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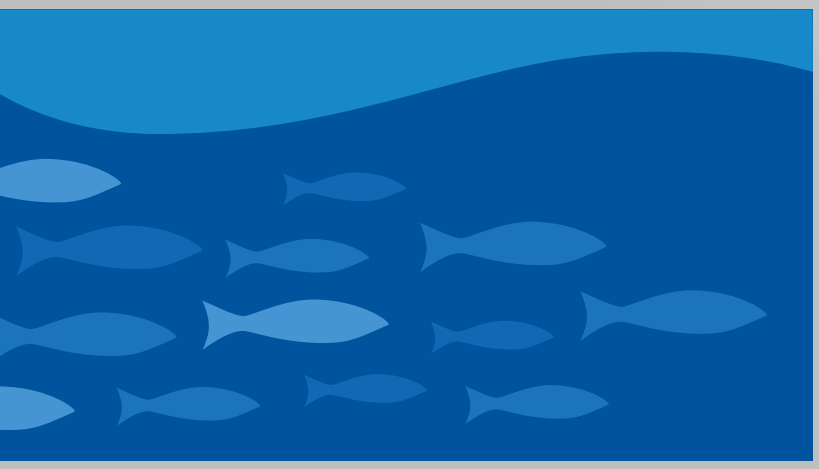
American Rivers
Natural Resources Defense Council

Getting Climate SMART

A Water Preparedness Guide for State Action



A Water Preparedness Guide for State Action

Getting Climate SMART

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Getting Climate SMART

About American Rivers

American Rivers is the leading organization working to protect and restore the nation's rivers and streams. Rivers connect us to each other, nature, and future generations. Since 1973, American Rivers has fought to preserve these connections, helping protect and restore more than 150,000 miles of rivers through advocacy efforts, on-the-ground projects, and the annual release of America's Most Endangered Rivers®.

About NRDC

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing.

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Disclaimer

This report and its recommendations are solely attributable to American Rivers and NRDC and do not necessarily represent the views of the abovementioned individuals.

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Table of Contents

Glossary

Climate Change Adaptation: The process of responding to and preparing for the impacts of climate change.

Climate Change Mitigation: The process of reducing the amount of greenhouse gas pollution released into the atmosphere.

Climate Preparedness: The process of helping communities, businesses and policy-makers anticipate the likely harmful effects of global climate change and take proactive steps to reduce or eliminate their vulnerability to those changes.

Climate Preparedness Team: The group of senior-level state agency staff and external stakeholders responsible for the overarching development and coordination of the state climate preparedness plan.

Low-Regret Strategies: Approaches that require investments at a minimal cost over no-regret strategies to prepare for and respond to future climate impacts. They may be "low-regret" if investments ultimately are not needed under future climatic changes.

No-Regret Strategies: Cost-effective, flexible approaches that are beneficial to communities today and even more beneficial with future climate impacts.

Resilience: The ability of a system to respond and adjust to climate impacts.

Risk Occurrence: The likelihood of a particular risk occurring under a climate change scenario.

Sector Work group (Work group): A group established to identify climate risks and vulnerabilities and to determine appropriate preparedness strategies in a specific area of interest (e.g., water management, urban infrastructure, agriculture, fisheries).

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

Foreword

In 2012, in southeastern Montana, a cattle rancher stood in a pasture blackened by wildfire. Looking out over his herd, he said, "That is 500 mouths to feed with nothing to eat in sight." In Duluth, Minnesota, a woman was forced from her home of 69 years by floodwaters higher than any she had ever seen before. In Colorado, a scientist pored over the year's snowpack data and observed, "The situation is pretty grim right now. It's going to be another dry year." In central Kansas, a farmer anxiously contemplated planting a new crop in the midst of a record drought: "We'll just keep praying that the next storm's on its way." In stark contrast, a financial analyst in Union City, New Jersey, watched the wind and rain of a superstorm ravage his hometown and pleaded, "Please let it end."

Drought and flood, wildfire and torrential rain, too much water and not nearly enough: These are the harbingers of a swiftly changing climate, and we are seeing their impacts on people and communities in the news almost every day. Patterns of rainfall and snowfall; annual flows of rivers and streams; the usual seasons, intensity and range of storm events that have been familiar and largely unchanged for centuries—all are increasingly unpredictable. Highs are higher, lows are lower, extremes are more extreme. Climate change is not coming. It's already here. And we need to be prepared.

It is this imperative to prepare for a swiftly changing climate that motivated American Rivers and the Natural Resources Defense Council (NRDC) to develop this blueprint for water and climate preparedness action. Too few states are moving with dispatch to prepare for the inevitable droughts, floods and superstorms that climate change will bring, let alone the less dramatic but no less important challenges to water supply and quality, public health and environmental protection that climate change will present.

Our hope is that a single volume that brings together practical guidance, planning tools, case studies and information resources will encourage state officials to take on climate change preparedness. No one needs to start from scratch. There is knowledge and experience on which to draw; there are models on which to build.

While the federal government has an important part to play, it is state and local governments that take the lead roles in water resources management. They must lead the way on climate preparedness as well. American Rivers, NRDC and other nongovernmental organizations, academic institutions and stakeholders of all kinds are ready to help, as this guide will attest.

So let's get to it.

Peter Lehner
Executive Director
Natural Resources Defense Council

Wm. Robert Irvin
President
American Rivers

Executive Summary

SUPERSTORM SANDY FLOODING, HOWARD BEACH, NY | PAMELA ANDRADE

Both 2011 and 2012 produced a record number of extreme weather events including floods, heat waves, droughts, fires and snowstorms. In 2011, 14 different extreme weather events resulted in damages of more than $1 billion each.[1] That trend has shown no signs of abating. In 2012, scorching heat brought widespread drought to more than 65 percent of the country and contributed to raging wildfires in the West that burned more than 9.2 million acres.[2,3] On top of that, the arrival of Superstorm Sandy in late October 2012 devastated communities along the northeastern seaboard with record-breaking storm surges and historic flooding. In the end, 2012 featured 11 billion-dollar extreme weather disasters, and it was the warmest year on record for the contiguous U.S. since record-keeping began in 1895.[4]

Many extreme weather events as well as warmer temperatures, changing precipitation patterns, increasing ocean acidity and rising sea levels are expected to intensify as climate change continues. In turn, these changes are fundamentally altering our communities and natural resources by threatening public health, affecting water availability and energy production, putting vulnerable homes and infrastructure at risk and jeopardizing vital ecosystems. As carbon pollution continues to contribute to extreme weather, it is critical that states begin planning for a new "normal," prioritizing climate preparedness in conjunction with improvements to disaster response and recovery.

To address these challenges, many states have begun to take action to reduce the carbon pollution that contributes to climate change and are beginning to prepare for potential climate impacts. More than 35 states have conducted some level of planning to reduce carbon pollution. Despite these and other efforts to reduce the release of heat-trapping pollutants, states already are experiencing the impacts of climate change and need to plan and prepare for the implications of increasingly warmer temperatures, changing precipitation patterns and rising seas. Only 10 states have developed comprehensive plans to prepare for these climate-related impacts.[5] Remarkably, most other states are not planning and remain ill-prepared for the challenges that climate change presents.

The failure to consider climate change in water resources planning and decision-making leaves states vulnerable to climate risks. By developing and implementing climate preparedness plans that contain flexible, adaptive and complementary strategies, states can better manage the impacts of climate change and protect public health, the economy and the environment.

This guide provides state governments, water managers and other stakeholders with information to help comprehensively plan and prepare for the water-related impacts of climate change. Although this guide focuses exclusively on preparing states for climate impacts related to water, non-water impacts also will have wide-ranging ramifications for people, communities and ecosystems and must be considered in climate preparedness planning.

Climate impacts will vary by region, and the strategies and resources available to manage these impacts will be shaped and limited by existing state laws, policies and governance structures. Therefore, the process for developing a state climate preparedness plan for water resources contained in this guide is divided into three tracks: Basic, Moderate and Robust. States have the option to follow any of the three tracks or even choose to follow a different track for each step. Additionally, where possible, specific examples are included to illustrate how some states have already conducted their planning process. The most important message is that all states must start the planning process now. The impacts of a changing climate are already being seen, and continued delays in planning and preparedness will only magnify the impacts.

DROUGHT-STRICKEN CORN FIELD, MISSOURI | JANE LAGO

PLANNING TRACKS AND STEPS

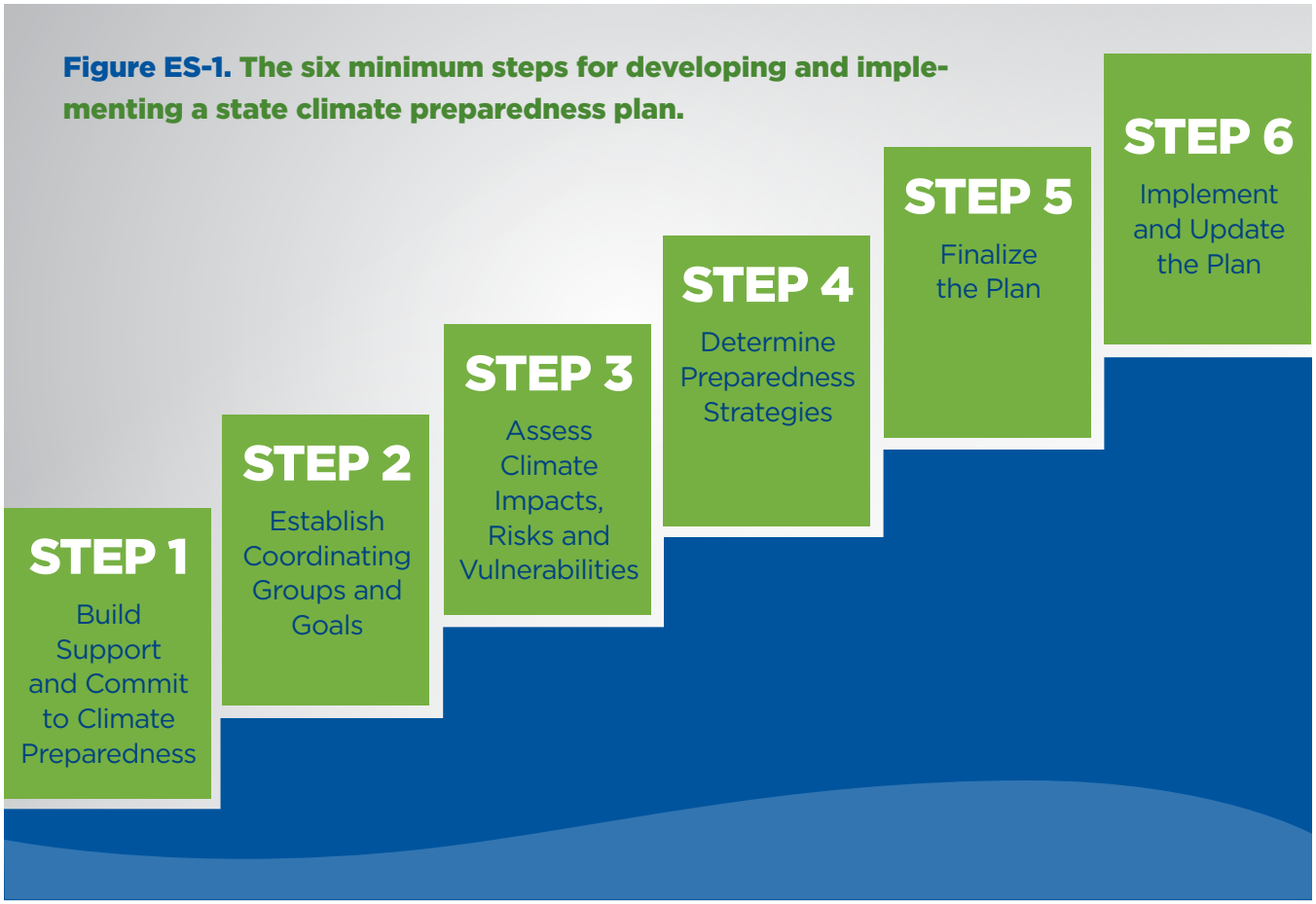
Basic: Every state can take meaningful steps to address the water-related threats from climate change. Components of this track are not likely to require additional funding, additional staff resources, or legislative or regulatory changes. Preparedness strategies focus on no-regret and low-regret approaches, which provide multiple benefits with relatively minor investments.

Moderate: States on this track have the capacity to mobilize more resources to develop a climate preparedness plan. They can conduct a more in-depth assessment of potential climate change impacts and related vulnerabilities and can consider more resource-intensive preparedness strategies. This track may require additional funding for the planning and implementation processes.

Robust: Climate change is a top-level priority for states choosing this track, and there is substantial support and capacity for climate preparedness planning. The planning process likely requires additional funding and technical resources and greater stakeholder engagement. Preparedness strategies considered for implementation include the creation of new institutions, system-wide retrofits and changes to regulatory and legal frameworks.

To develop and implement a state climate preparedness plan, this guide sets forth a six-step process.

Figure ES-1. The six minimum steps for developing and implementing a state climate preparedness plan.



STEP 1
Build Support and Commit to Climate Preparedness

Education and outreach around potential climate impacts often are necessary before a state can begin formal preparedness planning. Reaching out and informing state agency officials, legislators and the governor's office about local, regional and statewide impacts can help to build concern, interest and support for formal climate preparedness planning. A commitment to the planning process is necessary for a strong plan. This commitment can take many forms, including legislative and/or executive-level action.

STEP 2
Establish Coordinating Groups and Goals

Diverse teams and work groups are critical to ensuring that a wide variety of interests within the state are considered during the planning process. The challenges that states are likely to face require significant collaboration and leadership, not only between sectors, but also among different levels of government, nonprofit organizations, the private sector, other institutions and the public. Building collaborative and nontraditional partnerships will be crucial to managing risks as climate change intensifies. Additionally, the establishment of overarching goals and guiding principles helps facilitate the planning process and ensure that all work groups have similar expectations and objectives in mind.

STEP 3
Assess Climate Impacts, Risks and Vulnerabilities

It is critical to determine likely future changes in temperature, precipitation, hydrology, sea level and ocean acidification (if applicable) and the resulting impacts on various sectors in the state. By doing so, vulnerable sectors and systems can be identified and preparedness strategies can be prioritized. The timescale and spatial scale of climate impacts, risks and vulnerabilities are important factors during this process.

STEP 4
Determine Preparedness Strategies

Because stakeholders working on the plan have the most direct knowledge of and expertise with elements of their respective planning sectors, they collectively discuss, identify and prioritize preparedness strategies for inclusion in the plan.

Top 10 No-Regret Strategies

- **Reduce carbon pollution to minimize future climate impacts, thereby protecting public health and safety.**
- **Use green infrastructure to manage and collect stormwater and dry-weather runoff.**
- **Improve urban water conservation and efficiency.**
- **Improve water conservation and efficiency among commercial, industrial and institutional (CII) users.**
- **Increase agricultural water efficiency and manage water-quality impacts.**
- **Increase the use of reclaimed wastewater.**
- **Increase water efficiency in energy production to save water (and fish).**
- **Preserve and restore wildlife habitat for source-water and flood protection.**
- **Improve land-use planning to reduce building in vulnerable areas.**
- **Ensure effective emergency response and hazard mitigation planning.**

This guide contains a toolbox of strategies for dealing with climate risks as they relate to agriculture; energy, transportation and urban infrastructure; fisheries and aquatic ecosystems; oceans and coastal resources; public health and safety; tourism and recreation; and water management. As a starting point, all states should consider the Top 10 No-Regret Strategies.

