is eroding, the loss due to erosion will add to the loss resulting from inundation.

Figure B-3 shows the influence of tides and sea level rise on low-wave energy beaches. Table B-3 provides some useful resources for inundation studies. Local Tidal Elevations are available from tide gauges maintained by NOAA. Where there are no nearby gauges, NOAA recommends the VDatum software.

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95 Tidal datums are based on the latest National Tidal Datum Epoch (NTDE) published by NOAA and are the mean of the observed sea levels over a 19-year period. The latest published epoch is 1983-2001. This tidal epoch can be considered equivalent to the year 2000 baseline for the NRC projections.

96 Historical trends of high and low tide have changed differently than mean sea level (Flick *et al.* 2003). Based on historical trends, the changes to various tidal elements are likely to track closely with, but not identically with, changes to mean sea level. The future variability of changes to the tidal components, compared with changes to mean sea level will normally fall within the uncertainty for sea level rise projections and can be disregarded in almost all situations. As this phenomenon of tidal change is better understood and can be modeled, it may be appropriate in the future to include the changes in tidal components into the analysis of inundation and various water level projections.

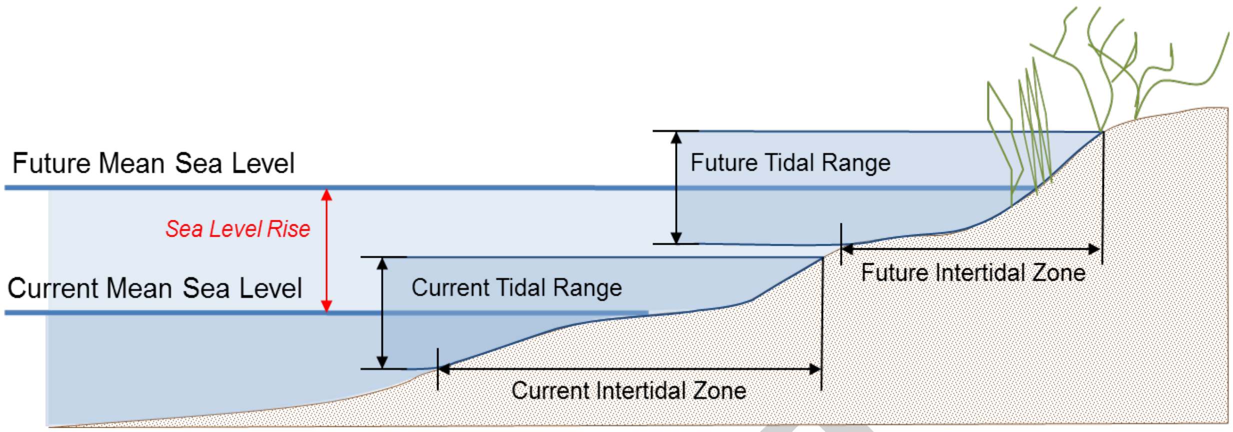

Figure B-3. Sea level rise and changes to tide range and intertidal zone. (*Source: L. Ewing, 2013*).

Table B-3. General Resources for Inundation Studies

Resource	Description	Link
Aerial Photographs	Useful for general information on shoreline trends; ortho-rectified photos can help quantify trends	California Coastal Records Project, www.californiacoastline.org; Huntington Library; Local Libraries
LIDAR	Fairly detailed topography providing GIS layers for current conditions and comparable with LIDAR data sets for temporal changes.	NOAA Digital Coast, http://coast.noaa.gov/digitalcoast/data/coastallidar
Topographic Maps	Useful for basemaps to overlay site changes; often not at a scale to distinguish small changes in inundation or tidal action..	USGS Map Center, http://www.usgs.gov/pubprod/maps.html
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Useful to show changes in water level location if there are no changes in the land due to erosion.	NOAA Digital Coast, http://coast.noaa.gov/digitalcoast/tools/slr/
NOAA Tidal Data	Measured and predicted tidal components for locations along the open coast and in bays.	NOAA Center for Operational Oceanographic Products and Services, http://tidesandcurrents.noaa.gov/
NOAA Technical Report NOS 2010-01: *Technical Considerations for use of Geospatial Data in Sea Level Change Mapping and Assessment*	Provides technical guidance to agencies, practitioners, and decision makers seeking to use geospatial data to assist with sea level change assessments.	NOAA National Ocean Service http://www.tidesandcurrents.noaa.gov/publications/tech_rpt_57.pdf

VDatum Software	A Vertical Datum Transformation program that allows users to transform geospatial data among various geoidal, ellipsoidal and tidal vertical datums.	NOAA National Ocean Service, http://www.nauticalcharts.noaa.gov/csdl/vdatum_enhancements.html
Cal-Adapt – Exploring California's Climate	Shows coastal areas that may be threatened by flooding from a 4.6 ft (1.4 m) rise in sea level and a 100-year flood event. Maps were developed using the Pacific Institute SLR Maps and do not now include any influence of beach or dune erosion or existing protective structures.	http://cal-adapt.org/sealevel/
Estimating Sea Level for Project Initiation Documents	Provides guidance on converting tidal datums and predicting future sea levels.	Caltrans Office of Land Surveys, http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/Estimating_Sea_Level_v1.pdf

Outcome from Step 2: *Provide information on the projected changes to the tidal range and future zones of inundation. For locations without any influence from erosion, storm surge, or wave energy, the identification of new inundation areas may be sufficient for project analysis and planning efforts. This projected new inundation area may also be useful for anticipating the likely migration of wetlands and low-energy water areas or as input for analysis of changes groundwater salinity. For most open coast situations, this information will be used to inform further project planning and analysis that examines erosion, surge and storm wave conditions.*

Step 3 – Determine still water changes from surge, El Niño events, and PDOs

Estimates of surge, El Niño, and PDO water elevation changes are developed primarily from historical records. There are no state-wide resources for this information, although it may be included in some Regional Sediment Management Plan studies. General guidance on water level changes that can be expected from surge, El Niño events, and PDOs is provided in Table B-4.

The remaining discussion provides general information on some of these phenomena. It is provided to acquaint readers to the main issues associated with each phenomenon. Readers with a strong background in ocean-atmospheric conditions may want to skim or skip the rest of this section.

The Pacific Ocean is a complex system. Sea level in the Pacific Ocean responds to multiple oceanic and atmospheric forcing phenomena, occurring with different intensities and at different temporal and spatial scales. Some phenomena may reinforce each other, while others may act in opposition, reducing the net effect. Scientists and researchers are attempting to identify the various signals from the multiple phenomena, but these are nascent sciences and there is still much we need to learn.

Regional water levels can be influenced by surge as well as by high and low pressure systems. Surge is a short-term change in water elevation due to high wind, low atmospheric pressure, or both. It is most often associated with East Coast and Gulf Coast hurricanes that can cause up to 15 or 20 ft (4-6 m) or more of short-term water level rise over many miles of the coast. Along the West Coast, storm surge tends to be much smaller, and is rarely a coastal hazard, except in enclosed bays. In southern California, it rarely exceeds 1 ft (0.3 m) and in central California, it rarely exceeds 2 ft (0.6 m). Surge becomes a concern as one of several cumulative factors that cause a temporary rise in sea level. Each rise may be small, but when surge occurs during high tides and/or in combination with storms, it increases the threat of coastal flooding, wave impacts, and erosion.

Two of the more recognized phenomena that affect water temperature in the Pacific are the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO cycles, which occur on inter-annual timescales (approximately 2-7 years), involve ocean-basin-spanning changes in sea surface temperature (SST) and in the depth of the mixed layer in the Equatorial Pacific, but also drive changes in ocean conditions and atmospheric circulation at higher latitudes. El Niño events result in the transfer of warm surface waters into the normally cool eastern equatorial Pacific, resulting in elevated SST and water levels along much of the west coast of the Americas. El Niños also tend to increase the strength and frequency of winter low pressure systems in the North Pacific. These events can persist for months or years at a time, and strongly influence local and regional sea level. For example, the pulse of warm water from the large 1982-83 El Niño caused water levels along the California to be elevated by approximately 0.4-0.7 ft (0.12-0.21 m) for many months, with short-term water elevation peaks up to approximately 1 ft (0.3 m; Flick 1998). The opposite phase of ENSO, characterized by unusually cool SSTs and lower water elevations along the eastern Pacific margin, are called La Niña events. Between El Niños and La Niñas are periods of neutral SST and water elevation changes.

The PDO is an ENSO-like pattern of SST and atmospheric variability occurring over multiple decades. In contrast to ENSO, the PDO is more strongly expressed in the North Pacific than in the tropics. The positive or warm phase of the PDO is associated with unusually warm surface water throughout the eastern North Pacific (along the western US coast), while the negative or cool phase PDO is associated with colder than normal waters. As with the ENSO effects, the warm phase PDO has tended to cause elevated sea levels in the eastern Pacific and along the California coast, while the cool phase of the PDO tends to lower sea level in this region.

The PDO has basin-wide influence. Elevated water levels in one part of the Pacific are often accompanied by lowered water levels elsewhere. The cool phase PDO can result in a drop of water level along the eastern Pacific (western US Coast) and a rise in water level along the western Pacific. Recently, sea level along the western Pacific has been rising about three times faster than the global mean sea level rise rate, due in part to the PDO (Bromirski *et al.* 2011; Merrifield 2011). This does not mean the eastern Pacific will experience sea level rise that is three times faster than the global mean sea level rise when there is the next shift in the PDO, but does show that the PDO can have a major influence on basin-wide and regional sea level.

The above discussion of El Niño and the PDO may suggest that they are well-understood phenomena, with easily anticipated changes in sea level. However, it is important to note that El Niños have varying strengths and intensities, resulting in different sea changes from one event to the next. Also, changes in regional mean sea level along the eastern Pacific have not always shown a strong connection to the PDO cycles. An apparent jump in regional mean sea level occurred after the mid-1970s shift to the warm phase of the PDO, yet the expected continued rise in sea level along the West Coast seems to have been suppressed by other forces. Tide gauge records for the Washington, Oregon, and California coasts have shown no significant interannual rise in sea level from 1983 to 2011 (Cayan *et al.* 2008; Bromirski *et al.* 2011; NOAA 2013). Bromirski *et al.* (2011, 2012) postulate that persistent alongshore winds have caused an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. Both of these factors could have caused a drop in sea level, canceling out the sea rise that would otherwise be expected from a warm phase PDO signal.

Water level changes from surge, atmospheric forcing, El Niño events and the PDO can occur in combination. The water elevation changes from each factor may each be only about 1 ft (0.3 m) or less, but each can cause changes in the water level over a time period of days, months, or a few years – far more rapidly than sea level rise. In combination, they can potentially cause a significant localized increase in water level.

When high water conditions occur in combination with high tides, and with coastal storms, the threat of coastal flooding, wave impacts and erosion also increases. These conditions can be additive, as shown in Figure B-4. Also, these changes in water level will continue to be important to the overall water level conditions along the California coast and they need to be examined in conjunction with possible changes due to regional sea level rise.

As stated earlier, estimates of surge, El Niño and PDO water elevation changes are developed primarily from historical records. There are no state-wide resources for this information, although it may be included in one of the Regional Sediment Management Plans, available for many coastal areas (see http://www.dbw.ca.gov/csmw/). General guidance on water level changes, surge, and El Niño events is provided in Table B-4.