STEP 5
Finalize the Plan

The climate change risks and preparedness strategies identified by stakeholders are compiled into a draft plan, which is then released for public comment. The public comment period is a crucial opportunity for individuals and groups not directly involved with the planning process to provide input and feedback. Revisions are made to the draft based upon comments received, and a final version is released.

STEP 6
Implement and Update the Plan

Following the release of the final state climate preparedness plan, implementation begins. The identification of tasks, time frames and lead agencies responsible for implementation during plan development helps to facilitate this process. Preparing for climate change may require an iterative approach. Therefore, once implementation begins, it is necessary to monitor and reevaluate strategies as they are implemented to determine whether they are effective in achieving preparedness goals. Additionally, the state should regularly reevaluate climate change projections as new research is completed. Finally, committing to updating the state climate preparedness plan on a regular basis to incorporate these new developments is key to building long-term resilience to climate impacts.

To weather the variability inherent in the future climate, states need to plan and prepare for a wide range of possible impacts to ensure that communities remain resilient in the face of climate change. Whether states experience a significant lack of water or far too much, recent extreme weather and climate disasters serve as a reminder of how dependent we are on our limited water resources and how vulnerable we are to deviations from the norm. Many more states need to develop and implement climate preparedness plans to protect individuals, communities and ecosystems from the extremes at both ends of the spectrum. The mark that climate change is leaving on our nation's water resources and on our communities is already being seen, and with climate impacts intensifying, it is critical that states start planning and preparing now. We cannot afford to wait any longer. There is far too much at stake.

Introduction

FLOODING IN CEDAR RAPIDS, IA | DON BECKER, USGS

Across the United States, the impacts of climate change on water resources are already being observed. Historic floods, droughts and other extreme events in recent years illustrate nature's force and what we should continue to expect in a changing climate. The U.S. Global Change Research Program (USGCRP) has found that increasing air temperatures have already begun to alter the water cycle. Furthermore, changes in precipitation patterns and intensity, runoff and soil moisture, and drought frequency already have been observed, as have increases in evaporation and snowmelt, loss of lake and river ice and rising water temperatures.[7] These changes, along with rising sea levels, are beginning to fundamentally alter our communities and natural resources by affecting all sectors that rely on and are impacted by water, including

Observed Impacts to the Water Cycle from Climate Change[6]

- Changes in precipitation patterns and intensity
- Changes in the incidence of drought
- Widespread melting of snow and ice
- Increasing atmospheric water vapor
- Increasing evaporation
- Increasing water temperatures
- Reductions in lake and river ice
- Changes in soil moisture and runoff
- Rising sea levels

water supply and quality, public health and safety, transportation networks, energy production and vital ecosystems, among others. Increasing variability and uncertainty in water resources and the subsequent impacts on people, communities and ecosystems will only intensify as the release of heat-trapping greenhouse gases continues to grow and temperatures rise further.

In addition to water-related impacts, rising temperatures from climate change also will result in a wide range of impacts in other areas, including increases in the severity and frequency of heat waves, increases in wildfire risk, reductions in crop productivity, changes in disease vectors, losses in biodiversity and changes in forest species composition, to name a few.[8] Because of the interconnected nature of ecosystems, these impacts also can affect water resources. For example, wildfires contribute to the sedimentation of reservoirs and erosion of streams, damage aquatic habitats and can increase water treatment needs.[9]

Around the country, states are taking action to address the causes and effects of climate change. More than 35 states have recognized the importance of reducing carbon pollution and have developed reduction plans. Additionally, many of these states are now implementing mechanisms to reduce the emissions of heat-trapping pollutants from major sources. Ten states also have developed comprehensive plans to prepare for the projected impacts of climate change.[10] While this is a start, more states need to plan ahead and prepare for these impacts. The failure to consider climate change in water resources decision-making leaves states unnecessarily vulnerable to climate impacts. By developing and implementing preparedness plans, states can manage the impacts of climate change by protecting public health, the economy and the environment.

The goal of this guide is to provide state governments, water managers and other stakeholders with information to help them comprehensively plan and prepare for the impacts of climate change on water resources by identifying vulnerabilities, implementing adaptive solutions and building the resilience of relevant sectors. This document focuses exclusively on preparing states for water-related climate change impacts and the resulting implications for communities and the environment; therefore other impacts are not directly addressed. However, the planning process and examples described in this guide are applicable to and can be used to develop a comprehensive climate change preparedness plan that addresses all climate impacts. Non-water impacts (e.g., heat waves, declining air quality) will have wide-ranging ramifications for people, communities and ecosystems. To effectively prepare for climate change, states also must understand and consider these impacts when following the preparedness planning steps included in this guide.

To develop this guide, state agency officials who were instrumental in the development of their state's climate preparedness plan were interviewed. These officials shared information regarding their planning and implementation experiences, including the process utilized and the challenges encountered. Additionally, an extensive literature review of resources developed by governments, research institutions and nongovernmental organizations (NGOs) was conducted to inform both the planning process discussed in this guide and the preparedness strategies recommended. Some of these resources are listed in Appendix III.

This guide does not intend for every state to follow a single path to prepare for climate change. Indeed, climate impacts will vary by region, and the strategies available to manage these impacts will be shaped and limited by existing state laws, policies and governance structures. Further, there are significant variations among the states with respect to budgetary funding, staffing resources and political support for climate change preparedness.

To assist in accommodating these differences, the process for developing a state climate preparedness plan for water resources contained in this guide is divided into three tracks: Basic, Moderate and Robust. States can choose the most appropriate track to guide them in creating a water-focused preparedness plan. Each step of the planning process, from developing a coordinating group and identifying vulnerabilities to determining strategies and writing a final plan, is outlined for the three tracks.

PLANNING TRACKS

Basic: Every state can take meaningful steps to address the water-related threats from climate change. Components of this track are not likely to require additional funding, additional staff resources, or legislative or regulatory changes. Preparedness strategies focus on no-regret and low-regret approaches, which provide multiple benefits with relatively minor investments.

Moderate: States on this track have the capacity to mobilize more resources to develop a climate preparedness plan. They can conduct a more in-depth assessment of potential climate change impacts and related vulnerabilities and can consider more resource-intensive preparedness strategies. This track may require additional funding for the planning and implementation processes.

Robust: Climate change is a top-level priority for states choosing this track, and there is substantial support and capacity for climate preparedness planning. The planning process likely requires additional funding and technical resources and greater stakeholder engagement. Preparedness strategies considered for implementation include the creation of new institutions, system-wide retrofits, and changes to regulatory and legal frameworks.

In some steps of the planning process, the Moderate and Robust tracks progressively build upon actions contained in the preceding track(s). These more resource-intensive actions are necessary for states that are fully committed to ensuring they are best prepared for a changing climate. States also have the option to follow different tracks for each step, given differences in state priorities, resources, and legislative and regulatory processes. Where possible, state examples are included in this guide to illustrate how some states have conducted their planning process.

Given the variability of future climate change, it will be essential for states to prioritize the implementation of flexible and adaptive strategies, including no-regret strategies, that perform well in the face of uncertainty and increasing climate variability. In addition, to effectively prepare for the impacts of climate change, states will need to integrate climate preparedness concepts into routine planning and management practices. For example, the California Department of Water Resources developed the *Climate Change Handbook for Regional Water Planning* to help regional water-governance cooperatives incorporate climate change considerations into regional water management planning.[11] Additionally, the California Natural Resources Agency and the California Emergency Management Agency developed the *Adaptation Planning Guide* to help municipalities incorporate climate change considerations into planning.[12] Implementation continues to be the most challenging component of climate preparedness. While developing plans is an essential step, planning alone will not make states more resilient to a changing climate.

No-Regret Strategies

Cost-effective, flexible approaches that are beneficial to communities today and even more beneficial with future climate impacts.

A comprehensive, two-pronged policy approach is necessary to manage climate change risks to human and natural systems. Reducing the release of heat-trapping pollutants and taking measures to reduce the vulnerability of natural and human systems to climate change impacts are both critical.[13] Globally, the level of greenhouse gas emissions determines the severity of climate change impacts. The only way to minimize climate change is to reduce the emission of heat-trapping greenhouse gases. As states address climate preparedness, they should also formally adopt climate change mitigation policies that establish greenhouse gas emissions targets and reduce emissions by, among other things, improving energy efficiency, cleaning up existing sources of pollution and pursuing clean energy technologies. In order to reduce the risk of potentially catastrophic events, stringent actions also must be taken by industry and individuals to reduce carbon pollution.

While it is essential that efforts to reduce global warming pollution continue, the impacts of climate change will affect communities for the foreseeable future even with the most stringent efforts to reduce the release of heat-trapping pollutants into our atmosphere. To ensure that our communities are safe and resilient to the climate change impacts already under way, it is critical that states embrace climate preparedness planning and begin working toward integrating climate change into routine program operations and planning. By both addressing the underlying cause of climate change and preparing for its impacts, states across the nation can take action to protect the safety, well-being and livelihoods of people and preserve the integrity of natural resources for future generations.

STEP 1
Getting Started

1.1 Recognizing the Threats and Building Support

In order to build public support and galvanize state officials to develop a state climate preparedness plan, climate impacts affecting the state need to be understood. Often, it is necessary to describe localized impacts and build concern, interest and support for climate action before embarking on a formal process to develop a state preparedness plan.

To assess the likely changes in climate and their consequences for the state, research into climatic changes should be conducted. Projected changes in temperature, precipitation and sea level can be based on state-specific studies, which may be available from research institutions within the state or in nearby states. If state-specific data are not available, resources on regional climate impacts are available from sources such as the U.S. Global Change Research Program's (USGCRP) National Climate Assessment, U.S. Environmental Protection Agency's (EPA) Climate Ready Water Utilities program, the Intergovernmental Panel on Climate Change (IPCC) and others. In particular, USGCRP's 2013 National Climate Assessment has up-to-date regional climate change and sea level scenarios.[14] Additionally, Appendix I of the Center for Climate Strategies' *Adaptation Guidebook* contains a compendium of useful resources for national, regional, state, local and sector-focused climate change assessments.[15]

Once this information is compiled, education and outreach directed at state agency officials, legislators and the governor's office can help to build concern, interest and support for formal climate preparedness planning. Educating the public about climate impacts and the need for planning also can help persuade government officials and legislators to act.

1.2 Committing to Preparedness Planning

A commitment to the planning process is necessary for a strong plan. This commitment can take many forms. While not a prerequisite for state-level preparedness planning, legislative and/or gubernatorial action (e.g., legislative act, executive order) has been the initial driving force for many states that have conducted climate preparedness planning. Formal support by the state legislature and/or the governor is an important component for affirming, sustaining and institutionalizing state-level actions on climate change.

States that utilize legislative means are likely to sustain progress and effective action on climate preparedness because legislation is generally legally enforceable and not as susceptible to changes

in the executive branch. Depending on the level of engagement and political support, there are several options available to initiate and sustain preparedness planning:

1.2 Basic Track

- Staff-led directives
- Request by governor or agency executive
- Executive Order

1.2 Moderate Track

- Legislative act

1.2 Robust Track

- Comprehensive legislative act

For additional information and examples of the different types of formal commitments a state can make, refer to Appendix I.

1.3 Allocating Initial Resources for the Planning Process

After formally committing to climate preparedness, it is critical to identify available funding and staffing resources for developing the plan. Possible sources of funding include state and federal programs and funding potentially available from non-profits, foundations and the private sector. Available federal funding sources include Coastal Zone Management (CZM) funds from the National Oceanic and Atmospheric Administration (NOAA) and funds from the Federal Emergency Management Agency (FEMA). Collaborations with universities to obtain assistance from graduate students and researchers also represent key opportunities to leverage expertise during the planning process. For a list of potential funding sources for developing a climate preparedness plan, refer to Appendix II.

Wisconsin Initiative on Climate Change Impacts[16]

The Wisconsin Initiative on Climate Change Impacts (WICCI), a collaborative partnership between the University of Wisconsin and the Wisconsin Department of Natural Resources, is an example of a state climate preparedness planning effort that originated outside of the executive or legislative level. As part of WICCI, researchers, scientists, resource managers and policy-makers contributed to the development of a state preparedness plan. In 2011, WICCI released a comprehensive report, developed by 15 working groups, detailing likely climate change impacts in the state and potential adaptation strategies. The success of WICCI has attracted the attention of neighboring states like Michigan, which modeled its Michigan Climate Coalition after WICCI.

Washington State Legislation[17]

In 2009, Washington Governor Christine Gregoire signed legislation passed by the Washington State Legislature directing state departments to develop an integrated climate change response strategy. Senate Bill 5560 (2009) required the departments with authority over ecology, agriculture, community, trade, economic development, fish and wildlife, natural resources and transportation to collaboratively develop a strategy. In April 2012, Washington released its climate response strategy, which built upon interim recommendations made by four topic advisory groups created to assist in this process.

Funding Sources for Delaware and Maryland[18]

Some states have utilized federal funding for state coastal management programs to help develop their climate preparedness plans. Delaware used grant funding from NOAA for its recently completed sea level rise vulnerability assessment, in which the Sea Level Rise Advisory Committee (SLRAC) evaluated the state's vulnerability to a sea level rise of 0.5 to 1.5 meters (1.6 to 4.9 feet) by the end of the century. To complete the first phase of the state's adaptation strategy, which focused on risks from sea level rise and coastal storms, Maryland used federal CZM Act funds for the publication process. For the state's phase II strategy, which focused more broadly on other affected sectors, Maryland utilized funding from a local foundation to hire staff from the University of Maryland to help facilitate the planning process and draft portions of the final report.

1.3 Basic Track

- Conduct preparedness planning utilizing existing funds, staff and planning processes available within state agencies (e.g., using the existing planning process for the state water plan, wildlife management plan, drought plan and hazard mitigation plan)

1.3 Moderate Track

- Utilize resources identified in the Basic Track, and allocate additional funding and staff for plan development

1.3 Robust Track

- Utilize resources identified in the Basic Track, and allocate additional funding for new staff or consultants to help with components of the planning process (e.g., conducting a vulnerability assessment, facilitating work groups, drafting reports)

In addition to identifying available funding and staffing resources, establishing a time line for the planning process is crucial for timely development of a state climate preparedness plan. Directives to develop a plan (e.g., agency executive request, governor's executive order, legislation) may contain a final deadline for plan completion and should be taken into consideration when setting a time line and developing a work plan. The completion of a state preparedness plan should be prioritized so that implementation of strategies identified in the plan can promptly begin.

STEP 2
Establishing Coordinating Groups and Goals

After a state agency, the governor's administration or the state legislature has demonstrated support for the development of a climate preparedness plan, the management and logistics of the planning process must be determined. Diverse teams and work groups are critical to ensuring that a wide variety of interests within the state are considered during the planning process. The challenges that states are likely to face require significant collaboration and leadership, not only between sectors, but also among different levels of government, nonprofit organizations, the private sector, other institutions and the public. In particular, states should recognize that many decisions regarding water resources management, land use and planning are made at the regional and local levels. Strategy implementation by the public and private sectors and individuals at these spatial scales will be integral to building community and statewide resilience to climate impacts. These local and regional decision-makers should be a key component of the state planning process. Building collaborative and nontraditional partnerships will be crucial to managing risks as climate change intensifies. The ability to work together and to leverage existing collaborative relationships is an invaluable resource for increasing climate resilience.

GROUP PLANNING | CERTS

Adaptive Institutions[19]

One of the main challenges in preparing for climate change is that many institutions charged with implementing strategies are very static and adhere to prevailing concepts in the way they approach water management. To adeptly manage these changes, institutions will need to become more adaptive and flexible. For example, in addition to developing water management plans for a 50-year time horizon, institutions also need to plan over the short term, taking into account the variability and uncertainty associated with climate change and its impacts on water resources.

2.1 Building the Climate Preparedness Team

A Climate Preparedness Team, composed of senior-level staff and stakeholders, is responsible for the overarching development and coordination of the state's climate preparedness plan. Additionally, it is instrumental in identifying individuals and agencies that will be responsible for implementing the plan's recommendations. In the Moderate and Robust tracks, sector work groups advise the Climate Preparedness Team by identifying climate risks, assessing vulnerabilities to projected water-related climate impacts (e.g., warmer temperatures, precipitation changes, rising sea levels) and identifying specific strategies to address these vulnerabilities. These work groups are an essential component of the planning process, although their size and composition vary between the two tracks. In the Basic Track, the Climate Preparedness Team conducts the climate risk and vulnerability assessment and determines appropriate strategies itself.

In all three tracks, the Climate Preparedness Team coordinates the overall development and imple-

mentation of the plan by establishing overarching principles and goals to guide the planning process and by leading decision-making regarding the plan (including organizing the technical analysis for the climate risk and vulnerability assessment). With the exception of the Basic Track, the Climate Preparedness Team also is responsible for establishing sector work groups. Once the work groups have recommended strategies, the Climate Preparedness Team reviews these strategies, identifies common themes among the sectors and determines a final set of strategies for the plan.

It is critical for state entities with jurisdiction over areas that are likely to be impacted by climate change—such as water quality, water supply, emergency response, transportation, energy, public health, aquatic wildlife and coastal management—to be members of the Climate Preparedness Team. Below are potential agencies to include:

- Department of Energy
- Department of Environmental Protection
- Department of Fisheries and Wildlife
- Department of Natural Resources
- Department of Public Health
- Department of Tourism
- Department of Transportation
- Department of Water Resources
- Emergency Management Agency
- Public Utilities Commission

The names and composition of these agencies vary from state to state, so it is critical that a thorough assessment and review of all relevant agencies, boards, commissions and other public entities be conducted.

Members of the Climate Preparedness Team also should have the authority or ability to make or influence management and policy decisions within state agencies, the governor's administration or the state legislature. In addition, external stakeholders must be involved to provide additional perspectives and help to garner broad support within the state. Stakeholders from local, county and federal government, research institutions, community organizations, vulnerable populations, impacted sectors and NGOs have important perspectives to contribute as part of the Climate Preparedness Team. The number of external stakeholders on the Climate Preparedness Team may vary depending on the track followed.

Table 1. Members of the Climate Preparedness Team in the Basic, Moderate and Robust Tracks.

GROUP	TASK	TRACK	MEMBERS
Climate Preparedness Team	**Coordinate development of the plan, identify common themes and compile the final plan**	Basic	State agencies and entities impacted by climate change and some external stakeholders
		Moderate and Robust	State agencies and entities impacted by climate change and multiple external stakeholders with cross-cutting areas of expertise

2.2 Building the Sector Work Groups

In the Moderate and Robust tracks, sector work groups are established by the Climate Preparedness Team to identify climate risks and vulnerabilities and determine appropriate preparedness strategies in their areas of expertise. In the Basic Track, the Climate Preparedness Team conducts these activities itself. Examples of sectors that are likely to be affected by impacts and possible work groups to establish in the Moderate and Robust tracks are included in Table 2. The Climate Preparedness Team determines the composition of the work groups, which can include members from the Climate Preparedness Team in addition to other stakeholders. Similar to the external stakeholders on the Climate Preparedness Team, members from state and local entities, research institutions, academia, NGOs, community groups, business and industry, and other interested parties have substantial expertise and knowledge to contribute as part of the work groups.

Table 2. Members of the sector work groups in the Basic, Moderate and Robust Tracks.

GROUP	TASK	TRACK	MEMBERS
Sector Work Group(s)	**Identify sector risks, assess vulnerability and recommend strategies to prepare for climate impacts**	Basic	There are no separate sector work groups as the Climate Preparedness Team conducts these activities itself.
		Moderate	Representatives from government agencies and external stakeholders. Work groups could include: ■ Communities and Infrastructure ■ Commerce, Tourism and Recreation ■ Public Health and Safety ■ Natural Resources
		Robust	Representatives from government agencies and external stakeholders, representing many different sectors. Work groups could include: ■ Agriculture ■ Energy, Transportation and Urban Infrastructure ■ Fisheries and Aquatic Ecosystems ■ Ocean and Coastal Resources (if applicable) ■ Public Health and Safety ■ Tourism and Recreation ■ Water Management

The Climate Preparedness Team and/or each work group appoints a chairperson (or co-chairs), responsible for coordinating and leading work group meetings and activities. This leader also meets regularly with other work group chairpersons to discuss common issues and to routinely communicate findings and progress to the Climate Preparedness Team. Work groups should meet at least once per month during the planning process. Early in the process, the Climate Preparedness Team also establishes procedures and protocol governing how the work groups operate and function.

2.2 Basic Track

There are no sector work groups in this track because members of the Climate Preparedness Team identify climate risks and vulnerabilities and determine the necessary strategies for implementation. However, as necessary, the Climate Preparedness Team should seek input from state agency staff and other experts who are not formal members of the team.

Oregon's Planning Group

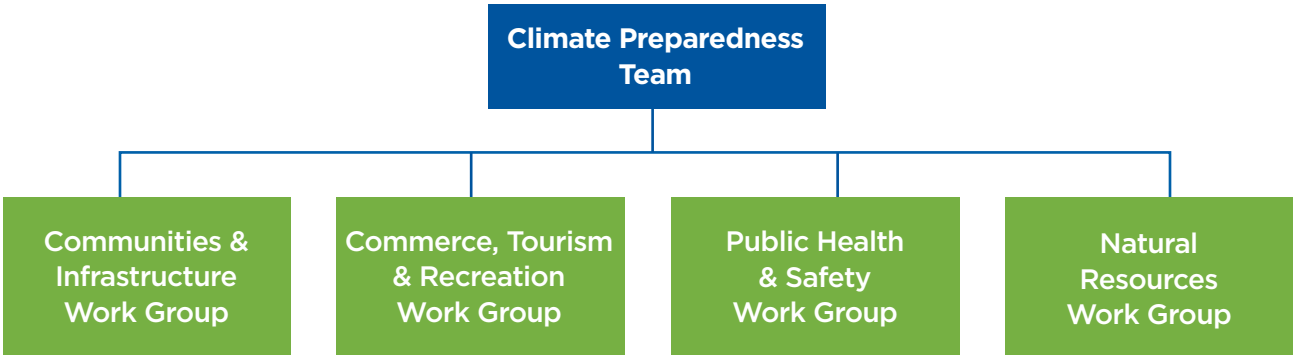
Oregon established one group to cover the array of sectors likely to be impacted by climate change. Members consisted of both a staff-level and a director-level employee from each of more than 20 state agencies and university institutions. External stakeholders were not included in Oregon's planning process to try to facilitate a rapid assessment of policy and quickly establish the initial foundation for future state-level actions on climate preparedness.[20] While this may have helped to streamline the state's planning process, the lack of external stakeholders also precluded a wider range of perspectives and ideas from being considered.

2.2 Moderate Track

The Moderate Track requires greater engagement than the Basic Track. Within the Moderate Track, specific work groups are clustered by topical area. This structure allows greater collaboration, inclusiveness and the development of strategies that provide benefits to multiple sectors. Potential work groups for this track include the following topical areas:

- **Communities and Infrastructure**—covering climate change implications for water resources management; transportation, energy and communications infrastructure; buildings; and land use
- **Commerce, Tourism and Recreation**—covering climate impacts on commercial fisheries, water recreation, agriculture and water-based transport
- **Public Health and Safety**—covering climate change implications for public health and emergency management
- **Natural Resources**—covering climate change impacts on aquatic, marine and riparian ecosystems

Figure 1. Examples of sector work groups in the Moderate Track.



Work group participants come mainly from government agencies; however, each work group should also include numerous external stakeholders to allow for the consideration of a wide range of perspectives, expertise and preparedness strategies. The chairperson of the work group is responsible for organizing the group's activities and leading the meetings. This individual can be either an external stakeholder or from a state agency. The chairperson also is a member of the state's Climate Preparedness Team. Additionally, staff from state agencies provide administrative support and help facilitate discussion and collaboration among work group members.

Pennsylvania's Work Groups[21]

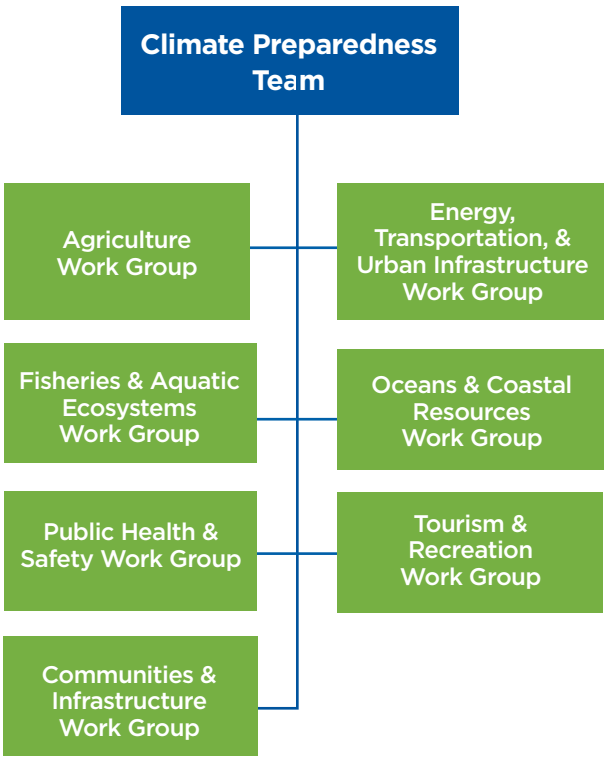
During Pennsylvania's preparedness planning process, four work groups were convened to address climate change impacts on various sectors: infrastructure, natural resources, tourism and outdoor recreation, and public health and safety. In order to equally represent the public and private sectors, co-chairs (one from each sector) were responsible for the coordination of each work group. Sixteen public meetings were held throughout the planning process to allow additional stakeholders and interested parties to weigh in on climate impacts, risks and potential strategies. The sector work groups allowed for numerous stakeholders to work together collaboratively—many for the first time. After receiving input from the general public, the co-chairs finalized their respective lists of preparedness strategies for inclusion in the final report.

2.2 Robust Track

The Robust Track requires the greatest level of commitment, engagement and resources. Work groups focus on individual sectors with significant external stakeholder input and participation. The larger number of work groups allows individual groups to thoroughly assess climate risks and to comprehensively determine potential preparedness strategies. It also ensures that additional stakeholders have the opportunity to participate in the planning process. Examples of sector work groups include:

- **Agriculture**
- **Energy, Transportation and Urban Infrastructure**
- **Fisheries and Aquatic Ecosystems**
- **Oceans and Coastal Resources** (where applicable)
- **Public Health and Safety**
- **Tourism and Recreation**
- **Water Management**

Figure 2. Examples of sector work groups in the Robust Track.



Work Groups in Wisconsin and Massachusetts[22]

Fifteen work groups were established to develop Wisconsin's climate impacts and adaptation strategies report. These groups focused on sectors as well as issues specific to geographic regions within the state. Their topics included adaptation, agriculture, Central Sands hydrology, climate, coastal communities, cold-water fishes and fisheries, forestry, Green Bay, human health, Milwaukee, plants and natural communities, soil conservation, stormwater, water resources, and wildlife. Some working groups had two or more chairpersons, reflecting the substantial roles of the University of Wisconsin system and the Wisconsin Department of Natural Resources. The Science Council of the Wisconsin Initiative on Climate Change Impacts (WICCI) oversaw the activities of the 15 work groups. WICCI also has an advisory committee composed of stakeholders from the public and private sectors, an outreach committee and an operations unit. In all, more than 200 people played a role in the development of the state's climate report.

Five technical subcommittees were established under the Climate Change Adaptation Advisory Committee in Massachusetts: natural resources and habitat, key infrastructure, human health and welfare, local economy and government, and coastal zone and oceans. A sixth subcommittee, focusing on land use, also was organized within the local economy and government subcommittee. Members of the subcommittees included full-committee members in addition to other experts and stakeholders. The subcommittees met multiple times during the planning process to review climate change impacts, identify risks and vulnerabilities, and determine preparedness strategies.

The work groups in the Robust Track include participants from both government agencies and external stakeholders, allowing a wide range of perspectives and ideas to be considered. In contrast to the other tracks, work groups are led by a pair of chairpersons, one from state government and the other from an external stakeholder organization. These individuals are jointly responsible for organizing the work group's activities and leading meetings. With the additional funding available in the Robust Track, a professional facilitator experienced in strategic planning and consensus building plays a key role in facilitating focused and productive discussion, resolving potential disputes and synthesizing recommendations.

2.3 Setting Overarching Goals and Guiding Principles

Overarching goals and guiding principles help facilitate the planning process. Common goals and principles ensure that all work groups have similar objectives in mind when identifying sector vulnerabilities and determining strategies to address these vulnerabilities. Guiding principles and goals should be established with respect to two criteria. First, the guiding principles and goals should create a template for how sector work groups will operate. Second, they should provide guidance as to what preparedness strategies should be priorities, taking into consideration economic, environmental and social costs and benefits.

These goals and principles provide a foundation for the planning process. Depending on the track, the Climate Preparedness Team, either alone or in conjunction with the sector work groups, determines what goals and priorities are critical to the success of the planning process. The final report contains a discussion of the goals and principles as well as common themes and strategies, providing an illustration of how the Climate Preparedness Team and sector groups were guided in their work.

2.3 Basic Track

The Climate Preparedness Team establishes overarching goals, priorities and guidelines for the planning process. Priorities address sectors that either are at the greatest risk from climate impacts, face the most severe impacts or are the most socially important to consider. If there are multiple priorities, they are ranked according to importance.