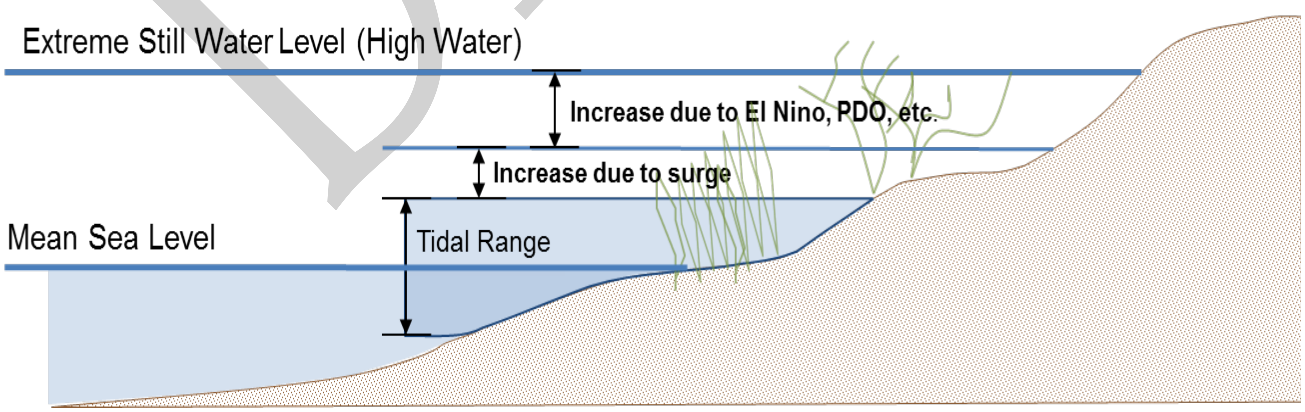

Figure B-4. Changes to extreme still water level due to surge, El Niño events, and PDOs. (*Source: L. Ewing, 2013*).

Table B-4. General Resources for Determining Still Water Elevation, Surge, El Niño events, and PDOs

Resource	Description	Link
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels within wetland areas, and provided visualizations for various amounts of sea level rise. For bays and estuaries, it also provides information on inland areas with the potential to flood if existing barriers to water connectivity are removed or overtopped. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	NOAA Digital Coast, http://coast.noaa.gov/digitalcoast/tools/slr/
Pacific Institute Sea Level Rise Maps	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise and population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report "The Impacts of Sea Level Rise on the California Coast" visit: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/
Cal-Adapt – Exploring California's Climate	Shows coastal areas that may be threatened by flooding from a 4.6 ft (1.4 m) rise in sea level and a 100-year flood event. Maps were developed using the Pacific Institute SLR Maps (see above) and do not now include any influence of beach or dune erosion or existing protective structures.	http://cal-adapt.org/sealevel/
Regional Sediment Management Plans	Plans for regions of the state to identify how governance, outreach and technical approaches can support beneficial reuse of sediment resources within that region without causing environmental degradation or public nuisance.	http://www.dbw.ca.gov/csmw/

***Outcome from Step 3**: Provide estimates of water elevations that can result from surge, El Niño events, and PDOs. When combined with the sea level changes to the tidal range, developed in Step 4, these can provide information on the extreme still water level. For most open coast situations, this information will be used to inform further project analysis and planning that examines erosion, surge and storm conditions.*

Step 4 – Estimate beach, bluff, and dune change from erosion

Predictions of future beach, bluff, and dune erosion are complicated by the uncertainty associated with future waves, storms and sediment supply. As a result, there is no single specific accepted method for predicting future beach erosion. At a minimum, projects should assume that there will be inundation of dry beach and that the beach will continue to experience seasonal and inter-annual changes comparable to historical amounts. When there is a range of erosion rates from historical trends, the high rate should be used to project future erosion with rising sea level conditions (unless future erosion will encounter more resistant materials, in which case lower erosion rates may be used). For beaches that have had a relatively stable long-term width, it would be prudent to also consider the potential for greater variability or even erosion as a future condition. For recent studies that provide some general guidance for including sea level rise in an evaluation of bluff and dune erosion, see, for example, Heberger *et al.* (2009) or Revell (2011). Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion can also be used. Table B-5, at the end of this section, provides some resources that can be used for projecting future erosion.

The following sections discuss specific concerns associated with beach, bluff and dune erosion and are provided to acquaint readers to the main issues associated with each system. Readers with a strong background in coastal systems may want to skim or skip the rest of this section.

Beach Erosion

Beach erosion and accretion occur on an on-going basis due to regular variability in waves, currents and sand supply. The movement of sand on and off of beaches is an ongoing process. Along the California coast, periods of gradual, on-going beach change will be punctuated by rapid and dramatic changes, often during times of large waves or high streamflow events.

The overall dynamics of beach change have been described many times.[97] Sand moves on and off shore as well as along the shore. Normal sources of sand to a beach are from rivers and streams, bluff erosion or gullies, and offshore sand sources. Sand leaves a beach by being carried downcoast by waves and currents, either into submarine canyons or to locations too far offshore for waves to move it back onto shore. Beaches are part of the larger-scale sediment dynamics of the littoral cell, and in very simple terms, beaches accrete if more sand comes onto the beach than leaves and beaches erode if more sand leaves than is added. Changes in sand supply are a major aspect of beach change.

Beach changes are often classified as being either seasonal or long-term/inter-annual changes. Seasonal changes are the shifts in beach width that tend to occur throughout the year and are usually reversible. During late fall and winter, beaches tend to become narrower as more high energy waves carry sand away from the beach and deposit it in offshore bars. This is later followed by beach widening as gentler waves again bring sand landward, building up a wider

[97] See for example, Bascom 1980, Komar 1998, and Griggs *et al.* 2005.

dry-sand summer beach. These changes are considered seasonal changes, and if the beach widths return to the same seasonal width each year, then the beach experiences seasonal changes but no long-term or inter-annual changes. If the seasonal beach widths become progressively wider or narrower, these changes become long-term or inter-annual change, and suggest a long-term beach change trend – accretion if the beach is widening and erosion if the beach is narrowing.

If development is at or near beach level, erosion of the beach can expose the development to damage from waves, flooding, and foundation scour. Additionally, waves that hit the coast bring with them vegetation, floating debris, sand, cobbles, and other material which can act like projectiles, adding to the wave forces and flood damage.

At present, approximately 66% of the California beaches have experienced erosion over the last few decades, with the main concentration of eroding beaches occurring in southern California (Hapke *et al.* 2006). This erosion has been due to a combination of diminished sand supplies and increased removal of sand by waves and currents. With rising sea level, beach erosion is likely to increase due to both increased wave energy[98] that can carry sand offshore or away from the beach, and to decreased supply of new sediments to the coast.[99]

There are several factors that will contribute to the effects of sea level rise on seasonal and inter-annual beach change. There will be the changes to the beach due to inundation by rising water levels, as shown in Figure B-5 (see the discussion on inundation earlier in this Appendix for more information on how to determine this change). If the beach cannot migrate inland to accommodate these changes, then the inundation will result in a direct loss or erosion of beach width. This will result in a narrower seasonal beach as well as inter-annual loss of beach.

Seasonal and inter-annual beach conditions will also be affected by changes to waves and sediment supply. Since waves are sensitive to bottom bathymetry, changes in sea level may change the diffraction and refraction of waves as they approach the coast, thereby changing the resulting mixture of beach-accreting and beach-eroding waves. However, the influence of climate change (not just rising sea level) on wave conditions, through changes in wave height, wave direction, storm frequency, and storm intensity, will likely be far more significant than the slight changes from bathymetric changes. In addition, changing precipitation patterns will modify the amount and timing of sediment delivery to the beach.

[98] In shallow water, wave energy is proportional to the square of the water depth. As water depths increase with sea level rise, wave energy at the same location will likewise increase.

[99] Many parts of the developed coast are already experiencing drops in sand supplies due to upstream impoundments of water and sediment, more impervious surfaces, and sand mining.

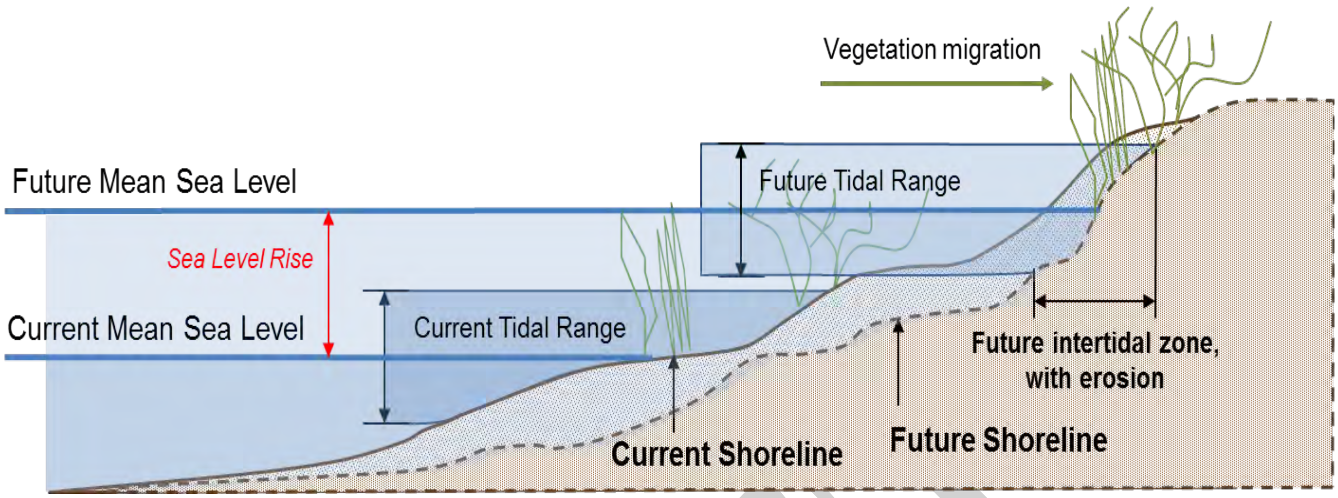

Figure B-5. Changes to the intertidal zone with sea level rise and erosion, without wave impacts. (*Source: L. Ewing, 2013*).

Bluff Erosion

A second type of erosion occurs on coastal bluffs.[100] There is no fully-accepted methodology for estimating future bluff erosion with sea level rise. Guidance for coastal analysts in Hawaii is to assume erosion will increase as a proportion of historical erosion (Hwang 2005). One approach used in the past by the Commission has been to apply one of the higher rates of historical erosion to represent average future trends. A more process-based methodology, used in the Pacific Institute study of erosion due to rising sea level, is to correlate future erosion rates of bluffs with a higher still water level that will allow waves to attack the bluff more frequently (Heberger *et al.* 2009; Revell 2011). This approach assumes that all bluff erosion is due to wave impacts and that erosion rates will change over time as the beach or bluff experiences more frequent or more intense wave attack. Such an approach should be considered for examining bluff erosion with rising sea level. Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion can also be used.

Bluff retreat occurs via many different mechanisms. Landslides, slumps, block failures, gullies, and rilling are examples of bluff retreat. At the most basic level, bluff retreat or collapse occurs when the forces leading to collapse of the bluff face are stronger than the forces holding the bluff in place. Forces causing bluff retreat can include earthquakes, wind, burrowing animals, gravity, rain, surface runoff, groundwater, and sheet flow. Coastal bluffs have the added factor of wave attack. Resistance to collapse is mainly a characteristic of the bluff material. For example, granitic bluffs like those along the Big Sur coast retreat at a much slower rate than the soft sandstone and marine terrace bluffs of Pacifica.

[100] Bluffs can be built or expanded during interglacial cycles or following seismic uplift. Many of the marine terraces that are visible along the California coast are remnants of past beach areas that have been uplifted to become bluffs and cliffs. However, natural bluff rebuilding is a millennial or multi-millennial process, and it will not occur during the time periods over which most development projects are evaluated.

Coastal bluff erosion can occur throughout the year, but it often occurs during or after storm periods, when the dry beach will be narrow or non-existent. When coastal bluffs are fronted by wide sand beaches, most waves break on the beach face and the beaches protect the bluffs from direct wave attack. When the beach is narrow, there is less buffering of the wave energy and waves can break directly against the bluffs. A general depiction of bluff retreat with rising sea level is provided in Figure B-6.