California's Guiding Principles[23]

These principles guided the state through a collaborative planning process by providing the framework for how the process should flow, what entities should be included and what issues should be prioritized:

- Use the best available science in identifying climate change risks and adaptation strategies.
- Understand that climate science is evolving, and that future climate scenarios are also always going to be evolving with new science, knowledge and models.
- Involve all relevant stakeholders in identifying, reviewing and refining the adaptation strategy.
- Establish relationships with all levels of government, tribes, business owners, landowners and nongovernmental organizations to develop and implement adaptation strategies.
- Give priority to adaptation strategies that initiate and enhance existing efforts to improve economic and social welfare, public safety and health, and ecosystem protection and function.
- When possible, give priority to adaptation strategies that modify and enhance existing policies over those requiring new funding and staffing.
- Understand the need for adaptation policies that are effective and flexible enough for circumstances that may not yet be fully predictable.

2.3 Moderate and Robust Tracks

The Climate Preparedness Team and the sector work groups collectively establish the overarching goals, priorities and guiding principles for the planning process. Through an open and fully engaged discussion, the team and work group members collectively determine the main objectives for developing a state climate preparedness plan. This goal-setting exercise helps to guide the work groups and resolve potentially competing interests. Sector work groups also individually develop more specific goals and priorities, which are aligned with the established overarching goals and guiding principles.

2.4 Promoting Cross-Sector Collaboration

While the tracks vary in terms of funding, staff resources and external stakeholder involvement, successful coordination and communication among the sector work groups is essential for any track. Work group chairpersons must coordinate with one another and meet regularly to discuss common and overlapping issues. Not only does this help to facilitate coordination and maintain progress toward established goals, but it also helps to foster relationships among the work groups, which can help promote continued collaboration during the implementation process.

2.4 Basic Track

Regular communication among members of the Climate Preparedness Team during the planning process is vital to building cross-sector relationships, promoting collaboration between state agencies and identifying cross-cutting issues encountered during the planning process.

2.4 Moderate and Robust Tracks

The Moderate and Robust tracks require a more in-depth approach to promote cross-sector collaboration and the identification of cross-cutting themes. The Climate Preparedness Team and work group chairpersons meet as often as once a month (Moderate) or even twice a month (Robust) to discuss themes and strategies arising from sector work group discussions. The identification of cross-cutting themes helps to determine preparedness strategies that allow all state agencies and external stakeholders to work together, reducing duplicative efforts, wasted resources and unnecessary confusion.[25] An individual section within the final preparedness plan should be devoted to a discussion of these common themes.

Cross-sector Collaboration in California[24]

When developing its 2009 adaptation strategy, California recognized the importance of cross-sector collaboration. Sector work group chairpersons met as a group at least once per month (usually twice) and had additional conversations over the phone to develop and resolve cross-sector issues. The state's climate adaptation strategy discusses the importance of collaboration in addition to detailing preparedness strategies common to multiple sectors. By doing so, the plan ensures that state agencies share responsibility and work together to achieve common goals. The collaborative efforts discussed in the 2009 strategy have persisted, and climate officials in state agencies continue to communicate regularly and coordinate preparedness actions.

WILDFIRE, NO NAME CREEK, CO | STEVE WILSON

STEP 3
Assessing Climate Impacts, Risks and Vulnerabilities

Increases in temperature and changes in precipitation patterns alter hydrologic cycles that, along with rising sea levels, will have wide-ranging impacts. It is critical for planning groups to first understand these potential changes and their impacts in order to then identify, prioritize and implement the most effective climate change preparedness strategies.

3.1 Scoping Climate Impacts and Risks

Once planning groups have been established, the next crucial step is to determine likely future changes in temperature, precipitation, hydrology, sea levels and ocean acidification (if applicable) and the resulting impacts on sectors in the state. Climate change impacts on water resources will have wide-ranging ramifications for people, communities and ecosystems. Table 3 summarizes some of the potential impacts, consequences and sectors affected by climate change; depending on the physical and climatological features of a state, these impacts may vary by region. The timescale of climate impacts also is an important decision. When determining the timescale of climate impacts to consider, the Climate Preparedness Team should examine the need for interim benchmarks, the time horizon of critical decision points and whether large investments or new infrastructure are being planned.

Table 3. Summary of potential water-related climate change impacts.

			SECTOR(S) AFFECTED						
CLIMATE CHANGE	**HYDROLOGIC IMPACT**	**CONSEQUENCE**	**Agriculture**	**Energy, Transportation & Urban Infrastructure**	**Fisheries & Aquatic Ecosystems**	**Oceans & Coastal Resources**	**Public Health & Safety**	**Tourism & Recreation**	**Water Management**
Temperature Increases	Increased Evapotranspiration	Reduced Lake and Reservoir Levels	●	●	●			●	●
		Reduced Streamflow	●	●	●			●	●
		Reduced Soil Moisture	●						
	More Precipitation as Rain Than as Snow	Reduced Snowpack	●	●	●			●	●
		Increased Winter Flooding in Watersheds That Historically Have Developed Large Seasonal Snowpack	●	●			●		●
	Earlier Snowmelt	Earlier Peak Runoff			●				●
		Reduced Summer Streamflow		●	●		●		●
	Increased Water Temperature	Changes in Range of Species			●	●		●	
		Reduction in Available Dissolved Oxygen			●			●	
		More Favorable Conditions for the Spread of Waterborne Disease					●	●	●
		Increased Competition From Invasive Species			●	●		●	
Precipitation Changes	Reduced Precipitation	Reduced Lake and Reservoir Levels	●	●	●			●	●
		Reduced Streamflow	●	●	●			●	●
		Reduced Soil Moisture	●						
		Reduced Groundwater Recharge	●						●
		Increased Wildfire Risk		●	●		●	●	●
	Increased Precipitation	Increased Discharges of Untreated Sewage During Combined Sewer Overflow (CSO) Events			●	●	●	●	●
		Flooding of Vulnerable Structures and Land	●	●			●		●
		Increased Stormwater Runoff and Flushing of Pollutants and Sediment into Waterways			●	●	●	●	●

Table 3 (continued)**. Summary of potential water-related climate change impacts.**

			SECTOR(S) AFFECTED						
CLIMATE CHANGE	**HYDROLOGIC IMPACT**	**CONSEQUENCE**	**Agriculture**	**Energy, Transportation & Urban Infrastructure**	**Fisheries & Aquatic Ecosystems**	**Oceans & Coastal Resources**	**Public Health & Safety**	**Tourism & Recreation**	**Water Management**
Sea Level Rise	Saline Intrusion	Contamination of Coastal Aquifers/Surface Water	●			●			●
		Degradation of Estuarine Habitats			●	●		●	
	Tidal and Wave Erosion	Loss of Coastal Habitats			●	●		●	
		Erosion of Vulnerable Structures	●	●		●	●	●	●
	Coastal Inundation	Flooding of Vulnerable Structures	●	●		●	●	●	●
Ocean Acidification	Marine Ecosystem Impacts	Degradation of Carbonate-based Marine Habitats (e.g., coral reefs and oyster reefs)			●	●		●	
		Impairment of Organisms' Ability to Build/Maintain Calcium Carbonate Shells and Skeletons			●	●		●	
		Alteration of Marine Food Webs			●	●		●	

RAPTURE REEF, FRENCH FRIGATE SHOALS, HI | GREG MCFALL, NOAA

3.1 Basic Track

The Climate Preparedness Team builds on the climate risk and vulnerability information initially identified during the support-building phase by first carefully considering what spatial scale and timescale will be used for the risk and vulnerability assessments. These factors determine the scope of the preparedness plan's recommendations. Once the timescale is determined, more in-depth research into climate impacts can begin.

In addition to the resources listed in Step 1, another potential source of information is the Regional Integrated Sciences and Assessments (RISA) program within NOAA. Eleven teams are currently operating throughout the U.S., conducting climate research for local decision-makers.[26] In addition, climate change research data may be available from the Department of the Interior (DOI). DOI has eight regional Climate Science Centers (CSCs), which provide scientific information and decision support to 22 Landscape Conservation Cooperatives (LCCs). The LCCs are a network of public-private partnerships that cover the entire U.S. and aim to protect and conserve the nation's landscapes, fish, wildlife, plants and cultural heritage.[27] Additional information on the RISA teams, CSCs and LCCs is located in Appendix III. In the absence of local or regional-scale climate change projections, states can assess their vulnerability on the basis of experiences in the recent past and identify areas where climate change could worsen impacts.

Working with existing state-specific or regional climate change research, the Climate Preparedness Team conducts a qualitative assessment of potential climate change risks related to water. Because the Basic Track focuses mainly on actions that can be achieved in the short term, the Climate Preparedness Team should consider climate change scenarios and likely risks over the next 20 to 40 years.

3.1 Moderate and Robust Tracks

Strong scientific information is the crucial foundation for effective decision-making when it comes to climate change preparedness. Therefore, the Climate Preparedness Team enlists the help of research institutions or consultants to either identify (from existing scientific research) or independently develop climate change scenarios for temperature, precipitation, sea level rise and other important factors (e.g., hydrologic changes) at the state level and at useful regional and local scales. Potentially useful organizations during this process include universities within the state or in neighboring states, state climatology offices, NOAA RISA teams, DOI LCCs and CSCs, and technical consulting firms.

Climate Change in the Oklahoma Comprehensive Water Plan [28]

For the 2012 Oklahoma Comprehensive Water Plan, a technical consultant developed five climate change scenarios for the Oklahoma Water Resources Board: hot/dry, warm/dry, hot/wet, warm/wet, and a scenario representing the central tendencies of the four other scenarios. These scenarios were based on ensembles of climate model projections for temperature and precipitation for both the 2030 and 2060 time frames. To capture the full range of climate projections, the extreme scenarios (hot/dry and warm/wet) were used to determine surface water availability and changes in water demand over the next 50 years. A hydrology model was used to simulate changes in runoff, and a water demand model was used to simulate changes in water use for the municipal and industrial sector and the agricultural irrigation sector under both climate scenarios.

Given the uncertainties about the exact magnitude of future climatic changes, the Climate Preparedness Team and work groups should consider utilizing at least three scenarios, representing the low end, midrange and high end of climate change projections.[29] Alternatively, planning for a range that is bounded by the low and high extremes is acceptable. The climate planning scenarios should address likely changes over the next 20 to 100 years, depending on the management needs and issues impacting the state. The Climate Preparedness Team and the sector work groups should collectively identify and discuss likely climate change risks to relevant sectors on the basis of these climate change scenarios.

Climate Modeling and Uncertainty

Projections of future changes in temperature and precipitation are based on complex computer models called general or global circulation models, which replicate atmospheric and other processes that affect climate. However, due to the global scale of these models, they generally do not provide data for application directly at the regional or local level.[30] Consequently, data from global models often must be downscaled to more appropriate spatial scales using statistical or dynamical techniques (e.g., regional climate models). The output of these models, temperature and precipitation, can be further utilized in other models (e.g., runoff, soil moisture, pollutant transport) to increase understanding of potential future hydrologic changes and aid in planning for them. Global climate models are useful for projecting future climate, but there is still some uncertainty with these models. With high ambiguity on future carbon emissions and continued uncertainty regarding some earth system processes, long-term model projections can contain wide ranges in output.

While models are skillful at simulating processes at the continental to global scale, projections at regional and local levels have significantly more uncertainty over the exact extent and timing of future local impacts. Still, current models provide sufficient information on the range of likely impacts for planning to occur. Because climate modeling techniques are continually evolving, it is critical that planners maintain awareness of new developments and use the best scientific data available when determining potential climate impacts.

For additional information on climate modeling, please consult these references:

- National Academy of Sciences, "Climate Modeling 101," www.nas-sites.org/climatemodeling/index.php.
- IPCC, Climate Models and Their Evaluation (2007), www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter8.pdf.
- U.S. Climate Change Science Program, Climate Models: An Assessment of Strengths and Limitations (2008), www.climatescience.gov/Library/sap/sap3-1/final-report/sap3-1-final-all.pdf.

Potential Climate Impacts

Between 1906 and 2005, global surface temperatures increased approximately 1.3°F (0.74°C), or at an average rate of 0.13°F (0.074°C) per decade.[31] In recent decades, this rate of warming has accelerated. From 1956 to 2005, the warming trend averaged 0.23°F (0.13°C) per decade—nearly twice the rate of warming over the century as a whole.[32] According to the Intergovernmental Panel on Climate Change (IPCC), average global temperatures are projected to increase by 2°F to 11.5°F (1.1°C to 6.4°C) by the end of this century, depending on the rate of future emissions and the sensitivity of the climate system.[33] Increasing temperatures, changing precipitation patterns and rising sea levels are fundamentally altering our communities and ecosystems. The nature, extent and severity of these impacts will vary geographically.

Unfortunately, climate change and human activities have already affected and continue to affect the ability of natural systems to provide both ecological benefits and vital ecosystem services to our communities.[34] Maintaining these services will become increasingly important as the climate changes further and more intense and frequent extreme events occur. States with the most significant loss of natural resources will have fewer natural climate defenses, making them more vulnerable when it comes to mitigating impacts on human health, water supply, agriculture, coastal areas, and many other aspects of society and the natural environment.

Hydrologic Impacts

As temperatures increase further, the impacts on water resources are expected to intensify. Warmer temperatures increase evaporation from land and ocean surfaces, leading to greater moisture in the atmosphere. These atmospheric changes, in turn, are altering the distribution of precipitation by shifting storm tracks and amplifying hydrologic extremes, making wet areas wetter and dry areas drier.[35] Flooding events are also likely to become more common as more precipitation occurs during heavier and more intense events.[36] Conversely, drought conditions are also likely to occur more frequently as hotter temperatures reduce soil moisture and dry periods between rainfall events lengthen.[37]

As precipitation patterns and evapotranspiration rates change, runoff will also be affected. Reductions in snowpack, as well as increases in precipitation falling as rain instead of snow due to warmer air temperatures, impact the timing and quantity of runoff in snowfall-dominated watersheds in the western and northeastern U.S.[38] Furthermore, climate models project that eastern areas of the U.S. will experience increased runoff, while parts of the western interior and southwestern U.S. will face substantial declines.[39] Groundwater recharge rates will likely be reduced in areas where precipitation declines or surface runoff increases.[40]

Water quality also is expected to be affected by climate change. Warmer water temperatures that result from increasing air temperatures could impact aquatic habitats by reducing dissolved oxygen availability and prolonging stratification, in addition to exceeding the thermal tolerance of sensitive species, especially cold-water fish.[41] Increases in heavy rainfall events also could degrade water quality by flushing pollutants and increasing stormwater runoff into waterways, and seasonal reductions in streamflow could serve to increase the concentration of pollutants in streams, threatening drinking water supplies and the safety of recreation areas.[42] Furthermore, these conditions could lead to more frequent waterborne disease outbreaks as well as greater potential for algal blooms, particularly in water bodies that are experiencing low streamflow.[43]

These changes to hydrologic conditions will have wide-ranging impacts on our nation's cities, towns, neighborhoods and natural resources. Changes in streamflow and rates of groundwater recharge will have implications for water supply, and shifts in streamflow timing could impact hydropower production as well as aquatic wildlife. Wintertime flood risks could increase as snowmelt occurs earlier and more precipitation falls as rain as opposed to snow. More extreme rainfall events also are likely to increase flooding risks to property and overwhelm infrastructure such as wastewater treatment plants, which could lead to discharges of untreated sewage, exposing people to pathogens and increasing infectious disease risks. Drought conditions could potentially threaten all water users, including municipalities, agriculture and industry. Warmer temperatures also could compound water availability issues by increasing demand for irrigation and power plant cooling water.[44]

Coastal and Ocean Impacts

Many coastal areas will be particularly threatened by climate change as sea levels rise. Global sea level rise occurs due to the thermal expansion of water as it warms and the melting of land-based polar and glacial ice. Relative sea level rise is the net change in local sea level over time due to a combination of global sea level rise, local land subsidence or emergence (i.e., the falling or rising of the earth's crust) and changes in coastal and ocean circulation. From 1961 to 2003, the global average sea level rose at an average rate of 0.07 inch (1.8 mm) per year.[45] Like temperatures, the global rate of sea level rise has accelerated within recent decades. Between 1993 and 2003, the rate averaged about 0.12 inch (3.1 mm) per year.[46] In some coastal states, such as Louisiana, Texas and Virginia, land subsidence is contributing to rates of relative sea level rise of as much as 0.36 inch (9.24 mm) per year.[47] In its most recent assessment report, the IPCC projects that global average sea levels could rise 0.6 to 1.9 feet (18 to 59 cm) by 2100.[48] However, recent studies suggest that dramatically greater sea level rise, on the order of 2.5 to 6.2 feet (75 to 190 cm) by the end of the century, is possible due to the rapid melting of ice[49]—though there is considerable uncertainty regarding future acceleration of ice sheet mass loss.[50] In fact, NOAA recently released a report on global sea level rise for the U.S. National Climate Assessment, indicating that global mean sea level will rise between 0.7 and 6.6 feet (20 cm and 200 cm) by 2100.[51]

Because coastal areas are generally heavily populated and developed, many people and communities, and much property and infrastructure, could be at risk from permanent inundation, flooding and erosion associated with sea level rise. Low-lying areas will be subject to permanent inundation and flooding from both normal tidal events and storm-related surges. Sea level rise will increase water levels associated with normal tidal events and storm surge events, leading to more areas at risk from flooding. Sea level rise also is expected to exacerbate saltwater intrusion into coastal freshwater aquifers.[52] Since freshwater is less dense than saltwater, it forms the top layer of a coastal aquifer. The combination of freshwater withdrawals from aquifers and rising sea levels increases the likelihood that the saltwater layer in coastal aquifers will move closer to the surface.

Natural habitats also will be affected by rising seas. Coastal wetlands, beaches, natural dunes and barrier islands will be subject to permanent inundation and erosion. A sea level rise of 3 feet would submerge approximately 65 percent of all coastal marshlands and swamps in the U.S.[53] In many areas, wetlands act as a buffer against storm surge, wave action and erosion. In coastal areas where saltwater and freshwater mix, salinity changes from a combination of shifts in freshwater inflow and sea level rise could negatively impact vegetation and estuarine species. These ecosystems provide habitat for a wide range of

fish, birds and other wildlife.[54] In addition, commercially important shellfish and finfish species rely on tidal wetlands for habitat.[55] Consequently, changes to coastal habitats could have severe repercussions for a variety of estuarine and marine species.

As air temperatures rise, sea surface temperatures will rise as well. During this century, coastal waters are likely to warm by 4°F to 8°F.[56] Warmer ocean temperatures would undoubtedly impact the distribution and health of marine species. A northward shift in the distribution of marine species has already been observed as coastal waters have warmed beyond the temperature tolerance of some species.[57] Surface water warming also can lead to coral bleaching, which happens when corals become stressed and release their symbiotic algae.[58] When corals release these algae, they become white, and if the stress continues, the corals die. Coral reef ecosystems in the Atlantic, Caribbean and Pacific are rich in biodiversity and provide habitat and food to many marine species, in addition to being a large tourism draw.[59] Increasing atmospheric concentrations of carbon dioxide also are causing a decline in the pH of the oceans. More acidic conditions in the ocean impact the ability of marine organisms to maintain and build calcium carbonate shells and skeletons.[60] Plankton, shellfish and coral reefs are particularly vulnerable, and any reductions in populations of these species would disrupt the food chain.

Transportation and Energy Infrastructure Impacts

Changes in precipitation and rising temperatures may shorten the life span and increase the maintenance cost of all types of transportation infrastructure, including roadways, railways, ports and air transportation facilities, as greater flooding and hotter temperatures increase damage and the need for repairs. Transportation in coastal areas is at greater risk of damage from frequent and more permanent flooding from sea level rise and potential storm surge.[61] Areas that are expected to see a decrease in precipitation may see positive results in the form of less roadwork, but the impacts on shipping could be detrimental if water levels decline and become too shallow for ships and barges.[62] Transportation infrastructure is not only critical for the transport of people, goods and services, but also essential for evacuation in the case of disasters and emergencies.

Energy and water are indisputably connected. Water cannot be pumped, transported or treated without the use of energy. Conversely, in many places electricity cannot be generated without water to cool power plants or to move turbines at hydroelectric generation facilities. Changes in precipitation will likely impact energy production. Power plants often use a significant amount of water for cooling purposes. In areas with decreasing water supplies, water will increasingly become a source of conflict.[63] Also, because water is used for cooling, warmer water temperatures can negatively impact the efficiency of thermoelectric power plants or even result in shutdowns. Additionally, changes in streamflow can jeopardize energy production at hydroelectric power generation facilities.[64] Finally, extreme weather events and coastal flooding threaten energy infrastructure, supply and transportation systems located in vulnerable areas. In particular, coastal storms and sea level rise in the Gulf of Mexico will have significant effects on the oil and gas industry. Extreme storms and flooding also can damage power lines and electrical distribution centers.[65]

3.2 Assessing Sector Vulnerability

After determining potential climate impacts in a state, assessing the vulnerability of various sectors helps to inform whether preparedness strategies are needed. According to the IPCC, vulnerability is a function of a system's exposure to climate change and variability, its sensitivity (the degree to which it is affected) and its adaptive capacity (the ability to cope or moderate climate impacts).[66] Within the context of this guide, a system could be a building, a piece of infrastructure, a population group, a neighborhood or community, or a wildlife species, among others. The level of analysis used to assess a state's vulnerability to climate change largely depends on the resources available and the track followed. In particular, the spatial and timescales at which vulnerabilities are assessed are important considerations for the Climate Preparedness Team and the sector work groups.

For a more detailed discussion of the vulnerability assessment process, please consult additional planning resources, such as:

- California Department of Water Resources, U.S. EPA Region 9, U.S. Army Corps of Engineers and the Resources Legacy Fund, *Climate Change Handbook for Regional Water Planning (2011),* www.water.ca.gov/climatechange/CCHandbook.cfm.
- California Emergency Management Agency and California Natural Resources Agency, *California Climate Change Adaptation Planning Guide* (2012), resources.ca.gov/climate_adaptation/local_government/adaptation_policy_guide.html.
- Center for Climate Strategies, *Comprehensive Climate Action Planning: The Center for Climate Strategies Adaptation Guidebook* (2011), www.climatestrategies.us/library/library/download/908.
- David C. Major and Megan O'Grady, *Adaptation Assessment Guidebook* (2010), New York City Panel on Climate Change, onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/abstract.
- Patty Glick, Bruce A. Stein and Naomi A. Edelson (eds.), *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment* (2011), www.nwf.org/vulnerabilityguide.
- Roger Jones and Rizaldi Boer, "Technical Paper 4: Assessing Current Climate Risks," *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures* (2005), content.undp.org/go/cms-service/stream/asset/?asset_id=2200851.
- The Climate Impact Groups, University of Washington, King County, and ICLEI-Local Governments for Sustainability, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (2007), www.icleiusa.org/action-center/planning/adaptation-guidebook.

BRIDGE WASHOUT, SALISBURY, VT | ADAM FRANCO

3.2 Basic Track

Based on the potential climate risks identified, the Climate Preparedness Team determines the implications for sector vulnerability by addressing the following questions for various sector components over the short-term and mid-term time frames (e.g., the next 20 to 40 years):

- How sensitive is the system to the likely climate impacts identified?
- How adaptive, or able to cope, is the system likely to be to changing climatic conditions?
- What barriers exist in the system's ability to adapt?
- What is the level of exposure associated with future climate change scenarios?
- Based on the sensitivity, adaptive ability and level of exposure, how vulnerable is the system?

This process helps to identify the systems and sectors that are the most vulnerable to climate change impacts.

3.2 Moderate and Robust Tracks

Each sector work group considers the climate change scenarios developed and determines the sensitivity, exposure and adaptive capacity of systems in its respective sector to these changes. Vulnerabilities are assessed at different planning time frames: short-term (e.g., the next 20 years), mid-term (e.g., the next 40 years) and long-term (e.g., the next 100 years). Assessing vulnerabilities at different spatial scales also is critical, due to regional differences. Large states, and even small ones, have significant regional differences with respect to socioeconomic factors, natural resources distribution and topography that influence exposure, sensitivity and adaptive capacity to climate impacts. Sector work groups also consider the potential effects of non-climate factors, such as population growth, economic development and land use changes, which may increase vulnerability.

In addition, research or data gaps that present obstacles to accurate assessment of the vulnerability of specific systems should be identified and prioritized for further investigation. As additional research is completed, these data gaps can be narrowed, and strategies to address these vulnerabilities can be incorporated in future planning efforts.

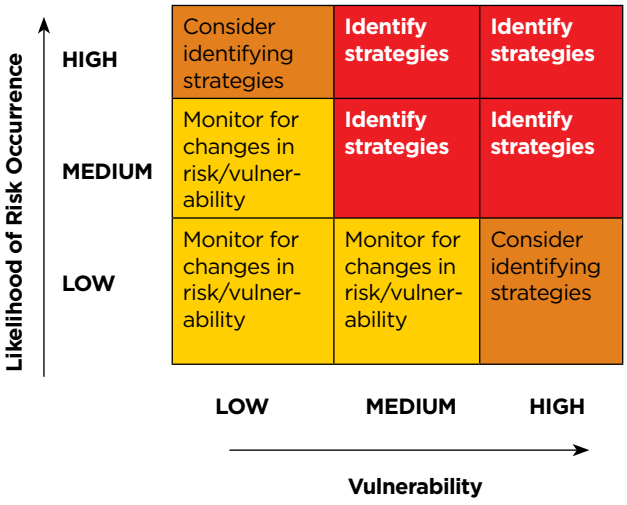
Delaware Sea Level Rise Planning [67]

As part of Delaware's process for developing a statewide preparedness plan for sea level rise, the Sea Level Rise Advisory Committee comprehensively assessed the state's vulnerability to a rise of between 0.5 and 1.5 meters (1.6 to 4.9 feet) by the end of the century. This analysis found that substantial portions of the state's coastal wetlands, flood-protection structures, coastal and industrial port facilities, and residential and commercial properties are vulnerable to future flooding and inundation. Critical public safety features, such as fire and rescue stations, police stations and evacuation routes, also are at risk from sea level rise. Public health is potentially further jeopardized by the thousands of septic tanks, more than 135 wastewater pumping stations and treatment plants, and 50-plus brownfield sites and landfills that are vulnerable to flooding from sea level rise.

3.3 Prioritizing Vulnerable Planning Systems and Areas

Vulnerability is an indicator of how susceptible a system or area is to the impacts of climate change. Risk occurrence is the likelihood that a particular event will occur under a given climate scenario. These two factors should be considered when determining which planning systems and areas will be priorities. Planning areas that are high in vulnerability and that are also highly likely to experience a particular climate risk should be prioritized for the identification of preparedness strategies (see Figure 3). For example, an area that is very likely to experience more intense storm events and that contains a high population density in low-lying areas has high risk occurrence and high vulnerability. Similarly, strategies should be developed for plan-

Figure 3. Planning prioritization matrix considering likelihood of risk occurrence and vulnerability.[68]



Prioritizing Planning Areas in New York, Alaska and Wisconsin[69]

Recognizing the dense population, vulnerable infrastructure and valuable assets located along New York's coastlines, the state legislature established the New York State Sea Level Rise Task Force in 2007 to recommend measures to protect coastal communities and natural resources from sea level rise. In 2010 the task force released a final report that proposed a range of strategies to address coastal climate change risks. Although many of the report's recommendations were not immediately implemented, the need to address coastal vulnerabilities relating to sea level rise, storm surge and flooding—and the urgency of this need—were underscored by Superstorm Sandy in 2012. The NYS 2100 Commission, one of four state commissions created in the aftermath of the storm, released recommendations in January 2013 for increasing the resilience of the state's infrastructure to future natural disasters.

Similarly, Alaska has prioritized the development and implementation of measures to protect Alaskan Native communities from climate change. Several villages have been deemed to be under "imminent threat" due to their remote locations, subsistence-based local economies and exposure to coastal hazards. These communities have received planning grants to design emergency shelters and even to evaluate relocation sites. Other vulnerable communities have received funding to assess local climate-change-related hazards due to erosion, flooding, storm surge and thawing permafrost. Yet the needed support for communities faced with displacement may be in jeopardy due to the dismantling of the state's Immediate Action Work group in 2011.

In Wisconsin's climate preparedness planning process, three working groups had a regional focus. The Central Sands hydrology, Green Bay and Milwaukee working groups were developed to address the unique local and regional factors in these three areas. The Central Sands region has been heavily altered by irrigated agriculture, the Green Bay area has an important ecosystem, and Milwaukee is the state's largest city. Each of these regions faces potentially different risks and vulnerabilities from climate change, so specific working groups were developed to address these challenges.

ning areas that are high-risk/medium-vulnerability, medium-risk/high-vulnerability or medium-risk/medium-vulnerability. Other combinations of risk and vulnerability also should either be considered for the development of strategies or be monitored for potential changes, depending on available resources.[70] In many cases, the prioritization of vulnerabilities also will be necessary at the regional or local level in order to reflect differing assets and values.

BIOSWALE, GREENDALE, WI | AARON VOLKENING

STEP 4
Determining Preparedness Strategies

Once the most vulnerable and at-risk areas and planning sectors have been identified, strategies that address these vulnerabilities need to be identified by the sector work groups, or in the case of the Basic Track, the Climate Preparedness Team.

4.1a Evaluating and Selecting Strategies

At the end of this guide is the Strategy Toolbox, which contains a comprehensive list of strategies to address water-related climate risks in seven main sectors: agriculture; energy, transportation and urban infrastructure; fisheries and aquatic ecosystems; oceans and coastal resources; public health and safety; tourism and recreation; and water management. These preparedness strategies have been identified from an extensive literature review and have been evaluated by subject matter experts to ensure they will help to build the resilience and reduce the vulnerability of people and ecosystems to climate change impacts. Many of these strategies are considered traditional best management practices because proper and effective management of existing threats to water resources helps to build long-term climate resilience. For example, the sustainable management of fisheries improves fish stocks and also helps to build ecosystem resilience to warmer water temperatures and changing streamflows brought about by climate change.

The Strategy Toolbox is organized first by sector, then by what goal or outcome the strategy achieves. Individual strategies are then generally listed from less intensive to more intensive in terms of resource needs, potential regulatory changes and the length of time likely necessary for implementation. However, given the vast differences among states in terms of existing resources, regulations and technical and financial capacity, state-specific circumstances will determine the feasibility and applicability of each strategy listed. Therefore, states should assess which strategies are most appropriate given the state and local contexts. Less intensive strategies are generally lower in cost and achievable in the short term—though these strategies often also provide long-term benefits. More intensive strategies may require the creation of new institutions, system-wide retrofits or comprehensive regulatory changes. Yet these strategies are likely to be the most effective at reducing long-term vulnerability to climate impacts.