Bluff retreat is often episodic – the bluff may be stable for a number of years and then retreat by tens of feet in a few hours or a few days. If the changes to a bluff are examined through endpoint analysis (*i.e.*, looking first at the initial position of the bluff and then at the position of the bluff sometime in the future), researchers can determine the amount of retreat that has occurred during the time from the initial to final positions. This gives information on an average retreat rate that has occurred, but provides no insight about the conditions leading to the retreat, the size of retreat, frequency of retreat events, or the progression of retreat and no retreat. The average retreat rates can give some indication of likely future changes, but they provide little information about when the next retreat episode might occur or how large it might be.

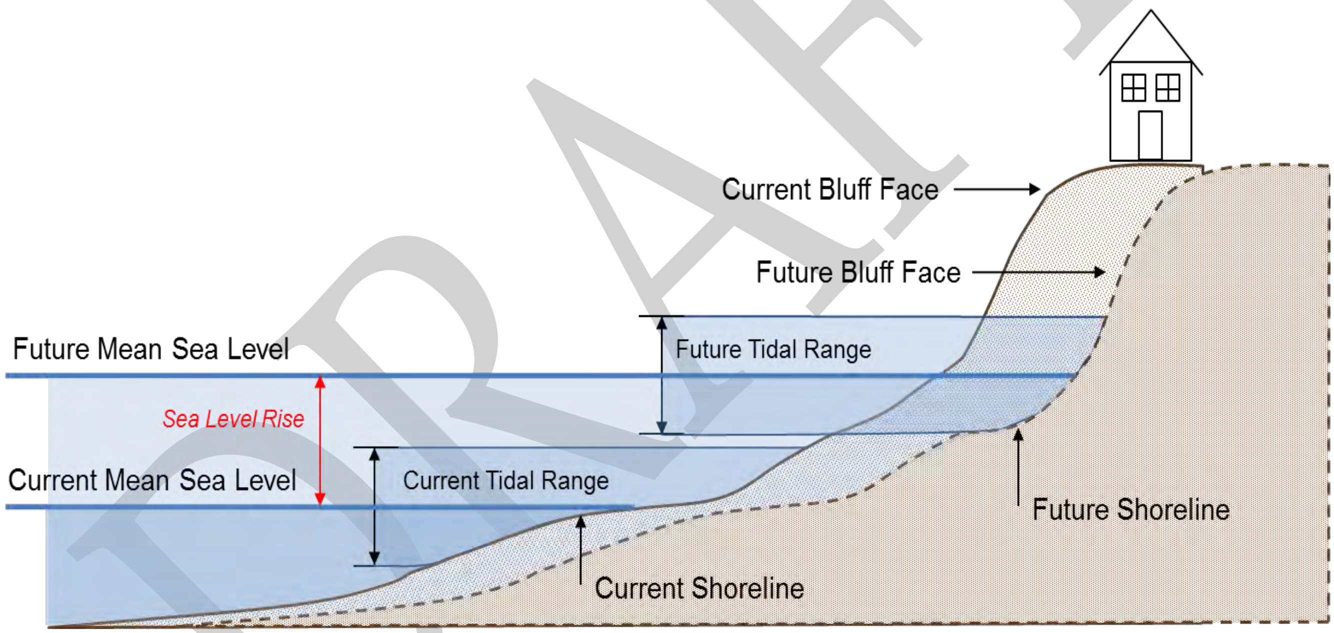

Figure B-6. Bluff erosion with changes in sea level. (*Source: L. Ewing, 2013*).

Dune Erosion

Just as there is no fully-accepted methodology for estimating changes to beach or bluff erosion with sea level rise, there is no fully-accepted methodology for dune erosion. A methodology somewhat similar to that for bluff erosion has been developed for dunes (Heberger *et al.* 2009; Revell 2011), and such an approach should be considered for examining dune erosion with rising sea level. Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion may also be used.

Dune erosion occurs when the waves break at or near the dunes, pulling sediment out of the dune. This process deposits sand onto the beach or in the nearshore area, but can result in short-term dune retreat. If sand is not returned to the dunes following these periods of short-term retreat, the sand losses will contribute to long-term dune erosion. Damage will occur to development located on dunes when the dune retreats back to the location of development, either through reversible, short-term retreat or long-term erosion.

For individual cases, determinations of future retreat risk are based on the site-specific conditions and professional analysis and judgment. However, the lack of information about the contributions of all the erosive forces to dunes and the beach-dune interactions makes it challenging to anticipate future changes to coastal dune retreat due to rising sea level and increased wave forces. As with beaches and bluffs for most situations, historical conditions provide a lower limit for future dune *retreat*, or the upper limit of dune *advance* for those sites that are now experiencing accretion or quasi-stability. Projections of future erosion should either: 1) use the high range of historical erosion; 2) develop a sea level rise influenced erosion rate, as done by Heberger *et al.* (2009) or Revell (2011); or, 3) develop another approach that considers shoreline changes that are likely to occur under rising sea level conditions.

Table B-5. General Resources for Information on Beach, Bluff and Dune Erosion

Resource	Description	Link
Aerial Photographs	Useful for general information on shoreline trends; ortho-rectified photos can help quantify trends	California Coastal Records Project, www.californiacoastline.org; Huntington Library; Local Libraries
LIDAR	Fairly detailed topography that an provide GIS layers for current conditions and is comparable with LIDAR data sets for temporal changes	NOAA's Digital Coast, http://coast.noaa.gov/digitalcoast/data/coastallidar
USGS National Assessment of Shoreline Change with GIS Compilation of Vector Shorelines	Statewide inter-annual beach and bluff erosion; GIS shorelines available for sandy shorelines & cliff edge, showing historical changes for long-term (70 to 100 years) and short-term (25 to 50 years). No projections of future erosion rates available.	Sandy Shorelines – Open File Report 2006-1219, http://pubs.usgs.gov/of/2006/1219, and GIS Data in Open File 2006-1251, http://pubs.usgs.gov/of/2006/1251; Bluff Shorelines – Open File Report 2007-1133, http://pubs.usgs.gov/of/2007/1133, and GIS Data in Open File 2007-1251, http://pubs.usgs.gov/of/2007/1112

Regional Sediment Management Studies	Summaries of seasonal and long-term erosion studies	CSMW Website, http://dbw.ca.gov/csmw/default.aspx; California Beach Erosion Assessment Survey, http://dbw.ca.gov/csmw/library.aspx
US Army Corps of Engineers, Coast of California Studies	Summaries of seasonal and long-term erosion studies	Studies for many regions are available through an internet search (addresses are too numerous to list here)
Beach Profiles and Surveys	Detailed beach or bluff changes with time	NOAA's Digital Coast, http://coast.noaa.gov/digitalcoast/tools/list; US Army Corps of Engineers; Regional Beach Studies; University Studies
The Impacts of Sea Level Rise on the California Coast (Pacific Institute Report)	Expected changes to bluff position over time for sea level rise of 4.6 ft (1.4 m) from 2000 to 2100 for California coast from Oregon border through Santa Barbara County.	Pacific Institute Website, http://www.pacinst.org/reports/sea_level_rise/maps/
CoSMoS	Tool for predicting climate change impacts from storms. The *Our Coast, Our Future* effort, from Half Moon Bay to Bodega Bay, does not predict long-term erosion, but can provide general information for short-term, storm-driven beach changes. The Southern California version (from Point Conception to the US-Mexico border, including the Channel Islands and coastal embayments) does account for shoreline change and fluvial inputs.	http://walrus.wr.usgs.gov/coastal_processes/cosmos/
Coastal Resilience Ventura	A partnership to provide science and decision-support tools to aid conservation and planning projects and policymaking to address conditions brought about by climate change. The primary goals of Coastal Resilience Ventura are assessing the vulnerabilities of human and natural resources, and identifying solutions that help nature help people. The mapping tool includes flooding and inundation risk, wave impacts, and erosion risk.	http://coastalresilience.org/geographies/ventura-county

Outcome from Step 4: *Provide projections of future long-term beach, bluff or dune erosion that takes into account sea level rise. For locations without any influence from storm surge, or wave energy, the identification of the extent of beach, bluff or dune erosion may be sufficient for project analysis and planning efforts. This projected new erosion area may also be useful for anticipating the appropriate setback distance for otherwise stable land forms (If slope stability if a concern, refer to Commission guidance on setbacks (*http://www.coastal.ca.gov/W-11.5-2mm3.pdf*)). For most open coast situations, this information will be used to inform further project analysis and planning that examines erosion, surge and storm conditions.*

Step 5 – Determine wave, storm wave, wave runup, and flooding conditions

The main concerns with waves, storm waves, and runup are flooding and damage from wave impacts. Flooding is the temporary wetting of an area by waves, wave runup, surge, atmospheric forcing (such as water elevation during El Niño events) and, at river mouths, the combination of waves and river flows. Wave impacts occur when high-energy waves, often associated with storms, reach backshore areas or development. Coastal flooding and wave impacts are worst when they coincide with high water level events (high tide plus high inundation). As sea level rises, inundation will move inland, and so will flooding and wave impacts. Beach erosion will aggravate these conditions and add to the inland extent of impacts.

Flooding

In most situations, factors that result in high water conditions, such as tides, surge, El Niño events, and PDOs, should be used to determine flood levels and flood areas, as shown below. If the area is exposed to storm waves, these forces should be examined as well.

Future Flooding Level = Higher High Tide + Sea Level Rise + Surge + Forcing + Wave Runup

Flooding Areas = Flooding + Seasonal Eroded Beach + Long-Term Beach Erosion

Waves

Waves, like tides, cause constant changes to the water levels that are observed at the coast. The rhythmic lapping of waves on the beach during summer can be one of the joys of a beach visit. At other times of the year, waves can increase in size and energy and damage or destroy buildings, and cause erosion of bluffs and cliffs. Routine ocean waves are generated by wind blowing across the surface of the water and can travel far from their source, combining with waves generated from other locations to produce the rather erratic and choppy water levels that are seen in most of the ocean. As waves move into shallow water and approach land, they are strongly modified by the offshore bathymetry. They take on a more uniform appearance, aligning somewhat parallel to the shoreline through processes of refraction and diffraction. During most of the year, moderate short-period waves break once they are in water depths of approximately 1.3 times the wave height.

Wave impacts depend greatly upon storm activity – both the intensity and the duration of the storm. Normally projects have used design wave conditions comparable to the 100-year event. For critical infrastructure or development with a long life expectancy, it may be advisable to use a greater design standard, such as a 200-year or 500-year event. It may be suitable for some proposed projects to adjust design waves or the frequency of high energy waves to analyze the consequences of worsening wave impacts.

Waves also vary greatly with bathymetry; offshore reefs and sand bars can cause waves to break far from the coast and greatly reduce the energy of the waves that come onshore. Therefore, changes in offshore water depths can alter the nature of nearshore wave propagation and resultant onshore waves. For areas with complex offshore bathymetry, wave impact changes due to rising sea level may need to be examined in the context of both offshore and nearshore conditions.

Wave impacts to the coast, to coastal bluff erosion and inland development, should be analyzed under the conditions most likely to cause harm. Those conditions normally occur in winter when most of the sand has moved offshore leaving only a reduced dry sand beach to dissipate wave energy (this seasonal change in beach width is often referred to as short-term or seasonal erosion). On beaches that will experience long-term erosion, trends expected to occur over the entire expected life of the development should also be considered. Just as the beach conditions to analyze should be those least likely to protect from damage over the life of the development, the water level conditions considered should also be those most likely to contribute to damage over the life of the development. Waves that cause significant damage during high tide will be less damaging during low tide; all other things being equal, waves will cause more inland flooding and impact damage when water levels are higher. Since water levels will increase over the life of the development due to rising sea level, the development should be examined for the amount of sea level rise (or a scenario of sea level rise conditions) that is likely to occur throughout the expected life of the development. Then, the wave impact analysis should examine the consequences of a 100-year design storm event using the combined water levels that are likely to occur with high water conditions and sea level rise, as well as a long-term and seasonally eroded beach.

Eroded Beach Conditions = Seasonal Erosion + Long-Term Erosion*

High Water Conditions = High Tide + Relative Sea Level Rise* + Atmospheric Forcing

Wave Conditions = 100-year Design Storm + High Water + Eroded Beach

* The time period for both long-term erosion and relative sea level rise will be at least as long as the expected life of the development.

The remaining discussion provides general information about waves, the California wave climate, and coastal flooding. It is provided to acquaint readers to the main issues associated with waves and coastal flooding. Readers with a strong background in waves or coastal processes may want to skim or skip the rest of this section.

Storm Waves

During storm conditions, winds can transfer large amounts of energy into waves, increasing wave height, length, and period. Energy transfer to waves depends upon three conditions: the wind energy that is available to be transferred to the water (intensity); the length of time over which the wind blows (duration); and the area over which the wind blows (the fetch). As any of these conditions increases, the energy in the waves will increase, as will the energy that these waves bring to the coastline. Coastal scientists separate waves that are generated far from the coast (swell) from waves that are locally generated (seas). Storms in the mid-Pacific can cause storm-like wave conditions along the coast, even when there are no storms in the area. Likewise, a local storm can cause storm waves along one part of the coast while waves in other sections of the coast may be fairly mild.

Some of the worst storm wave conditions occur when there are intense storms along a large portion of the coast and when this large, distantly generated swell combines with local seas. The 1982/83 El Niño has been cited often as one of the more damaging storm seasons in recent times. In late January 1983 waves from a distant storm combined with locally generated waves and the highest tides of the year. This one storm caused substantial damage along much of the California Coast. The coast was not able to recover before a series of storms in February and March caused additional damage. The full 1982/83 El Niño storm season resulted in damage to, approximately 3,000 homes and 900 businesses and destruction of 33 buildings. Damages exceeded $100 million to structures and $35 million to public recreational infrastructure (in 1982 dollars; Flick 1998).

Wave Runup

Wave runup, as depicted in Figure B-7, is the distance or extent to which water from a breaking wave will spread up the shoreline. Much of the wave energy will dissipate during breaking, but wave runup can also be damaging. The runup water moves quickly and can scour or erode the shoreline areas including the beach, damage structures, and flood inland areas.

Damage from waves and wave runup may increase in the future, due both to rising sea level and to changes in storm intensity and frequency. Waves will break farther landward when water levels are higher. Therefore, increased water levels due to tides, surge, ENSO or PDO variability, or sea level rise will enable more wave energy to reach the beach, back shore, or inland development. The higher water levels do not change the waves. Rather, higher water levels change the point of impact, the extent of runup, and the frequency of wave impact. In locations where high waves now hit the coast, that frequency will increase; in locations where high waves rarely hit the coast, exposure to wave impacts will increase. Increased exposure to wave impacts or wave runup can cause a greater risk of flooding, erosion, bluff failure, and/or damage to development. But, since the focusing of wave energy is strongly influenced by offshore bathymetry, locations of wave exposure may also change with rising sea level and modifications in wave propagation might result from future differences in water depths.

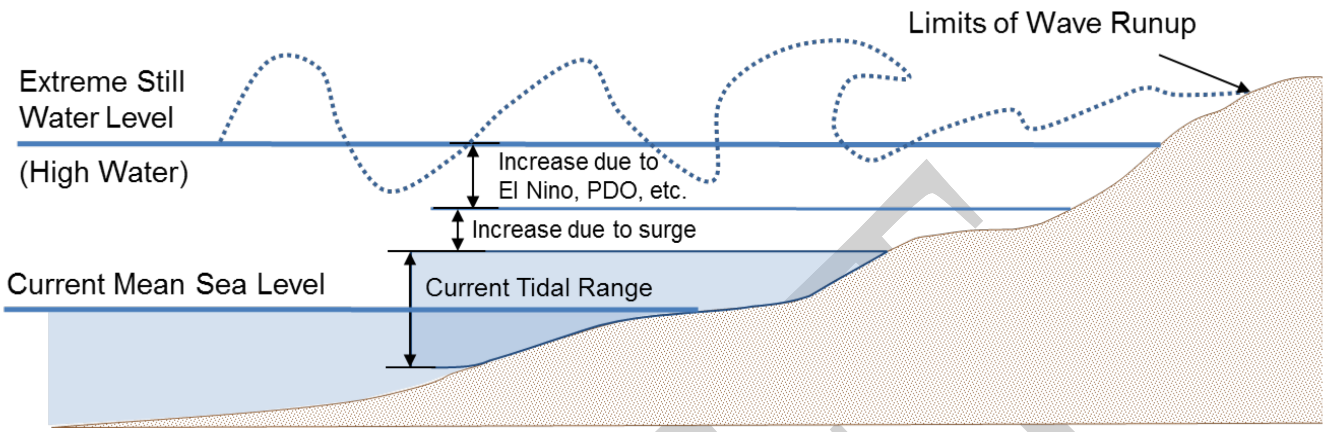

Figure B-7. Wave runup combined with extreme still water (High Water). (*Source: L. Ewing, 2013*).

Summary

Coastal flooding is a significant problem now and it will increase with rising sea level. At present, about 210,000 people in California are living in areas at risk from a 100-year flood event (Heberger *et al.* 2009). A rise in sea level of 55 in (1.4 m) with no change in development patterns or growth along the coast could put 418,000 to 480,000 people at risk from a 100-year flood (Cooley *et al.* 2012). Increases in storm intensity or in the density of development in flood-prone areas will increase the number of people at risk from flooding.

The frequency and intensity of high wave events depends upon the storm conditions that generate the waves. There is less consistency in the output of climate models related to projections of future storm conditions than there has been for temperature projections. A recent report on coastal flooding from years 2000 to 2100 for the California coast has found that "storm activity is not projected to intensify or appreciably change the characteristics of winter nearshore wave activity of the twenty-first century" (Bromirski *et al.* 2012, p. 33). This continuation of current storm conditions is not, however, an indication that storms will not be a problem in the future. Storm damage is expected to continue, and, if sea level rise by the end of the twenty-first century reaches the high projections of about 55 in (1.4 m), "coastal managers can anticipate that coastal flooding events of much greater magnitude than those during the 1982-83 El Niño will occur annually." (Bromirski *et al.* 2012, p. 36)

For most situations, the 100-year storm event should be used as the design storm. This is equivalent to a storm with a 1% annual probability of occurrence. However, most development does outlast one year and this probability of occurrence grows over time such that there is a 22% probability of occurrence during a 25-year period and over 53% probability that this storm will occur at least once during a 75-year period. Even so, the 100-year storm event, like the 100-year flood event, is often used as a design standard for development. However, for structures with a very long projected life or for which storm protection is very critical, a larger, 200-year or 500-year event might be appropriate.

Table B-6 lists many of the resources that are available for finding regional or state-wide information on waves and flooding. Local communities may have records of major erosion episodes or flood events as well.

Table B-6. General Resources for Flooding and Wave Impacts

Resource	Description	Link
CDIP (Coastal Data Information Program)	Current and historical information on wind, waves, and water temperature, wave and swell models and forecasting. As of 2013, there are 19 active stations along the California coast.	http://cdip.ucsd.edu/
Flood Insurance Rate Maps (FIRMs)	FEMA is updating coastal flood maps. Existing FIRMs are based on 1980s topography; flooding includes seasonal beach change but not long-term erosion. Maps do not include sea level rise. Inclusion of a site shows a flood hazard; but exclusion does not necessarily indicate a lack of flood hazard.	FEMA Flood Map Service Center, https://msc.fema.gov/portal
FEMA Flood Hazard Mapping Guidance	*Subsection D.2.8* provides guidance for calculating wave runup and overtopping on barriers. There are special cases for steep slopes and where runup exceeds the barrier or bluff crest.	https://www.fema.gov/media-library/assets/documents/13948
Regional Sediment Management Studies	Some studies show elements of beach flooding and wave impacts	http://dbw.ca.gov/csmw/default.aspx
Cal-Adapt – Exploring California's Climate	Shows coastal areas that may be threatened by flooding from a 4.6 ft (1.4 m) rise in sea level and a 100-year flood event. Maps were developed using the Pacific Institute SLR Maps and do not now include any influence of beach or dune erosion, or existing protective structures.	http://cal-adapt.org/sealevel/
US Army Corps of Engineers, Coastal Engineering Manual	Detailed information on all aspects of deep-water wave transformation, shoaling, runup, and overtopping.	http://chl.erdc.usace.army.mil/cem
European Overtopping Manual	Descriptions of available methods for assessing overtopping and its consequences. Provides techniques to predict wave overtopping at seawalls, flood embankments, breakwaters and other shoreline structures facing waves. Supported by web-based programs for the calculation of overtopping discharge and design details.	http://www.overtopping-manual.com/

CoSMoS	A tool to help understand, visualize, and anticipate vulnerabilities from sea level rise and storms. It does not predict long-term erosion, but can provide general information for short-term, storm-drive beach changes. Currently available for the central coast, but expanding to Southern California in 2015/2016.	http://walrus.wr.usgs.gov/coastal_processes/cosmos/
Coastal Resilience Ventura	A partnership to provide science and decision-support tools to aid conservation and planning projects and policymaking to address conditions brought about by climate change. The primary goals of Coastal Resilience Ventura are assessing the vulnerabilities of human and natural resources, and identifying solutions that help nature help people. The mapping tool includes flooding and inundation risk, wave impacts, and erosion risk.	http://coastalresilience.org/geographies/ventura-county

Outcome from Step 5: *Provide projections of future flooding and wave impacts resulting from waves, storm waves and runup, taking into account sea level rise.*

Step 6 – Examine potential flooding from extreme events

Extreme events[101], by their very nature, are those beyond the normal events that are considered in most shoreline studies. Examples of extreme events that might occur along the California coast include:

- An individual storm with an intensity at or above the 100-year event
- A series of large, long-duration storms during high tides
- A local storm that coincides with the arrival of distant swell and high tides
- Rapid subsidence, as might happen along the Northern California coast during a Cascadia Subduction Zone earthquake
- Global sea level rise greater than that projected to occur by 2100, when combined with a large storm during normal tides

Planning and project analysis need to consider and anticipate the consequences of these outlier events. In many situations, this assessment might be a qualitative consideration of consequences that could happen if an extreme event does occur. Analysis of the consequences of extreme events presents opportunities to address some of those potential impacts through design and adaptation.

[101] In its report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, the IPCC defines extreme events as "a facet of climate variability under stable or changing climate conditions. They are defined as the occurrence of a value or weather or climate variable above (or below) a threshold value near the upper (or lower) ends ("tails") of the range of observed values of the variable" (IPCC 2012).

In California, there may be some worsening of extreme precipitation and inland flooding from projected changes to atmospheric rivers, narrow bands of concentrated moisture in the atmosphere. In general, however, future extremes are likely to be comparable to the extremes of today, but with the added influence of sea level rise. Extreme storm waves or floods can be addressed with the guidance provided earlier, except that the extreme storm conditions would be used. For tsunamis it is recommended that, for most situations, the appropriate projection of sea level rise be added to the currently projected inundation level from tsunamis. This will provide a close approximation for future inundation from extreme tsunamis. If a detailed analysis of future tsunami impacts is needed, the analysis should be conducted by someone experienced in modeling tsunami waves.