In the Moderate and Robust tracks, the sector work groups play the primary role in determining preparedness strategies. Because members of the sector work groups have the most direct knowledge of and expertise with elements of their respective planning sectors, they should collectively work to discuss, identify and prioritize preparedness strategies for inclusion in the plan. Under the Basic Track, the Climate Preparedness Team conducts the strategy selection process.

To identify strategies for consideration, the Climate Preparedness Team (Basic) or sector work groups (Moderate/Robust):

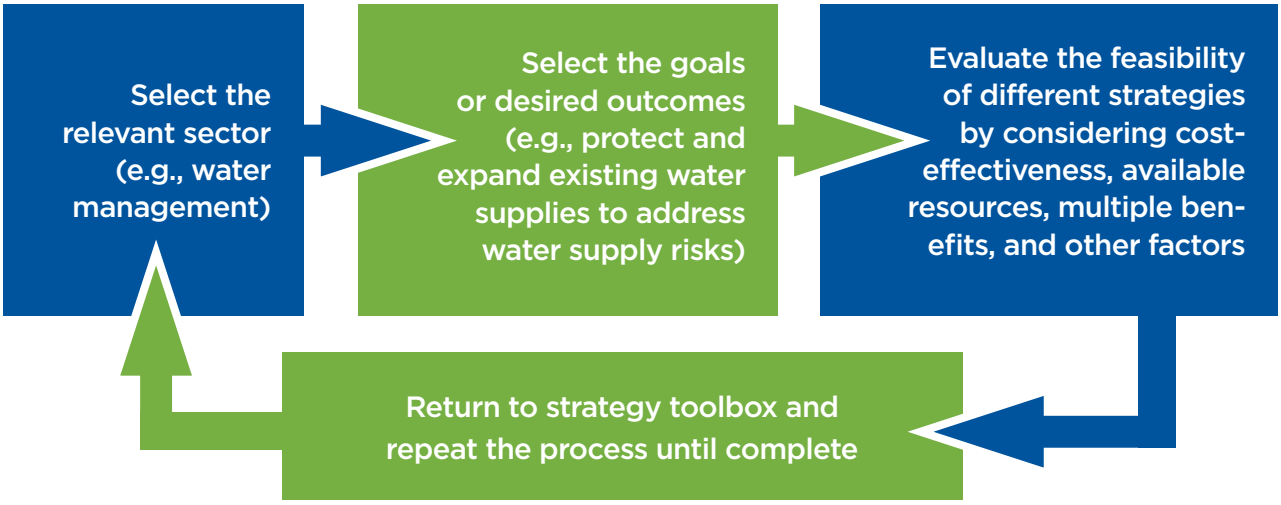


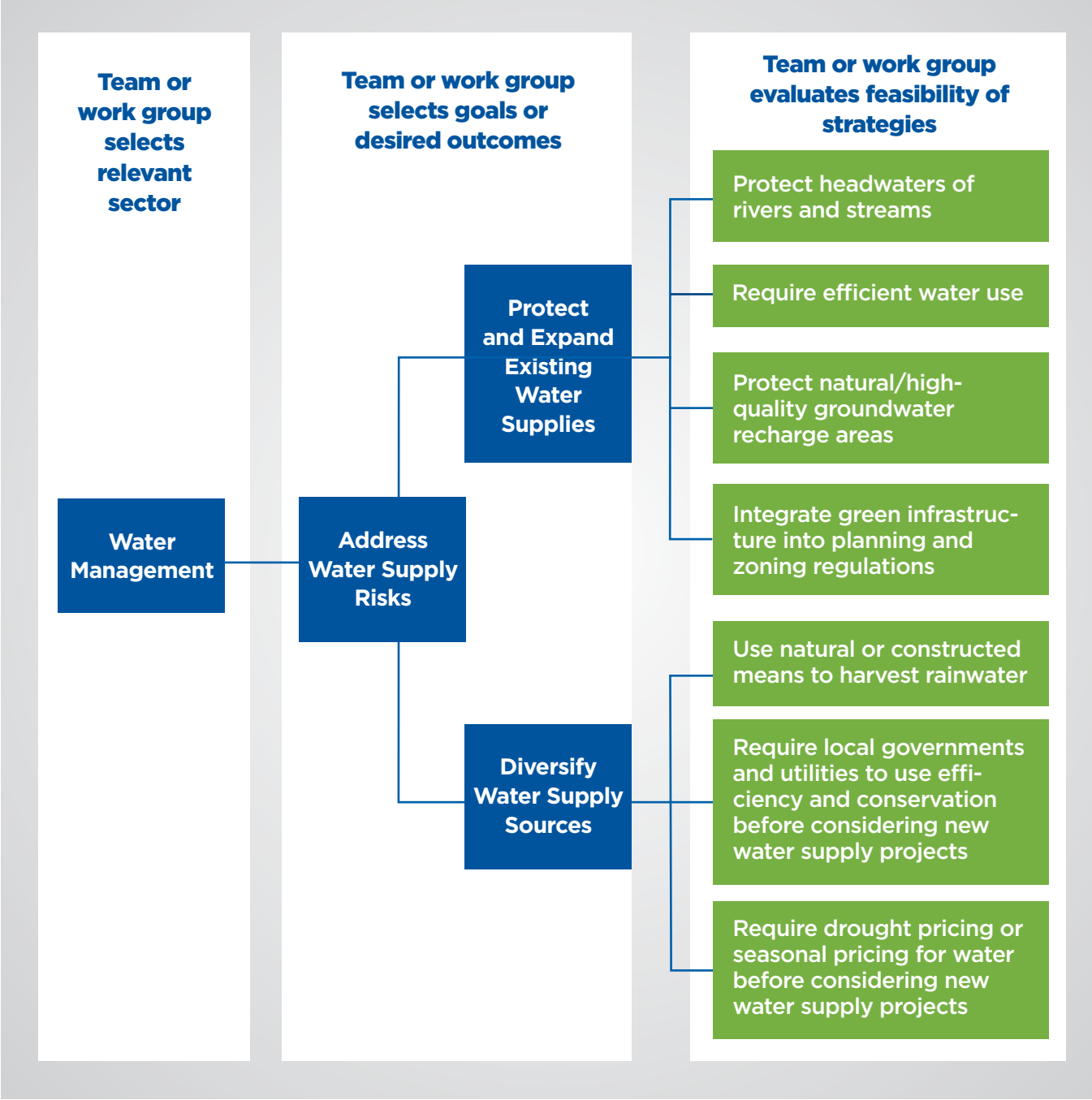
Figure 4. The process for using the Strategy Toolbox to determine strategies to include in the climate preparedness plan.

When determining the scope and nature of strategies to recommend, the Climate Preparedness Team or sector work groups should consider cost-effectiveness, potential resources necessary for implementation (including up-front costs and public support) and whether the strategy potentially yields multiple benefits, among other criteria. Institutional and physical barriers to implementation also should be considered, and strategies that are most likely to be successful in the existing regulatory and jurisdictional framework should be prioritized. As part of this process, the Climate Preparedness Team or sector work group needs to consider the actions that can be accomplished by state agencies and the existing opportunities and necessary support and incentives needed to facilitate action by regional and local agencies, the private sector and other nongovernmental entities.

Once a list of potential strategies has been developed, in the Moderate and Robust tracks, members of the sector work group determine which strategies to recommend to the Climate Preparedness Team. A state agency facilitator or professional facilitator can help members reach decisions on preparedness strategies. In the Basic Track, the Climate Preparedness Team determines which strategies to include in the final plan.

One of the most predominant impacts of climate change is likely to be increasing water scarcity. Warmer air temperatures and changing precipitation patterns are expected to reduce available water supplies while rising population and the growing need for water increase water demand. There are many strategies that states can implement to address water supply risks by protecting existing water sources and diversifying water supplies. An example of how the toolbox can be used to find strategies to address water supply risks is illustrated in Figure 5.

Figure 5. An example of how a Climate Preparedness Team or sector work group can use the Strategy Toolbox to find ways to address water supply risks.



Because water resources are utilized by multiple sectors, management decisions are inherently complex and must take into account many objectives. For example, decisions regarding the operation of surface water reservoirs must consider not only water supply, but also ecosystem stewardship, public safety, recreation and energy production. The goal of water resource management should be to consider these objectives in an integrated and holistic fashion. However, for the sake of simplicity and ease of use, the strategies in the toolbox are organized according to sector.

Although many of the preparedness strategies contained in the toolbox provide multiple benefits and address numerous climate risks, most strategies are listed only once—within the most relevant sector—to eliminate redundancy. Nonetheless, strategies to address coastal and ocean resource issues are also located within the public health and safety, tourism and recreation, and fisheries and aquatic ecosystems sections. Green infrastructure strategies, which provide multiple cross-cutting benefits such as stormwater management and groundwater recharge, are contained primarily within the water management section. In contrast, some strategies that may be under consideration by sector work groups could potentially be beneficial to some sectors while also being detrimental to the adaptive ability of other sectors. For example, the expanded use of reclaimed wastewater could have negative public health implications if not conducted properly. It is essential for work groups to communicate and collaborate (as discussed in Step 2) to eliminate strategies that may help one sector while having unintended or detrimental consequences for others. The Climate Preparedness Team also can help to eliminate potentially conflicting strategies. The potential overlap and interdependence of many of these strategies reflects the integrated nature of water resources.

Pennsylvania's Cross-cutting Strategies[71]

In Pennsylvania, some examples of cross-cutting strategies include green infrastructure, wildlife and fish habitat conservation, the establishment of a climate adaptation task force and the integration of adaptation and mitigation strategies into planning and operations.

4.1b Determining the Implementation Mechanism and Process

For each strategy recommended for inclusion in the final plan, the Climate Preparedness Team (Basic) or sector work groups (Moderate/Robust) must determine the potential implementation mechanism and process. The Climate Preparedness Team or sector work groups should consider the following possible options:

- Agency management practices
- Bond issues
- Building codes and design standards
- Emergency management powers
- Financial incentives
- Infrastructure development
- Permitting and enforcement processes
- Public outreach and education
- Public safety rules and regulations
- Utility rates and fee setting
- Taxation
- Zoning rules and regulations[72]

This process includes the identification of discrete tasks or actions necessary to fully implement each strategy—and an accompanying time line—as well as the state entity responsible for leading implementation. Each task or action should be assigned to a specific subunit within each lead agency, and

potential funding sources and a completion date should be determined. It is often more effective for states to integrate many of their preparedness strategies into existing planning processes, such as water management, wildlife management or land acquisition plans. Items that fall within existing programmatic duties also may not require additional funding or staffing.

An important part of this process is determining which actions can be accomplished by state agencies and what mechanisms exist to facilitate and support actions needed at the regional and local levels. For example, incentives or technical support may be needed to facilitate the implementation of a statewide preparedness plan by local resource managers.

Additionally, performance indicators and metrics to track progress and gauge the effectiveness of each strategy when implementation occurs are developed as part of this process. Examples of potential performance indicators or metrics to track progress in achieving goals are shown in Table 4.

Climate Change in Colorado's Drought Plan [73]

In 2010, Colorado adopted an updated drought mitigation and response plan that considers the impact of climate change. Climate change is likely to increase the frequency of drought events in the state, and this, along with warmer temperatures, will reduce water yields and change patterns of stream runoff. As warmer temperatures result in more precipitation falling as rain than snow and earlier spring snowmelt, reduced summer runoff will impact water availability when demand is greatest. By integrating climate change considerations into the state's existing drought plan, Colorado is helping to ensure that the plan remains relevant and its proposed strategies remain effective in the face of more frequent drought events.

Table 4. Examples of strategy goals and possible performance indicators/metrics to track progress and evaluate whether goals are being achieved.

GOAL	EXAMPLES OF PERFORMANCE INDICATORS/METRICS
Protect headwaters of rivers and streams	Number of acres protected
Integrate green infrastructure into planning and zoning regulations	Reduction in impervious surface cover, reduction in stormwater runoff volume, number of acres transformed to green space
Use natural or constructed means to harvest rainwater	Number of rain barrels distributed, reduction in landscape irrigation demand
Require local governments and utilities to use efficiency and conservation before considering new water supply projects	Decrease in municipal gallons per capita per day (GPCD), percent unaccounted-for water (%UAW)

4.1 Basic Track

Given constraints on available resources, the Climate Preparedness Team generally focuses on the less intensive strategies—those that are primarily low-cost and short-term actions. In particular, no-regret strategies, which provide benefits regardless of future changes in climate, and low-regret strategies, which are developed in response to anticipated climate impacts but are of relatively low cost, should be prioritized.

For example, green infrastructure—green roofs, rain gardens, porous pavement, bioswales and other features—is an important strategy for managing water quality degradation, flooding and water supply risks. Green infrastructure is an approach to water management that protects, restores or mimics natural hydrology. It is effective and economical, and it also enhances community safety and quality of life. Further, green infrastructure is a flexible solution for managing stormwater and dry-weather runoff by treating it on-site and allowing for maximum water infiltration, while also reducing localized flooding.[74] These measures help to reduce combined sewer overflows (CSOs), which occur when wet-weather events introduce more stormwater than either the collection system or the wastewater treatment plant can handle. Consequently, untreated sewage is discharged directly into water bodies, posing serious public health and water quality risks. Green infrastructure techniques like rain barrels or cisterns also can help to capture rainwater for use, thereby reducing demand for potable water.

Water conservation and efficiency are two additional strategies states should prioritize when preparing for climate impacts such as drought or reductions in snowpack. Water efficiency is not simply about using less water; it is about using water wisely, and it is a proven, cost-effective and immediate way to ensure clean water is available not only for communities but also for rivers, lakes and streams. Water conservation reduces water use, particularly for irrigation, manufacturing and household needs,

GREEN ROOF, SOUTH AFRICA | MARK TURNER

and it also reduces energy use because significant amounts of energy are required to treat and move water. Retrofitting communities with water-efficient fixtures and appliances and requiring water suppliers to prepare and adopt water conservation plans are relatively low-cost, no-regret solutions that will serve to expand the availability of existing water supplies.

Planning and designing new infrastructure with future climatic impacts in mind can reduce costs and damages associated with those impacts. A critical initial step to ensuring that climate change is integrated into routine operations and planning is providing outreach and training to water management professionals. Planning ahead by developing drought and flood management plans also helps states build resilience to climate impacts.

A complete list of strategies is available in the Strategy Toolbox. The Climate Preparedness Team should evaluate the suitability of these strategies for addressing the climate risks and vulnerabilities identified in Step 3. In particular, the Climate Preparedness Team should prioritize the inclusion of this guide's Top 10 No-Regret Strategies—which provide benefits under current conditions as well as future climatic conditions—in the state's climate preparedness plan.