Tsunamis

Tsunamis are large, long-period waves that can be generated by submarine landslides, subaerial landslides (slope failures from land into a water body), large submarine earthquakes, meteors, or volcanic eruptions. They are rare events, but can be extremely destructive when they occur. The extent of tsunami damage will increase as rising water levels allow tsunami waves to extend farther inland. Thus the tsunami inundation zone will expand inland with rising sea level. There has been no research that suggests that climate change will increase the intensity or frequency of seismically-generated tsunamis. However, the number and size of coastal subaerial landslides may increase because of increased coastal erosion due to sea level rise, which in turn may increase the potential for tsunamigenic landslides along the California coast (Highland 2004; Walder *et al.* 2003).

The detailed changes to the inundation zone with rising sea level need to be determined by modeling; however, modeling of long-waves, such as tsunamis, is a specialized area of coastal engineering, and will not be covered in this general Guidance. For most situations, it will be sufficient to get information on possible inundation from the most recent tsunami inundation maps (currently on the Department of Conservation website, http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/Statewide_Maps.aspx). The California Geological Survey and California Governor's Office of Emergency Services are creating new tsunami inundation maps based on probabilistic tsunami hazard analysis (CPTHAWG 2015). As a rough approximation, the change to the tsunami inundation level can be estimated as equal to the change in water elevation due to sea level; a 1-ft rise in sea level could be assumed to result in a 1-ft rise in the inundation elevation. However, in many places, particularly shallow bays, harbors, and estuaries, the change in tsunami inundation zone is likely to scale non-linearly with sea level rise and require careful modeling. California Geological Survey is also working to evaluate the impact of sea level rise with numerical tsunami modeling to verify that an additive approach (tsunami height + SLR) is the appropriate method for integrating SLR and tsunamis inundation together. In areas with high tsunami hazards, or where critical resources are at risk, a site-specific analysis of sea level rise impacts on tsunami hazards is crucial, and someone experienced in modeling tsunami waves should be consulted.

Summary

Many different factors affect the actual water levels that occur along the coast and resulting hazards. In California, waves and tides have the largest routine effect on water levels. Tsunamis may have a very large, but infrequent effect on water levels. Sea level rise will affect water levels all along the coast. Until the mid-century, tides and storms are expected to have the biggest effects on local water levels, with sea level rise being a growing concern. After Year 2050, sea level rise is expected to become increasingly influential on water levels and in contributing to damages to inland areas from flooding, erosion and wave impacts. Table B-7 provides a general characterization of all the factors that can affect local water levels, with general estimates of their range and frequency of occurrence.

Outcome from Step 6: *Projections of potential flooding from extreme events including rapid subsidence, extreme precipitation, and tsunamis.*

Table B-7. Factors that Influence Local Water Level Conditions

Factors Affecting Water Level	Typical Range for CA Coast (ft)	Typical Range for CA Coast (m)	Period of Influence	Frequency
Tides	3 – 10	1 – 3	Hours	Twice daily
Low pressure	1.5	0.5	Days	Many times a year
Storm Surge	2 – 3	0.6 – 1.0	Days	Several times a year
Storm Waves	3 – 15	1 – 5	Hours	Several times a year
El Niño events (within the ENSO cycle)	<1.5	< 0.5	Months - Years	2 – 7 years
Tsunami waves	20 – 50 (max) 3 – 10 (typical)	6 – 15 (max) 1 – 3 (typical)	Minutes, Hours, Days	Infrequent but unpredictable
Historical Sea Level, over 100 years	0.7	0.2	On-going	Persistent
NRC State-wide Sea Level Projections 2000 – 2050	0.7 – 1.4	0.2 – 0.4	Ongoing	Persistent
NRC State-wide Sea Level Projections 2000 – 2100	0.3 – 4.69 ft (North of Cape Mendocino) 1.38 – 5.48 ft (South of Cape Mendocino)	0.1 – 1.43 m (North of Cape Mendocino) 0.42 – 1.67 m (South of Cape Mendocino	Ongoing	Persistent

Note that all values are approximations. The conversions between feet and meters have been rounded to maintain the general ranges and they are not exact conversions. *Sources*: Flick 1998; NRC 2012; Personal communications from Dr. Robert Guza (Scripps Institution of Oceanography), Dr. William O'Reilly (Scripps Institution of Oceanography and University of California, Berkeley), and Rick Wilson, California Geological Survey; and professional judgment of staff.

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Appendix C

Resources for Addressing Sea Level Rise

This section contains lists of sea level rise viewers, guidebooks, guidance documents, and state agency-produced resources, and data clearing houses related to sea level rise. These resources will be particularly relevant for informing Steps 1-6 of the LCP planning process (Chapter 5). Tables include:

- Table C-1 – Sea Level Rise Mapping Tools.
  This may be particularly relevant for Steps 1-3.

- Table C-2 – Sea Level Rise Data and Resource Clearinghouses.
  This may be particularly relevant for Steps 1-4.

- Table C-3 – Adaptation Planning Guidebooks.
  This may be particularly relevant for Steps 1-3.

- Table C-4 – Resources for Assessing Adaptation Measures.
  This may be particularly relevant for Step 4.

- Table C-5 – Examples of Sea Level Rise Vulnerability Assessments in California.
  This may be particularly relevant for Steps 1-3.

- Table C-6 – California Climate Adaptation Plans that Address Sea Level Rise.
  This may be particularly relevant for Steps 1-4.

- Table C-7 – California State Agency Resources

Table C-1. Sea Level Rise Mapping Tools

Tool	Description	Link
Statewide		
NOAA Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels with a slider bar. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	http://coast.noaa.gov/digitalcoast/tools/slr/
Cal-Adapt – Exploring California's Climate	Shows coastal areas that may be threatened by flooding from a 4.6 ft (1.4 m) rise in sea level and a 100-year flood event. Maps were developed using the Pacific Institute SLR Maps (see below) and do not now include any influence of beach or dune erosion or existing protective structures.	http://cal-adapt.org/sealevel/
Climate Central Surging Seas	Overlays sea level rise data with socio-economic information and ability to analyze property values, population, socio-economic status, ethnicity, and income or areas at risk. Can compare exposure across the whole state or selected county.	http://sealevel.climatecentral.org/ssrf/california
Pacific Institute Sea Level Rise Maps (Heberger *et al.* 2009)	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise and population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report *The Impacts of Sea-Level Rise on the California Coast*, see: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

Sea Level Affecting Marshes Model (SLAMM)	Simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. Map distributions of wetlands are predicted under conditions of accelerated sea level rise, and results are summarized in tabular and graphical form.	http://www.warrenpinnacle.com/prof/SLAMM
Coastal Storm Modeling System (CoSMoS)	A numerical modeling system to predict coastal flooding due to both sea level rise and storms driven by climate change. Used in the *Our Coast Our Future* project (along the Central Coast) and for the entire Southern California Bight (expected to be available in 2015).	*OCOF*: http://data.prbo.org/apps/ocof/ Southern CA: http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal2.0/index.html
	North Coast	
Humboldt Bay Sea Level Rise Adaptation Project	This project is a multi-phased, regional collaboration. Phase I produced the *Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment* which describes current shoreline conditions and vulnerabilities under the current tidal regime. Phase II included hydrodynamic modeling to develop vulnerability maps of areas surrounding Humboldt Bay vulnerable to inundation from existing and future sea levels. Phase II produced the *Humboldt Bay Sea Level Rise Modeling Inundation Mapping Report* and the *Humboldt Bay Sea Level Rise Conceptual Groundwater Model*.	All reports are available at: http://humboldtbay.org/humboldt-bay-sea-level-rise-adaptation-planning-project

North Central Coast		
Our Coast Our Future (map available for Bodega Head to Half Moon Bay)	Provides online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms, including seamless Digital Elevation Model (DEM) at 6.6 ft (2 m) horizontal resolution; 9.8 in (25 cm) increment sea level rise projections between 0-6.6 ft (0-2 m) with a 16.4 ft (5 m) extreme; storm scenarios using the Coastal Storm Modeling System (CoSMoS); and interactive maps overlaying infrastructure and ecosystem vulnerabilities.	http://data.prbo.org/apps/ocof/
South Coast		
Coastal Resilience Ventura	A partnership to provide science and decision-support tools to aid conservation and planning projects and policymaking to address conditions brought about by climate change. The primary goals of Coastal Resilience Ventura are assessing the vulnerabilities of human and natural resources, and identifying solutions that help nature help people.	http://maps.coastalresilience.org/california/ http://coastalresilience.org/geographies/ventura-county
Southern California Coastal Impacts Project, including the Coastal Storm Modeling System (CoSMoS)	A numerical modeling system to predict coastal flooding due to both sea level rise and storms driven by climate change; conditions will be specifically selected for and downscaled to the southern California region (from Point Conception to the US-Mexico border, including the Channel Islands and coastal embayments). This version will take into account shoreline change and fluvial inputs; additionally, even more robust modeling of coastal erosion and shoreline change will be provided for the Los Angeles region.	http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal2.0/index.html

Table C-2. Sea Level Rise Data and Resource Clearinghouses

Resource	Description	Link
California Climate Commons	Offers a point of access to climate change data and related resources, information about the science that produced it, and the opportunity to communicate with others about applying climate change science to conservation in California.	http://climate.calcommons.org/
Climate Adaptation Knowledge Exchange (CAKE)	Provides an online library of climate adaptation case studies and resources, plus ways to connect with an online climate adaptation community/ network.	http://www.cakex.org/
Ecosystem Based Management Tools Network Database	Provides a searchable database of tools available for climate adaptation, conservation planning, sea level rise impact assessment, *etc.*	http://www.ebmtools.org/about_ebm_tools.html
Climate.Data.gov	Recently launched federal government data portal that includes a number of data sets on climate change, including sea level rise impacts.	http://www.data.gov/climate/
NOAA Digital Coast	This NOAA-sponsored website is focused on helping communities address coastal issues. The Digital Coast provides coastal data, tools, training, and information from reputable sources.	http://coast.noaa.gov/digitalcoast/

Table C-3. Adaptation Planning Guidebooks

Title	Description	Link
Scanning the Conservation Horizon (National Wildlife Federation 2011)	Designed to assist conservation and resource professionals to better plan, execute, and interpret climate change vulnerability assessments.	http://www.habitat.noaa.gov/pdf/scanning_the_conservation_horizon.pdf
Adapting to Sea Level Rise: A Guide for California's Coastal Communities (Russell and Griggs 2012)	Intended to assist California's coastal managers and community planners in developing adaptation plans for sea level rise that are suited to their local conditions and communities.	http://seymourcenter.ucsc.edu/OOB/Adapting%20to%20Sea%20Level%20Rise.pdf
California Adaptation Planning Guide (APG) (Cal EMA/CNRA 2012)	Provides guidance to support regional and local communities in proactively addressing the unavoidable consequences of climate change. Includes a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.	http://resources.ca.gov/climate/safeguarding/adaptation_policy_guide/
Preparing for Climate Change: A Guidebook for Regional and State Governments (Snover *et al.* 2007)	Assists decision makers in a local, regional, or state government prepare for climate change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools.	http://www.icleiusa.org/action-center/planning/adaptation-guidebook
Adapting to Climate Change: a Planning Guide for State Coastal Managers (NOAA 2010)	Guide offers a framework for state coastal managers to follow as they develop and implement climate change adaptation plans in their own states.	http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf

Using Scenarios to Explore Climate Change: A Handbook for Practitioners (NPS 2013)	Describes the five-step process for developing multivariate climate change scenarios taught by the Global Business Network (GBN). Detailed instructions are provided on how to accomplish each step. Appendices include a hypothetical scenario exercise that demonstrates how to implement the process and some early examples of how national parks are using climate change scenarios to inform planning and decision making.	http://www.nps.gov/subjects/climatechange/upload/CCScenariosHandbookJuly2013.pdf
Scenario Planning for Climate Change Adaptation: A Guidance for Resource Managers (Moore *et al.* 2013)	Step-by-step guide to using scenarios to plan for climate change adaptation for natural resource managers, planners, scientists, and other stakeholders working at a local or regional scale to develop resource management approaches that take future climate change impacts and other important uncertainties into account.	http://scc.ca.gov/files/2013/07/Scen-planning_17july2013_FINAL-3.pdf

Table C-4. Resources for Assessing Adaptation Measures

Resource	Description	Link
General		
Georgetown Climate Center's Climate Adaptation Toolkit – Sea Level Rise and Coastal Land Use	Explores 18 different land-use tools that can be used to preemptively respond to the threats posed by sea level rise to both public and private coastal development and infrastructure, and strives to assist governments in determining which tools to employ to meet their unique socio-economic and political contexts.	http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use
What Will Adaptation Cost? (ERGI 2013)	"This report provides a framework that community leaders and planners can use to make more economically informed decisions about adapting to sea level rise and storm flooding. The four-step framework can be used to perform a holistic assessment of costs and benefits of different adaptation approaches across a community, or to focus in on select infrastructure. The report also discusses the expertise needed at each step in the process."	http://coast.noaa.gov/digitalcoast/publications/adaptation
Center for Ocean Solutions: Adaptation in Action: Examples from the Field	Provides case studies of various adaptation strategies including overlay zones, non-conformities, setbacks, buffers, development conditions, shoreline protection devices, managed retreat, capital improvement programs, acquisition programs, conservation easements, rolling easements, tax incentives, transfer development rights, and real estate disclosures.	http://www.centerforoceansolutions.org/sites/default/files/Application%20of%20Land%20Use%20Practices%20and%20Tools%20to%20Prepare.pdf

Combatting Sea Level Rise in Southern California: How Local Government Can Seize Adaptation Opportunities While Minimizing Legal Risk (Herzog and Hecht 2013)	Identifies how local governments can harness legal doctrines to support aggressive, innovative strategies to achieve successful sea level rise adaptation outcomes for Southern California while minimizing legal risk. Broadly outlines likely sea level rise impacts in Southern California, and evaluates the risks and opportunities of potential protection, accommodation, and retreat adaptation strategies that local governments could deploy.	http://www.law.ucla.edu/~/media/Files/UCLA/Law/Pages/Publications/CEN_EMM_PUB%20Combatting%20Sea-Level%20Rise.ashx
Strategies for Erosion-Related Impacts		
Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay	Provides a technical evaluation of various erosion mitigation measures, conducts a cost benefit analysis of some of the more promising measures, and includes recommendations for addressing coastal erosion in Southern Monterey Bay. The report is intended to be relevant for other areas of California as well.	http://montereybay.noaa.gov/new/2012/erosion.pdf
Rolling Easements		
Rolling Easements- A Primer (Titus 2011)	Examines more than a dozen different legal approaches to rolling easements. It differentiates opportunities for legislatures, regulators, land trusts, developers, and individual landowners. Considers different shoreline environments (*e.g.*, wetlands, barrier islands) and different objectives (*e.g.*, public access, wetland migration)	http://papers.risingsea.net/rolling-easements.html
No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast (Caldwell and Segall 2007)	Provides a description of sea level rise impacts to ecosystems and public access, strategies to address these impacts, and case study examples of rolling easement strategies for the California coast.	http://www.boalt.org/elq/documents/elq34-2-09-caldwell-2007-0910.pdf

Natural Resources		
PRBO Climate Smart Conservation	Lists science-based, climate-smart conservation planning and management tools and methods, including restoration projects designed for climate change and extremes.	http://www.pointblue.org/priorities/climate-smart-conservation/
US Forest Service System for Assessing Vulnerability of Species- Climate Change Tool	Quantifies the relative impact of expected climate change effects for terrestrial vertebrate species.	http://www.fs.fed.us/rm/grassland-shrubland-desert/products/species-vulnerability/savs-climate-change-tool/
The Nature Conservancy: Reducing Climate Risk with Natural Infrastructure report	Presents a series of nine case studies in which natural, "green" infrastructure was successfully used to mitigate climate impacts. The economic costs and benefits of the green infrastructure are compared with traditional "gray" approaches.	http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/california/ca-green-vs-gray-report-2.pdf
CDFW Essential Habitat Connectivity Project	"The California Department of Fish and Wildlife and the California Department of Transportation (Caltrans) commissioned a team of consultants to produce a statewide assessment of essential habitat connectivity by February of 2010, using the best available science, data sets, spatial analyses and modeling techniques. The goal was to identify large remaining blocks of intact habitat or natural landscape and model linkages between them that need to be maintained, particularly as corridors for wildlife."	https://www.wildlife.ca.gov/Conservation/Planning/Connectivity
CDFW Areas of Conservation Emphasis tool	Provides a mapping tool and reports on the best available statewide, spatial information on California's biological richness, including species diversity, rarity, and sensitive habitats, as well as recreational needs and opportunities throughout the state, including fishing, hunting and wildlife-viewing.	http://www.dfg.ca.gov/biogeodata/ace/

Table C-5. Examples of Sea Level Rise Vulnerability Assessments in California

Title	Description	Link
Santa Barbara Sea Level Rise Vulnerability Study (Russell and Griggs 2012)	Assesses the vulnerability of the City of Santa Barbara to future sea level rise and related coastal hazards (by Years 2050 and 2100) based upon past events, shoreline topography, and exposure to sea level rise and wave attack. It also evaluates the likely impacts of coastal hazards to specific areas of the City, analyzes their risks and the City's ability to respond, and recommends potential adaptation responses.	http://www.energy.ca.gov/2012publications/CEC-500-2012-039/CEC-500-2012-039.pdf
City of Santa Cruz Climate Change Vulnerability Assessment (Griggs and Haddad 2011)	Delineates and evaluates the likely impacts of future climate change on the city of Santa Cruz, analyzes the risks that these hazards pose for the city, and then recommends potential adaptation responses to reduce the risk and exposure from these hazards in the future.	http://seymourcenter.ucsc.edu/OOB/SCClimateChangeVulnerabilityAssessment.pdf
Developing Climate Adaptation Strategies for San Luis Obispo County: Preliminary Vulnerability Assessment for Social Systems (Moser 2012)	Describes the likely impacts of climate change on the resources and social systems of San Luis Obispo County, and assesses key areas of vulnerability. Sea level rise is identified as a major source of risk to fishing, coastal tourism, coastal development, and infrastructure.	http://www.energy.ca.gov/2012publications/CEC-500-2012-054/CEC-500-2012-054.pdf
Monterey Bay Sea Level Rise Vulnerability Study (Monterey Bay National Marine Sanctuary and PWA ESA; In progress)	Will assess potential future impacts from sea level rise for the Monterey Bay region. The project will estimate the extent of future coastal erosion in Monterey Bay due to accelerated sea level rise and evaluate areas subjected to coastal flooding by inundation from wave action and/or storm surges. The project will update and refine existing Monterey Bay coastal hazard zones maps (erosion and flooding).	Project scope and grant details: http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2012/1201/20120119Board03D_Monterey_Bay_Sea_Level_Rise.pdf

Sea Level Rise Vulnerability Study for the City of LA (Adapt LA) (USC Sea Grant 2013)	This report provides a summary of the initial research on the potential impacts of sea level rise and associated flooding from storms for coastal communities in the City of L.A. The study concentrates on the City's three coastal regions: Pacific Palisades from Malibu to Santa Monica; Venice and Playa del Rey; and San Pedro, Wilmington and the Port of Los Angeles.	http://dornsife.usc.edu/uscseagrant/adaptla/

Table C-6. California Climate Adaptation Plans that Address Sea Level Rise

Title	Description	Link
Adapting to Rising Tides (ART) Project	The ART project is a collaborative planning effort led by the San Francisco Bay Conservation and Development Commission to help SF Bay Area communities adapt to rising sea levels. The project has started with a vulnerability assessment for a portion of the Alameda County shoreline.	http://www.adaptingtorisingtides.org/ Vulnerability and risk assessment report: http://www.adaptingtorisingtides.org/vulnerability-and-risk-assessment-report/
Santa Cruz Climate Adaptation Plan	An update to the 2007 Hazard Mitigation Plan, the adaptation plan includes strategies and best available science for integrating climate change impacts into City of Santa Cruz operations.	Complete plan is available: http://www.cityofsantacruz.com/home/showdocument?id=23644
San Diego Bay Sea Level Rise Adaptation Strategy	The strategy provides measures to evaluate and manage risks from sea level rise and other climate change impacts, and includes a vulnerability assessment of community assets at risk, and broad recommendations to increase resilience of these assets.	http://www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance/san-diego-bay-sea-level-rise-adaptation-strategy-1/san-diego-bay-sea-level-rise-adaptation-strategy

Table C-7. California State Agency Resources

Agency	Document	Description and Link
California Natural Resources Agency	*Safeguarding California from Climate Change* (2014)	An update to the 2009 *California Climate Adaptation Strategy*: http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf
	California Climate Adaptation Strategy (2009)	Summarizes climate change impacts and recommends adaptation strategies across seven sectors: Public Health, Biodiversity and Habitat, Oceans and Coastal Resources, Water, Agriculture, Forestry, and Transportation and Energy: http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf
Office of the Governor	*Executive Order S-13-08* (2008)	This 2008 Executive Order required the CA Natural Resources Agency to develop a statewide climate adaptation strategy, and requested that the National Academy of Sciences convene an independent scientific panel to assess sea level rise in California. http://gov.ca.gov/news.php?id=11036
	Executive Order B-30-15 (2015)	This 2015 Executive Order established an interim greenhouse gas reduction target of 40 percent below 1990 levels by 2030 to expand upon the targets already included in AB32 and emphasized the need for adaptation in line with the actions identified in the *Safeguarding California* document. http://gov.ca.gov/news.php?id=18938
California Ocean Protection Council	*Resolution on Implementation of the Safeguarding California Plan for Reducing Climate Risks* (2014)	Resolves that OPC staff and the State Coastal Leadership Group on SLR will develop an action plan to implement the *Safeguarding California* plan. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20140827/Item5_OPC_Aug2014_Exhibit_1_Safeguarding_Resolution_ADOPTED.pdf
	Resolution on Sea Level Rise (2011)	Recognizes that state agencies should address SLR through various actions such as the consideration of SLR risks in decision making, investment of public funds, stakeholder engagement, state SLR guidance updates, etc. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/OPC_SeaLevelRise_Resolution_Adopted031111.pdf

Coasts & Oceans Climate Action Team (led by Ocean Protection Council)	*California State Sea-Level Rise Guidance Document* (2013)	Provides guidance for incorporating sea level rise projections into planning and decision making for projects in California. Updated to include NRC projections March 2013: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf
California Coastal Conservancy	*Climate Change Policy* (2010)	Includes policies on 1) consideration of climate change in project evaluation, 2) consideration of sea level rise impacts in vulnerability assessments, 3) collaboration to support adaptation strategies, and 4) encouragement of adaptation strategies in project applications mitigation and adaptation: http://scc.ca.gov/2009/01/21/coastal-conservancy-climate-change-policy-and-project-selection-criteria/
	Project Selection Criteria (2011)	Adds sea level rise vulnerability to project selection criteria: http://scc.ca.gov/2009/01/21/coastal-conservancy-climate-change-policy-and-project-selection-criteria/
	Guidance for addressing climate change in CA Coastal Conservancy projects (2012)	Includes the following steps: 1) conduct initial vulnerability assessment, 2) conduct more comprehensive vulnerability assessment, 3) reduce risks and increase adaptive capacity, and 4) identify adaptation options: http://scc.ca.gov/2013/04/24/guidance-for-grantees
San Francisco Bay Conservation and Development Commission (BCDC)	*Climate Change Bay Plan Amendment* (2011)	Amends *Bay Plan* to include policies on climate change and sea level rise. Policies require: 1) a sea level rise risk assessment for shoreline planning and larger shoreline projects, and 2) if risks exist, the project must be designed to cope with flood levels by mid-century, and include a plan to address flood risks at end of century. Assessments are required to "identify all types of potential flooding, degrees of uncertainty, consequences of defense failure, and risks to existing habitat from proposed flood protection devices": http://www.bcdc.ca.gov/proposed_bay_plan/bp_amend_1-08.shtml

	Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline (2009)	Provides the background staff report identifying vulnerabilities in the Bay Area's economic and environmental systems, as well as the potential impacts of climate change on public health and safety. The report provides the basis for all versions of the proposed findings and policies concerning climate change: http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf
California Department of Transportation (Caltrans)	*Estimating Sea Level for Project Initiation Documents* (2011)	Provides guidance on converting tidal datums and predicting future sea levels. http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/Estimating_Sea_Level_v1.pdf
	Guidance on Incorporating Sea Level Rise (2011)	Provides guidance on how to incorporate sea level rise concerns into programming and design of Caltrans projects. Includes screening criteria for determining whether to include SLR and steps for evaluating degree of potential impacts, developing adaptation alternatives, and implementing the adaptation strategies: http://www.dot.ca.gov/ser/downloads/sealevel/guide_incorp_slr.pdf
	Addressing Climate Change in Adaptation Regional Transportation Plans: A Guide for MPOs and RTPAs (2010)	Provides a clear methodology for regional agencies to address climate change impacts through adaptation of transportation infrastructure: http://www.camsys.com/pubs/FR3_CA_Climate_Change_Adaptation_Guide_2013-02-26_.pdf

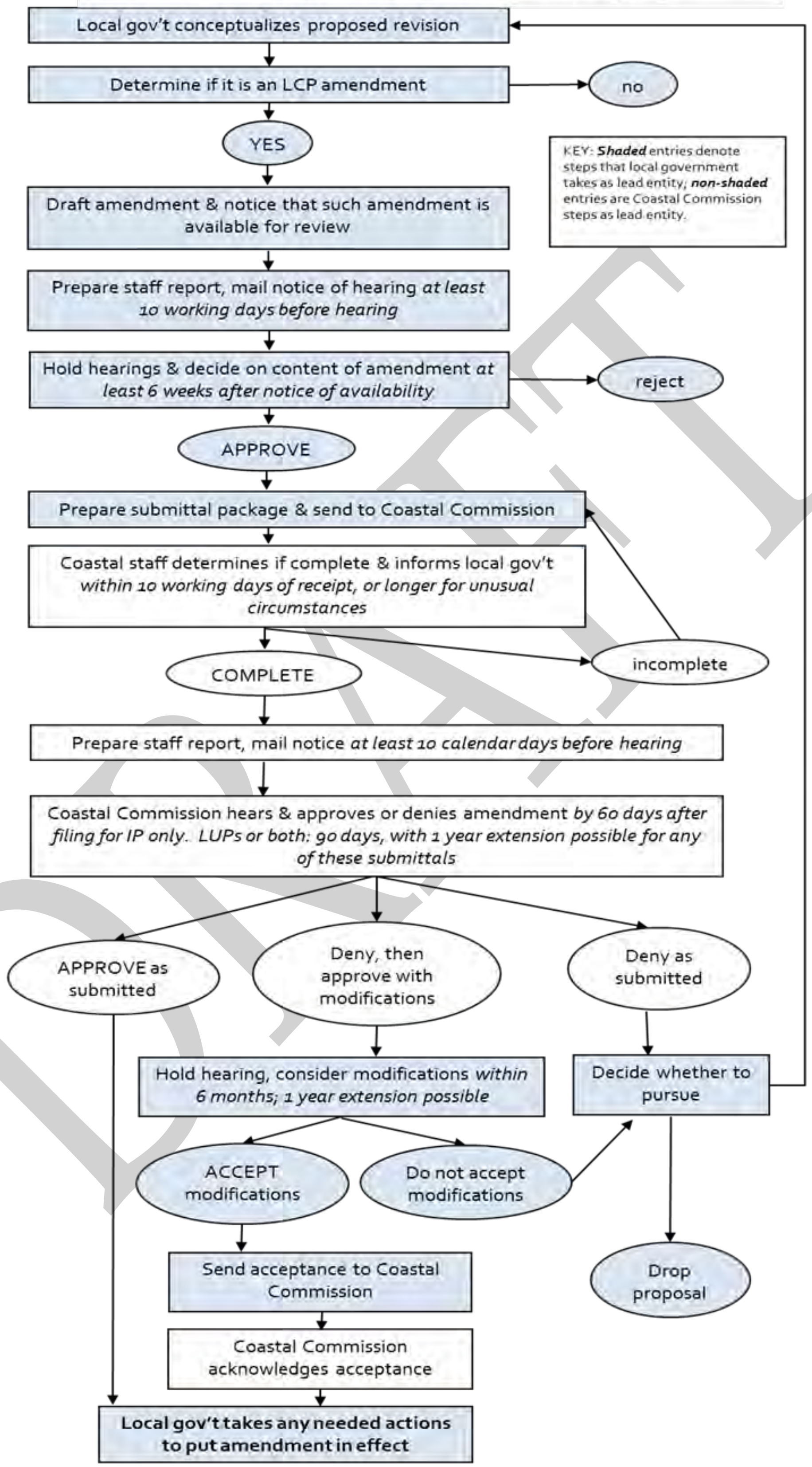
Cal OES	*California Multi-Hazard Mitigation Plan* (SHMP 2013)	"The 2013 SHMP represents the state's primary hazard mitigation guidance document, and provides an updated and comprehensive description of California's historical and current hazard analysis, mitigation strategies, goals and objectives. Innovative features of the California hazard mitigation plan include an expanded discussion of climate change and adaptation strategies, a new and expanded section on volcanic hazards in the state, as well as significant mitigation initiatives, strategies and actions completed since adoption of the 2010 SHMP." http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp
State Lands Commission	Application for Lease of State Lands (2011)	Requires assessment of climate change risks, and preference is given to projects that reduce climate change risks: http://www.slc.ca.gov/Online_Forms/LMDApplication/Lease_App_Form_2011.pdf
California State Parks	Sea level rise guidance (*in development*)	Will provide guidance to Park staff on how to assess impacts to parklands.
Groups of state agencies	California Climate Change Center's 3rd Assessment	Explores local and statewide vulnerabilities to climate change, highlighting opportunities for taking concrete actions to reduce climate-change impacts: http://climatechange.ca.gov/climate_action_team/reports/third_assessment/
	California Climate Adaptation Planning Guide (APG)	Provides a decision-making framework intended for use by local and regional stakeholders to aid in the interpretation of climate science and to develop a systematic rationale for reducing risks caused, or exacerbated, by climate change (2012): http://resources.ca.gov/climate/safeguarding/adaptation_policy_guide/

Appendix D

General LCP Amendment Processing Steps and Best Practices

Sea level rise is one of many topics that should be addressed in a Local Coastal Program (LCP) or LCP amendment. The Coastal Commission offers a *Local Coastal Program (LCP) Update Guide* that outlines the broad process for amending or certifying an LCP, including guidance for both Land Use Plans and Implementation Plans. It addresses major Coastal Act concerns, including public access, recreation and visitor serving facilities, water quality protection, ESHA and natural resources, agricultural resources, new development, archaeological and cultural resources, scenic and visual resources, coastal hazards, shoreline erosion and protective devices, energy and industrial development, and timberlands. Therefore, this *Sea Level Rise Policy Guidance* should be used in conjunction with the LCP Update Guide to perform complete LCP amendments or certifications. The following figure depicts the general LCP amendment process.

Figure I: General LCP Amendment Processing Steps



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Appendix E

Funding Opportunities for LCP Planning and Implementation

Project Implementation Funds

The following table includes a list of grant funding available for implementation of sea level rise adaptation projects and programs. Much of this information was compiled by the Governor's Office of Emergency Services (Cal OES).

Grant Name	Agency	Purpose	Contact
Pre-Disaster Mitigation (PDM) Program	Administered by: Cal OES Funded by: US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	Provides funds for hazard mitigation planning and projects on an annual basis. The PDM program was put in place to reduce overall risk to people and structures, while at the same time reducing reliance on federal funding if an actual disaster were to occur.	Cal OES http://www.caloes.ca.gov/cal-oes-divisions/hazard-mitigation/pre-disaster-flood-mitigation FEMA https://www.fema.gov/pre-disaster-mitigation-grant-program
Hazard Mitigation Grant (HMG) Program	Administered by: Cal OES Funded by: US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	Provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.	Cal OES http://www.caloes.ca.gov/cal-oes-divisions/recovery/disaster-mitigation-technical-support/404-hazard-mitigation-grant-program FEMA https://www.fema.gov/hazard-mitigation-grant-program
Flood Mitigation Assistance (FMA) Program	Administered by: Cal OES Funded by: US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	Provides grants to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP.	Cal OES http://www.caloes.ca.gov/cal-oes-divisions/hazard-mitigation/pre-disaster-flood-mitigation FEMA https://www.fema.gov/flood-mitigation-assistance-program

Public Assistance (PA) Program	US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	To provide supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process.	FEMA https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit
Community Development Block Grant (CDBG) Program	US Department of Housing and Urban Development	Program works to ensure decent affordable housing, to provide services to the most vulnerable in our communities, and to create jobs through the expansion and retention of businesses.	HUD http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs
Watershed Surveys and Planning	US Department of Agriculture, Natural Resource Conservation Service	To provide planning assistance to Federal, state and local agencies for the development or coordination of water and related land resources and programs in watersheds and river basins.	NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wsp/
Watershed Protection and Flood Prevention	US Department of Agriculture, Natural Resource Conservation Service	To provide technical and financial assistance in planning and executing works of improvement to protect, develop, and use of land and water resources in small watersheds.	NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Land and Water Conservation Fund Grants	US Department of the Interior, National Park Service	To acquire and develop outdoor recreation areas and facilities for the general public, to meet current and future needs.	NPS http://www.nps.gov/lwcf/index.htm

SBA Disaster Loan Program	US Small Business Administration	SBA provides low-interest disaster loans to businesses of all sizes, private non-profit organizations, homeowners, and renters. SBA disaster loans can be used to repair or replace the following items damaged or destroyed in a declared disaster: real estate, personal property, machinery and equipment, and inventory and business assets.	SBA https://www.sba.gov/content/disaster-loan-program
Clean Water Act Section 319 Grants	US Environmental Protection Agency	To implement state and tribal non-point source pollution management programs, including support for non-structural watershed resource restoration activities.	EPA http://water.epa.gov/polwaste/nps/319hfunds.cfm
Flood Control Works/ Emergency Rehabilitation	US Department of Defense, Army Corps of Engineers	To assist in the repairs and restoration of public works damaged by flood, extraordinary wind, wave or water action.	USACE http://www.usace.army.mil/Missions/EmergencyOperations/NationalResponseFramework/FloodControl.aspx
Emergency Streambank and Shoreline Protection	US Department of Defense, Army Corps of Engineers	To prevent erosion damages to public facilities by the emergency construction or repair of streambank and shoreline protection works (33 CFR 263.25)	USACE www.usace.army.mil
Small Flood Control Projects	US Department of Defense, Army Corps of Engineers	To reduce flood damages through small flood control projects not specifically authorized by Congress.	USACE www.usace.army.mil See also: https://www.cfda.gov/index?s=program&mode=form&tab=core&id=2216ee03c69db437c431036a5585ede6

Appendix F

Primary Coastal Act Policies Related to Sea Level Rise and Coastal Hazards

Legislative Findings Relating to Sea Level Rise

Section 30006.5 of the Coastal Act states (Legislative findings and declarations; technical advice and recommendations) states (emphasis added):