Top 10 No-Regret Strategies*

- **Reduce carbon pollution to minimize future climate impacts, thereby protecting public health and safety.**
- **Use green infrastructure to manage and collect stormwater and dry-weather runoff.**
- **Improve urban water conservation and efficiency.**
- **Improve water conservation and efficiency among commercial, industrial and institutional (CII) users.**
- **Increase agricultural water efficiency and manage water-quality impacts.**
- **Increase the use of reclaimed wastewater.**
- **Increase water efficiency in energy production to save water (and fish).**
- **Preserve and restore wildlife habitat for source-water and flood protection.**
- **Improve land-use planning to reduce building in vulnerable areas.**
- **Ensure effective emergency response and hazard mitigation planning.**

* See the end of this section for additional information on these strategies

The final strategies to include in the state's climate preparedness plan should be determined by the Climate Preparedness Team.

4.1 Moderate Track

The sector work groups should consider increasingly more intensive strategies to address both short- and long-term vulnerabilities. Given the uncertainty over the precise magnitude of future climatic changes and existing knowledge gaps, work groups should prioritize no-regret and low-regret strategies (denoted in the toolbox as less intensive—that is, shown in lighter colors) in the near term. More-intensive strategies should be considered to address longer-term vulnerabilities. In particular, flexible or adaptive options, which remain effective or can be readily adjusted in the face of a changing climate, can be used to address uncertainty. Green infrastructure and water conservation and efficiency measures are prime examples of no- and low-regret strategies that are flexible and adaptive to changing climatic conditions. These measures provide benefits to communities regardless of the magnitude of climate impacts.

Building on the green infrastructure strategies to reduce stormwater runoff and localized flooding identified in the Basic Track, sector work groups should also consider strategies that restore the natural hydraulic features of watersheds like flow regulation to increase resilience. Managing runoff by acquiring and protecting ecosystems like forested watersheds and wetlands provides numerous benefits, such as flood protection, water-quality protection and habitat preservation.

To achieve further adoption of water efficiency and conservation practices, sector work groups should consider the potential use of incentives, fees or regulations. More-stringent building or plumbing codes for fixtures (e.g., showerheads, urinals, toilets, landscape irrigation systems) as well as the use of financial incentives or disincentives to drive water conservation help to dramatically reduce water demand and prolong the use of existing water sources.

A complete list of strategies is available in the Strategy Toolbox for consideration by the sector work groups.

Water Conservation in California [75]

California's Water Conservation Act of 2009 requires a 20 percent reduction in per capita urban water use by 2020 as well as improvements in agricultural water efficiency. As part of the legislation, urban water suppliers are required to put in place measures to meet water use targets. Agricultural water suppliers are required to measure the volume of water being delivered to customers, adopt pricing structures that consider water quantity delivered and implement other efficiency practices. Water suppliers who do not adhere to these requirements are not eligible for state water grants or loans.

To develop a final list of sector strategies to recommend to the Climate Preparedness Team, the sector work groups evaluate the potential effectiveness of each proposed strategy given the range of climate scenarios and timescales (e.g., 20 to 100 years) identified in Step 3. As part of this evaluation process, sector work groups also account for potentially different priorities (e.g., cost-effectiveness, robustness) and possible obstacles to successful implementation of each strategy (e.g., resource availability).

Members of each work group should determine which strategies are submitted to the Climate Preparedness Team for inclusion in the final state plan to address the sector's respective climate risks and vulnerabilities.

4.1 Robust Track

Sector work groups follow the process outlined in the Moderate Track to identify possible preparedness strategies. The professional facilitator will play a critical role in ensuring that work group meetings are well organized and productive and that the viewpoints of all members are considered.

Sector work groups consider all of the applicable strategies, ranging from less intensive to more intensive, in the Strategy Toolbox.

More intensive strategies may involve system-wide retrofits, regulatory and management framework changes, major financial investments and transboundary agreements. Examples include greater use of reclaimed wastewater for non-potable needs, the adoption of regulatory and financial mechanisms to drive water efficiency and deter development in vulnerable areas, and more robust management of water resources statewide.

The use of reclaimed wastewater, with the appropriate public health protections in place, is an important long-term water supply strategy that maximizes the use of existing water resources that are often not being utilized to their full potential. In particular, applications that do not require water of potable quality, such as power plant cooling or industrial processes, can utilize reclaimed water to alleviate demand for existing surface and groundwater supplies. The use of regulatory or financial mechanisms to encourage increased water conservation and efficiency (e.g., conservation water pricing, tax incentives, efficiency standards) also helps to reduce water demand.

Effective management of water resources requires the careful oversight of statewide water withdrawals. To prevent the depletion of water supplies and to address potential conflicts among competing uses, states should have a comprehensive water management program to regulate the use and withdrawal of water resources, including groundwater supplies. Further, interstate agreements or compacts that govern shared water resources may have to be modified as climate change impacts water availability and, in turn, water allocations.[76]

Collaboration among water resource managers is necessary to address the impacts of climate change on fisheries and aquatic ecosystems. The restoration and reconnection of aquatic habitats can enhance resilience and allow aquatic species to migrate to more suitable habitat as environmental conditions change.

As flood risks to buildings and infrastructure increase, climate-adaptive revisions to building codes, zoning regulations and design standards are instrumental to enhancing the resilience and decreasing the vulnerability of new development. Areas that are susceptible to sea level rise, flooding and erosion may not be suitable for development, and existing at-risk structures and critical water, transportation, energy and communications infrastructure may need to be protected, modified, relocated or removed. Nonstructural alternatives for managing flood, storm surge and erosion risks, such as wetlands restoration, should be prioritized for implementation when feasible.

The sector work groups evaluate proposed strategies in the same general manner as described in the Moderate Track. However, to allow for greater public participation in the strategy selection process, public stakeholder workshops are conducted so individuals not previously involved with the planning process can provide input and feedback. These public workshops are publicized well in advance and include a brief discussion of the state's planning process, likely climate change impacts and preparedness strategies proposed by the work groups. Conducting public workshops in various locations around the state also helps to ensure that a wide variety of residents have the opportunity to learn about and engage in the planning process.

Public Engagement in Massachusetts[77]

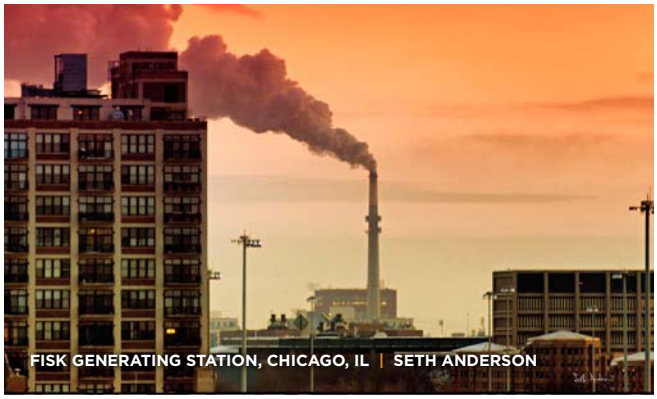
In Massachusetts, public input was an essential component of the planning process. Eight public information sessions were conducted across the state; these included an overview of the legislative act directing the state government to plan for climate impacts (the Global Warming Solutions Act), a review of projected global and regional climate change trends, and examples of how these trends could impact the state. At the conclusion of each session, an open public forum allowed attendees to comment and ask questions.

Top 10 No-Regret Strategies

Reduce carbon pollution to minimize future climate impacts, thereby protecting public health and safety

Carbon dioxide and other heat-trapping pollutants endanger public health and welfare by contributing to climate change. More severe heat waves, more intense smog, changes in temperature and rainfall that spread infectious and insect-borne diseases, and more frequent and severe storms, flooding and drought will cause deaths, injuries and illnesses.[78] A recent study of six climate change-related phenomena that are expected to worsen in the future, including ozone smog pollution, heat waves, hurricanes, mosquito-borne infectious disease, river flooding and wildfires, estimated that total health costs exceeded $14 billion between 2000 and 2009.[79]

Power plants, vehicles and factories not only are responsible for 85 percent of total U.S. carbon dioxide (CO_2) emissions each year, but also are major sources of other air pollutants.[80] Power plants, which account for about 40 percent of total CO_2 released in the U.S. and one-third of total U.S. greenhouse gas emissions, produce significant amounts of mercury, acid gases, sulfur dioxide and nitrogen oxides.[81] These pollutants have substantial public health risks. The EPA has estimated that reduced emissions of mercury, particulate matter and acid gases as a result of the Mercury and Air Toxics Standards will prevent as many as 11,000 premature deaths, 130,000 asthma attacks, 5,700 hospital visits, 4,700 heart attacks, 2,800 cases of chronic bronchitis and up to 540,000 missed work days each year—public health improvements valued at $37 billion to $90 billion.[82] Additionally, vehicles and factories are major sources of nitrogen oxides and volatile organic compounds (VOCs), which react with sunlight to form ground-level ozone, a health hazard particularly for children, older adults, people with asthma and other sensitive populations.[83]

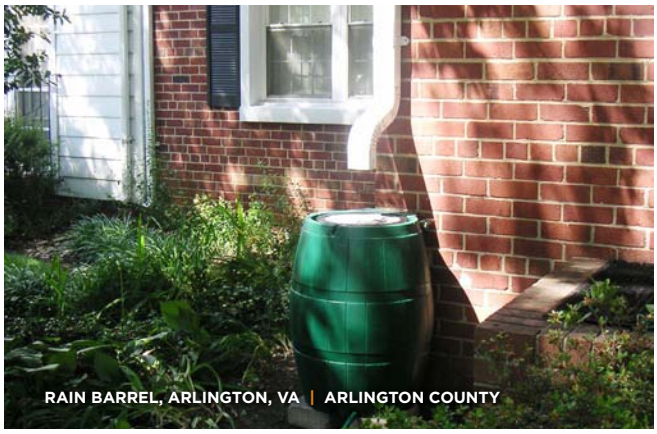


FISK GENERATING STATION, CHICAGO, IL | SETH ANDERSON

Reducing carbon pollution by using energy more efficiently, cleaning up power plants and other sources of carbon pollution and increasing the use of renewable energy sources will not only provide air quality and public health benefits now but also help to reduce future climate impacts resulting from warmer temperatures, changing precipitation patterns and rising seas.

Use green infrastructure to manage and collect stormwater and dry-weather runoff

Clean water is vital to communities, but despite great advances, ensuring a clean and consistent water supply for all Americans is becoming more challenging. Decades of poorly planned development have caused a rapid expansion of impervious surfaces (e.g., roofs and parking lots), which have destroyed small streams and wetlands. Rainfall carries pollution from these hard surfaces into nearby rivers and streams instead of infiltrating the ground and recharging water supplies. Further, the loss of small streams increases downstream flooding and pollution.[84] In many communities, the failure to maintain aging "gray" infrastructure like pipes and sewage treatment plants and the failure to invest in smarter solutions has contributed to frequent sewage spills, which threaten public health. These problems are compounded by climate change, which threatens clean and sufficient water supplies through stronger storms, more droughts and warmer water temperatures.



RAIN BARREL, ARLINGTON, VA | ARLINGTON COUNTY

Green infrastructure encompasses a wide range of water management practices that reduce polluted stormwater runoff, flooding and sewer overflows by maintaining or restoring the natural hydrology of an area. Plants and soils that collect and filter stormwater commonly are used to reduce the volume of stormwater runoff and prevent the pollution of streams and rivers. Green infrastructure includes community-wide approaches such as wetlands preservation and streamside buffers as well as individual practices such as rain gardens, green roofs and rain barrels. These green practices are often more effective and less expensive than traditional stormwater controls and can enhance the effectiveness of traditional infrastructure by diverting stormwater from overburdened pipes and reducing sewer overflows. These techniques also can capture dry-weather runoff, which comes from excess landscape irrigation, street and car washing, and other activities.

Green infrastructure also can be used to reduce potable water demand through rainwater harvesting. An NRDC analysis of eight U.S. cities found that the volume of rainwater falling on rooftops, if captured in its entirety, would be sufficient to meet the annual water needs of 21 percent to 75 percent of each city's population.[85] Other benefits of green infrastructure include increased water supplies through groundwater recharge, energy savings through reductions in municipal water use, community beautification, job creation and cooling and shading in urban areas.

By incorporating green infrastructure practices into permitting and planning, such as by requiring on-site stormwater retention for new development and redevelopment, communities can reduce energy costs and water demand, diminish the impacts of flooding, improve public health and reduce infrastructure costs. In addition, these practices can complement traditional infrastructure in effectiveness and affordability, giving stormwater managers the ability to create integrated solutions that rely on natural processes like evaporation, infiltration and plant transpiration.[86] Incorporating green infrastructure into stormwater management planning will help create sustainable communities capable of meeting future challenges, especially in the face of a changing climate.

Improve urban water conservation and efficiency

Water conservation and efficiency are effective means of increasing resilience to climate impacts such as increased drought, decreased precipitation and declining snowpack. These measures also lower water demand, improve the reliability of existing water supplies, delay capital expenditures for new water infrastructure and reduce energy demands associated with the treatment and delivery of water and wastewater. The adoption of state policies requiring water conservation planning during the water permitting process and the metering of all service connections for community water systems can serve to encourage the implementation of water-efficient practices by water utilities and customers.[87] Water-efficient landscapes, water-conserving plumbing fixtures, water rate mechanisms and the detection and repair of leaks in water distribution systems are a few examples of ways to reduce urban water demand.

In warm, dry climates, more than half of urban water supplies are used for landscape irrigation. Landscape design (including plant selection and groupings based on water needs and climatic conditions), installation and maintenance can and should be water-efficient. Ordinances that ensure efficient

landscapes in new developments and reduce water waste in existing landscapes are among the most cost-effective ways to stretch limited water supplies. Other benefits include reduced irrigation runoff, reduced pollution into waterways and improved drought resistance.[88] Further, relatively simple prescriptive measures, such as requiring the installation of rain shut-off devices in any new in-ground irrigation system, can be adopted initially while more involved but flexible rules requiring water budgets for new landscapes can be scheduled for gradual implementation.[89]

Switching out non-water-conserving fixtures with water-conserving ones, such as EPA WaterSense-certified fixtures, is a low-cost way to reduce water use.[90] For example, the installation of low-flow showerheads can save 10 gallons of water for every five-minute shower.[91] States can promote the use of these fixtures by adopting new efficiency standards covering the sale and installation of toilets and faucets and strengthening standards for showerheads used in new construction.[92] Water and wastewater rate structures also can be used to encourage water conservation and efficiency. Eliminating the use of declining block rates, whereby customers are offered lower unit costs as they consume more, and adopting seasonal water rates to reduce summer peak demand are methods to capture the full cost of treating and delivering water.[93] Additionally, the adoption of volumetric pricing for wastewater collection and treatment service, where customers are charged for actual usage, provides incentives for water efficiency and a more equitable pricing structure.[94] Water utilities regulated by the state that undertake conservation programs also should be allowed to recover costs and a portion of lost revenues through a decoupling mechanism.[95]

Many drinking water systems lose as much as 20 percent of treated drinking water each year due to leaks in their pipe networks. The collection, distribution and treatment of drinking water and wastewater nationwide consume tremendous amounts of energy and release approximately 58 million tons of CO_2 annually—as much global warming pollution as is created in a year by 10 million cars.[96] Water losses in the distribution system require even more water to be pumped and treated, which in turn requires more energy and chemical usage, resulting in wasted resources and lost revenues.[97] Leaks in the distribution system also pose contamination risks to already treated water supplies. States should require water systems to prepare and submit an annual water balance report and identify and eliminate water losses that are deemed economically recoverable.[98] Improving drinking water infrastructure would save water and energy, provide immediate water quality benefits to consumers, increase available water resources and reduce the global warming pollution that results from wasted energy.