> *The Legislature further finds and declares that sound and timely scientific recommendations are necessary for many coastal planning, conservation, and development decisions and that the commission should, in addition to developing its own expertise in significant applicable fields of science, interact with members of the scientific and academic communities in the social, physical, and natural sciences so that the commission may receive technical advice and recommendations with regard to its decisionmaking, especially with regard to issues such as coastal erosion and geology, marine biodiversity, wetland restoration, the question of sea level rise, desalination plants, and the cumulative impact of coastal zone developments.*

Public Access and Recreation

Section 30210 of the Coastal Act (Access; recreational opportunities; posting) states:

> *In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.*

Section 30211 of the Coastal Act (Development not to interfere with access) states:

> *Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.*

Section 30212 of the Coastal Act (New development projects) states:

> *(a) Public access from the nearest public roadway to the shoreline and along the coast shall be provided in new development projects except where: (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or (3) agriculture would be adversely affected. Dedicated accessway shall not be required to be opened to public use until a public agency or private association agrees to accept responsibility for maintenance and liability of the accessway.*

Section 30214 of the Coastal Act (Implementation of public access policies; legislative intent) states:

> (*a) The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances in each case including, but not limited to, the following:*
>
> *(1) Topographic and geologic site characteristics.*
>
> *(2) The capacity of the site to sustain use and at what level of intensity.*

> *(3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area and the proximity of the access area to adjacent residential uses.*
>
> *(4) The need to provide for the management of access areas so as to protect the privacy of adjacent property owners and to protect the aesthetic values of the area by providing for the collection of litter.*
>
> *(b) It is the intent of the Legislature that the public access policies of this article be carried out in a reasonable manner that considers the equities and that balances the rights of the individual property owner with the public's constitutional right of access pursuant to Section 4 of Article X of the California Constitution. Nothing in this section or any amendment thereto shall be construed as a limitation on the rights guaranteed to the public under Section 4 of Article X of the California Constitution.*
>
> *(c) In carrying out the public access policies of this article, the commission and any other responsible public agency shall consider and encourage the utilization of innovative access management techniques, including, but not limited to, agreements with private organizations which would minimize management costs and encourage the use of volunteer programs.*

Section 30220 of the Coastal Act (Protection of certain water-oriented activities) states:

> *Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.*

Section 30221 of the Coastal Act (Oceanfront land; protection for recreational use and development**)** states:

> *Oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area.*

Section 30223 of the Coastal Act (Upland areas) states:

> *Upland areas necessary to support coastal recreational uses shall be reserved for such uses, where feasible.*

Wetlands and Environmentally Sensitive Resources

Section 30231 of the Coastal Act (Biological productivity; water quality) states in part:

> *The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored…*

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

> *(a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:*

Section 30240 of the Coastal Act (Environmentally sensitive habitat areas; adjacent developments) states:

> *(a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.*
>
> *(b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.*

Coastal Act Section 30121 defines "Wetland" as follows:

> *"Wetland" means lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens.*

The California Code of Regulations Section 13577(b) of Title 14, Division 5.5, Article 18 defines "Wetland" as follows:

> *(1) Measure 100 feet landward from the upland limit of the wetland. Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats. For purposes of this section, the upland limit of a wetland shall be defined as:*
>
> > *(A) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover;*
> >
> > *(B) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or*
> >
> > *(C) in the case of wetlands without vegetation or soils, the boundary between land that is flooded or saturated at some time during years of normal precipitation, and land that is not.*
>
> *(2) For the purposes of this section, the term "wetland" shall not include wetland habitat created by the presence of and associated with agricultural ponds and reservoirs where:*

(A) the pond or reservoir was in fact constructed by a farmer or rancher for agricultural purposes; and

(B) there is no evidence (e.g., aerial photographs, historical survey, etc.) showing that wetland habitat pre-dated the existence of the pond or reservoir. Areas with drained hydric soils that are no longer capable of supporting hydrophytes shall not be considered wetlands.

In addition, Coastal Act Section 30107.5 defines “Environmentally sensitive area" as follows:

"Environmentally sensitive area" means any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

Agricultural and Timber Lands

Section 30241 of the Coastal Act (Prime agricultural land; maintenance in agricultural production) states:

The maximum amount of prime agricultural land shall be maintained in agricultural production to assure the protection of the areas’ agricultural economy, and conflicts shall be minimized between agricultural and urban land uses…

Section 30242 of the Coastal Act (Lands suitable for agricultural use; conversion) states:

All other lands suitable for agricultural use shall not be converted to nonagricultural uses unless (1) continued or renewed agriculture use is not feasible, or (2) such conversion would preserve prime agricultural land or concentrate development consistent with Section 30250. Any such permitted conversion shall be compatible with continue agricultural use on surrounding lands.

Section 30243 of the Coastal Act (Productivity of soils and timberlands; conversions) states:

The long-term productivity of soils and timberlands shall be protected, and conversions of coastal commercial timberlands in units of commercial size to other uses or their division into units of noncommercial size shall be limited to providing for necessary timber processing and related facilities.

Archeological and Paleontological Resources

Section 30244 of the Coastal Act (Archaeological or paleontological resources) states:

Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Marine Resources

Section 30230 of the Coastal Act (Marine resources; maintenance) states:

> *Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.*

Section 30231 of the Coastal Act (Biological productivity; water quality) states:

> *The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.*

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

> *(a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects…*
>
> *(d) Erosion control and flood control facilities constructed on watercourses can impede the movement of sediment and nutrients that would otherwise be carried by storm runoff into coastal waters. To facilitate the continued delivery of these sediments to the littoral zone, whenever feasible, the material removed from these facilities may be placed at appropriate points on the shoreline in accordance with other applicable provisions of this division, where feasible mitigation measures have been provided to minimize adverse environmental effects. Aspects that shall be considered before issuing a Coastal Development Permit for these purposes are the method of placement, time of year of placement, and sensitivity of the placement area.*

Section 30234 of the Coastal Act (Commercial fishing and recreational boating facilities**)** states:

> *Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.*

Section 30234.5 of the Coastal Act (Economic, commercial, and recreational importance of fishing) states:

> *The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.*

Coastal Development

Section 30250 of the Coastal Act (Location; existing developed area) states:

> *(a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able to accommodate it, in other areas with adequate public services and where it will not have significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.*
>
> *(b) Where feasible, new hazardous industrial development shall be located away from existing developed areas.*
>
> *(c) Visitor-serving facilities that cannot feasibly be located in existing developed areas shall be located in existing isolated developments or at selected points of attraction for visitors.*

Section 30251 of the Coastal Act (Scenic and visual qualities) states:

> *The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas...*

Section 30253 the Coastal Act (Minimization of adverse impacts) states in part:

> *New development shall do all of the following:*
>
> *(a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.*
>
> *(b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs...*

Section 30235 of the Coastal Act (Construction altering natural shoreline) states:

> *Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public*

> *beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible.*

Section 30236 of the Coastal Act (Water supply and flood control) states:

> *Channelizations, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (l) necessary water supply projects, (2) flood control projects where no other method for protecting existing structures in the flood plain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.*

Ports

Section 30705 of the Coastal Act (Diking, filling or dredging water areas) states:

> *(a) Water areas may be diked, filled, or dredged when consistent with a certified port master plan only for the following: …*
>
> *(b) The design and location of new or expanded facilities shall, to the extent practicable, take advantage of existing water depths, water circulation, siltation patterns, and means available to reduce controllable sedimentation so as to diminish the need for future dredging.*
>
> *(c) Dredging shall be planned, scheduled, and carried out to minimize disruption to fish and bird breeding and migrations, marine habitats, and water circulation. Bottom sediments or sediment elutriate shall be analyzed for toxicants prior to dredging or mining, and where water quality standards are met, dredge spoils may be deposited in open coastal water sites designated to minimize potential adverse impacts on marine organisms, or in confined coastal waters designated as fill sites by the master plan where such spoil can be isolated and contained, or in fill basins on upland sites. Dredge material shall not be transported from coastal waters into estuarine or fresh water areas for disposal.*

Section 30706 of the Coastal Act (Fill) states:

> *In addition to the other provisions of this chapter, the policies contained in this section shall govern filling seaward of the mean high tide line within the jurisdiction of ports:*
>
>> *(a) The water area to be filled shall be the minimum necessary to achieve the purpose of the fill.*
>>
>> *(b) The nature, location, and extent of any fill, including the disposal of dredge spoils within an area designated for fill, shall minimize harmful effects to coastal resources, such as water quality, fish or wildlife resources, recreational resources, or sand transport systems, and shall minimize reductions of the volume, surface area, or circulation of water.*

(c) The fill is constructed in accordance with sound safety standards which will afford reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters.

(d) The fill is consistent with navigational safety.

Section 30708 of the Coastal Act (Location, design and construction of port related developments) states:

All port-related developments shall be located, designed, and constructed so as to:

(a) Minimize substantial adverse environmental impacts.

(b) Minimize potential traffic conflicts between vessels.

(c) Give highest priority to the use of existing land space within harbors for port purposes, including, but not limited to, navigational facilities, shipping industries, and necessary support and access facilities.

(d) Provide for other beneficial uses consistent with the public trust, including, but not limited to, recreation and wildlife habitat uses, to the extent feasible.

(e) Encourage rail service to port areas and multicompany use of facilities.

Public Works Facilities

According to Coastal Act Section 30114, public works facilities include:

(a) All production, storage, transmission, and recovery facilities for water, sewerage, telephone, and other similar utilities owned or operated by any public agency or by any utility subject to the jurisdiction of the Public Utilities Commission, except for except for energy facilities [which are regulated by the Public Utilities Commission].

(b) All public transportation facilities, including streets, roads, highways, public parking lots and structures, ports, harbors, airports, railroads, and mass transit facilities and stations, bridges, trolley wires, and other related facilities. For purposes of this division, neither the Ports of Hueneme, Long Beach, Los Angeles, nor San Diego Unified Port District nor any of the developments within these ports shall be considered public works.

(c) All publicly financed recreational facilities, all projects of the State Coastal Conservancy, and any development by a special district.

(d) All community college facilities.

Greenhouse Gas Emissions Reduction

Section 30250(a) of the Coastal Act (Location, existing developed areas states) in part:

(a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able to accommodate it, in other areas with adequate public services and where it will not have

> *significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.*

Section 30252 of the Coastal Act (Maintenance and enhancement of public access) states:

> *The location and amount of new development should maintain and enhance public access to the coast by (1) facilitating the provision or extension of transit service, (2) providing commercial facilities within or adjoining residential development or in other areas that will minimize the use of coastal access roads, (3) providing nonautomobile circulation within the development, (4) providing adequate parking facilities or providing substitute means of serving the development with public transportation, (5) assuring the potential for public transit for high intensity uses such as high-rise office buildings, and by (6) assuring that the recreational needs of new residents will not overload nearby coastal recreation areas by correlating the amount of development with local park acquisition and development plans with the provision of onsite recreational facilities to serve the new development.*

Section 30253(d) of the Coastal Act (Minimization of adverse impacts) states in part:

> *New Development shall:*
>
> > *(d) Minimize energy consumption and vehicle miles traveled….*

Appendix G

Coastal Commission Contact Information

Figure G-1. Location of Coastal Commission offices

COASTAL COMMISSION DISTRICT OFFICE CONTACT INFORMATION

North Coast (Del Norte, Humboldt, Mendocino Counties)
(707) 826-8950

Headquarters and North Central Coast (Sonoma, Marin, San Francisco, San Mateo Counties)
(415)-904-5200

Central Coast (Santa Cruz, Monterey, San Luis Obispo Counties)
(831) 427-4863

South Central Coast (Santa Barbara and Ventura Counties, and the Malibu portion of Los Angeles County)
(805) 585-1800

South Coast (Los Angeles (except Malibu) and Orange Counties)
(562) 590-5071

San Diego (San Diego County)
(619) 767-2370

COASTAL COMMISSION STAFF SEA LEVEL RISE TEAM

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