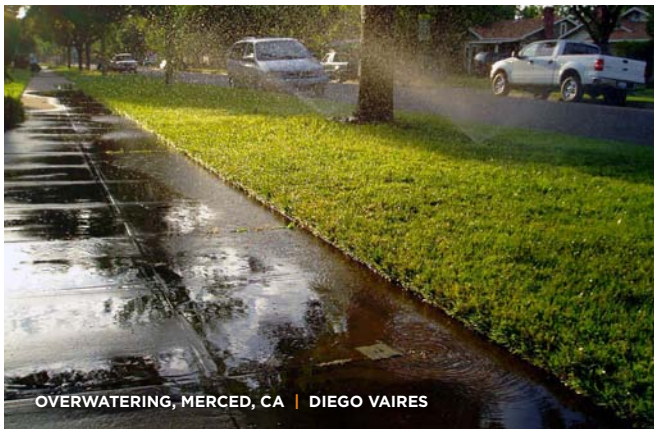
XERISCAPE GARDEN, SPRINGFIELD, MO | JOSE KEVO

Improve water conservation and efficiency among commercial, industrial and institutional (CII) users

Like urban water conservation and efficiency measures, measures in the CII sector have a significant impact on overall water demand and provide a range of economic and environmental benefits. Water efficiency measures and technologies can lower the cost of doing business, help to stretch limited water supplies and save energy. Water conservation and efficiency policies described previously, such as the regulation of landscape irrigation, universal metering, new plumbing efficiency standards and mandatory water conservation planning, also can

facilitate the implementation of water-efficient practices in the CII sector. Outdoor water use often is the largest single end use of water, and water used to irrigate large ornamental landscapes can be better managed when use is measured and billed.[99] The installation of water-conserving fixtures also reduces water demand in the CII sector. Considering the number of faucets, showers and toilets on-site in many commercial and institutional facilities such as hotels, hospitals, schools and office buildings, system-wide retrofits can be economical.[100] Additionally, state laws that prohibit the wasting of water—with clear definitions of practices deemed wasteful (e.g., once-through cooling with public water, failure to make timely repairs to visible leaks, excessive irrigation runoff) and penalties for violations—also can reduce water use. Requiring permit applicants for new or expanded withdrawals or wastewater discharges to complete water conservation plans also would reduce water use, particularly by large industrial users.

Considering the range of ways that the CII sector uses water, the best way to determine specific practices to improve water efficiency at a particular site is to perform an on-site audit. Water suppliers should perform no-cost on-site water audits for CII customers. Some examples of water efficiency measures for this sector include optimization of rinse processes at industrial and food processing facilities, use of wastewater from production processes for air scrubbers, use of ozone for product disinfection in food and beverage processing and installation of automatic shutoff valves on process equipment to stop water flow when production stops.[101]



OVERWATERING, MERCED, CA | DIEGO VAIRES

Further, cooling towers are the most common device used to regulate air temperature and cool equipment in buildings and are among the largest consumers of water in the CII sector. Cooling towers are water-intensive due to evaporative loss during the cooling cycle. Improving water efficiency can be achieved by using technology, such as conductivity and pH meters and controllers, to minimize the amount of water lost during this cycle.[102]

Increase agricultural water efficiency and manage water-quality impacts

Agriculture is the second-largest withdrawer of freshwater nationwide, accounting for 37 percent of all freshwater withdrawals in 2005.[103] It also consumes the most water of any sector.[104] Requiring agricultural water suppliers and districts to track water deliveries and prepare and adopt water conservation plans are basic policies that can help support the implementation of water efficiency measures by agricultural users. Modest crop shifting, smart irrigation scheduling, advanced irrigation management and efficient irrigation technology are just a few measures that have the potential to vastly improve water use efficiency in the agricultural sector. Shifting from lower-value, water-intensive crops (e.g., field crops) to higher value, more water-efficient crops (e.g., vegetables, fruits and nuts); using climate and soil data to schedule irrigation in accordance with crop requirements; applying water to crops below the level of full crop evapotranspiration (i.e., deficit irrigation); and using more water-efficient irrigation technologies can result in significant water savings. For example, switching from flood irrigation to drip irrigation can increase water use efficiency by as much as 30 percent.[105] These improvements often require significant capital investments. Providing incentives, such as sales tax or property tax exemptions and rebates, can reduce these implementation barriers for water conservation and efficiency improvements.[106]

In addition to being the largest consumer of water in the U.S., agriculture also significantly contributes to water pollution. Agricultural pollution impacts nearly 40 percent of the country's polluted rivers and streams.[107] Pesticides, herbicides and nutrients from fertilizers and animal waste can be washed into waterways if improperly managed or used. In turn, these contaminants can cause algal blooms, degrade drinking water supplies, spread pathogens and kill fish.[108] The use of buffer strips, slow-forming terraces, variable rate technology for pesticide and nutrient application (which allows for different application rates across a field), and improved manure application and management practices can reduce agricultural runoff and subsequent water quality impacts and protect public health. Policies such as reduced agriculture insurance rates for those who adopt best management practices can provide incentives for farmers to implement those practices.

Increase the use of reclaimed wastewater

In recent decades, the amount of wastewater that is treated and reused has increased dramatically. In 2004, the EPA estimated that 1.7 billion gallons of wastewater per day were being reused and that the volume of wastewater reuse was growing at a rate of 15 percent annually.[109] Reclaimed wastewater is used for a variety of applications. In many major urban areas across the U.S., reclaimed wastewater is commonly utilized for landscape irrigation, industrial processes and, to a lesser extent, some indirect potable applications like groundwater recharge. However, it also is used for agricultural irrigation, recreational lakes and habitat restoration projects. In Southern California, reclaimed wastewater has been injected underground to provide a barrier against saltwater intrusion.[110] Because municipal wastewater is the sole source, the supply of reclaimed wastewater is less susceptible than traditional water supplies to drought and other climate-related impacts.[111]

In addition, the use of reclaimed wastewater can reduce municipal drinking water demands and

ADVISORY SIGN, GRAND CANYON, AZ | LEO REYNOLDS

prolong the availability of existing water supplies. Given the likelihood that water will become increasingly scarce in many areas of the country as climate change and population growth fuel greater demand for water at the same time that warmer temperatures and changing precipitation patterns result in dwindling supplies, reclaimed wastewater presents a valuable opportunity to increase available water resources as long as appropriate public health protections are put in place. Establishing state laws and regulations allowing the use of reclaimed wastewater for purposes such as irrigation and industrial cooling can help to capitalize on the opportunities provided by this alternative water source.

Increase water efficiency in energy production to save water (and fish)

Historically, public policy and business practice have treated water and energy as separate resource entities, but they are inextricably linked. Water delivery and treatment systems and energy production and distribution infrastructure are intertwined and interdependent. In the U.S., thermoelectric power plants are the largest withdrawer of freshwater, accounting for 41 percent of all freshwater withdrawals in 2005.[112] Similarly, a significant amount of energy is utilized for the treatment and transport of water and wastewater. According to a recent study,

water-related energy uses make up nearly 13 percent of total annual primary energy consumption in the U.S.[113]

To reduce the amount of water used to produce electricity, changes in cooling technology at existing power plants must be coupled with long-term shifts to renewable sources of energy. A typical power plant using once-through cooling withdraws hundreds of millions to several billion gallons of water per day. As a consequence of this withdrawal, aquatic organisms are killed through entrainment, when organisms too small to be screened out are drawn through a cooling water intake into a plant's cooling system, and through impingement, when larger organisms are trapped on screening devices or other barriers. In total, billions of fish, shellfish and other aquatic organisms are killed by once-through cooling processes.[114]

Additionally, large water withdrawals by power plants jeopardize local water supplies and place other users and aquatic ecosystems at risk.[115] Policies requiring or incentivizing closed-cycle, dry or hybrid cooling technologies or the use of reclaimed wastewater can reduce freshwater withdrawals and associated fish mortality as climate change exacerbates local water supply risks. For example, recycling cooling water could lead to a 98 percent reduction in environmental damage caused by intake structures.[116] Eliminating existing stressors, such as entrainment and impingement, also helps to build the resilience of fish populations to climate change-related threats like warmer water temperatures and changing streamflow conditions. Further, renewable energy sources such as photovoltaic (PV) solar and wind require significantly less water to produce electricity compared to conventional sources like coal-fired power plants.[117] These sources of energy also do not directly result in the release of global warming pollution.

DEAD FISH | FLAVIA BRANDI

Preserve and restore wildlife habitat for source-water and flood protection

A healthy river, watershed and coast can increase property values, boost recreational opportunities and local business, reduce water pollution, provide clean water and protect people and property from flooding. In contrast, dams, levees, sea walls and other man-made structures disrupt the natural functions of rivers and coastal habitats, leaving many of them lifeless or cut off from their communities. Climate change is expected to alter temperature and precipitation and increase sea levels, further impacting natural habitats. Many plants and animals already have begun to react to climate change and will likely continue to respond by shifting their habitat range, where possible, but also may be at risk of extirpation or extinction if no suitable habitat exists.[118] The traditional approach to managing habitats, which assumes a stable climate, may no longer be successful. Instead, options that take into account changing conditions will need to be considered. Flexible and adaptive management strategies to preserve and connect habitats are critical if ecological strongholds are to be kept intact.

To build the resilience of habitats and the ecosystems that thrive within them, it is essential to reduce non-climate stressors, conserve high-quality habitats, restore degraded habitats and manage habi-

DELAWARE RIVER, DINGMANS FERRY, PA | NICHOLAS A. TONELLI

tats for ecological functions. Ensuring that all species within an ecosystem and habitat are preserved by promoting connectivity and reducing habitat destruction, pollutants, invasive species and pests strengthens the overall health of the ecosystem, thereby increasing resilience to climate change. Land use changes, water pollution and other human activities have impacted many habitats and ecosystems. Policies that reduce these impacts can help restore degraded habitats back to their original (or close to original) structure and function and increase the resilience of species and ecosystems. Additionally, habitat restoration helps to promote connectivity, which is becoming increasingly important as the climate changes.

Further, if functions like ecosystem hydrology are kept intact or improved, ecosystems will be better able to resist climatic impacts.[119] For example, the preservation and restoration of the headwaters of rivers and streams are instrumental to protecting the quality of critical drinking water supplies. By preserving and restoring the ecological functions of these habitats, drinking water sources can be protected from contamination. Riparian and coastal wetlands and floodplains also provide protective benefits. These natural features serve to absorb storm surge and floodwaters and dissipate wave energy, thereby mitigating storm surge, flooding and erosion risks. They also provide wildlife habitat, enhance fisheries, maintain natural shoreline dynamics, filter water pollutants and preserve public access to the shoreline.[120]

Improve land-use planning to reduce building in vulnerable areas

Floods are the most common natural disaster in the United States. Over the past 30 years, flooding events have caused an average of nearly $8 billion in damage each year.[121] According to NOAA, approximately 5 percent of the U.S. population, or more than 16 million people, now reside within the currently defined 100-year coastal floodplain.[122] Millions more live in floodplains along rivers. These individuals face existing flood risks from heavy precipitation events and storm surge, which are only expected to worsen with climate change and sea level rise. However, communities can take steps to protect people and structures from existing flood risks while also building their resilience to future floods.

These measures include inventorying vulnerable communities, assets and resources using the best available technology and developing and implementing legislative and regulatory mechanisms, particularly relating to land use, infrastructure and building codes.[123] It is increasingly critical to update flood maps to integrate changing risks. Some floodplain maps currently in use are outdated, and climate change is rapidly rendering inadequate the use of the historical 100-year flood as the standard for characterizing flood risks and hazards. New buildings in floodplains must be built to more rigorous standards, and outdated structures and infrastructure in hazardous floodplain areas should be considered for removal as they exceed their service lives.

Building code improvements, such as an updated definition for base flood elevation, additional margin-of-safety considerations, stricter regulations for critical facilities, and development setbacks and restrictions, serve to reduce future flood losses.[124] Further, the adoption of building standards that


CUMBERLAND RIVER FLOODING, NASHVILLE, TN | WAYNE HSIEH

exceed minimum National Flood Insurance Program (NFIP) requirements reduces insurance premiums for homeowners while also increasing flood resilience.[125] Changes to zoning practices also can help to direct new development away from hazardous, vulnerable or ecologically sensitive areas, reducing flood vulnerability and preserving the natural protective benefits of wetlands and floodplains.

Communities also should take steps to increase the resilience of residual risk areas, areas within the 100-year floodplain that are currently protected by levees and other flood protection devices. Often, flood insurance and more stringent land use and building standards are not mandatory for structures located in these areas. Yet flood-control structures frequently are inadequate and susceptible to overtopping and failure.[126]

Ensure effective emergency response and hazard mitigation planning

Due to the nature of natural disasters such as hurricanes, drought and floods, it is often difficult or impossible to accurately predict their location, severity or full impact well in advance. Climate change is making many of these extreme weather events more frequent and more intense. As a result, local and state emergency response and hazard mitigation planning is critical to reducing loss of life and property damage associated with natural disasters.

State governments and local communities are better prepared to deal with disasters when they are committed to continually planning, organizing, training, exercising, evaluating and improving emergency response.[127] A prompt warning to citizens to evacuate, take shelter or lock down a site can save many lives. In particular, vulnerable populations should be identified and evacuation plans should be developed. Additionally, greater efforts to educate the public regarding potential risks and emergency procedures can enhance public safety when disasters do occur. However, efforts to proactively mitigate hazards can reduce vulnerability and disaster impacts before these events even occur.

As a part of the hazard mitigation planning process, states and communities should undertake a comprehensive effort to accurately identify hazards, taking into account the potential for climate change to exacerbate existing risks.[128] By fully understanding the potentially changing risks associated with natural disasters, governments can identify and implement strategies for prevention and mitigation and prepare plans and resources for disaster response, continuity and recovery.[129] A critical component of the hazard mitigation process is the proactive implementation of policies that reduce vulnerability to natural disasters. For example, requiring that vital components of HVAC, electrical systems and fuel supply systems in emergency facilities be elevated above flood level can help to ensure that critical services are not lost when disasters strike. Additionally, the acquisition and demolition or relocation of structures and buildings in flood-prone areas reduces future loss of life and damage from flood events. While these preparedness actions do not necessarily influence whether a disaster occurs, they can play a pivotal role in determining the ultimate economic and human health toll that a disaster places on a community.

STEP 5
Finalizing the Plan

In finalizing the plan, the Climate Preparedness Team does the following:

1. Finalizes the section of the plan that examines cross-cutting themes, highlighting the most critical elements;
2. Compiles the sector chapters, which contain information on climate risks, vulnerabilities and preparedness strategies;
3. Releases a final draft plan for public comment; and
4. Addresses meaningful public comment and releases a final plan.

Basic Track

In the Basic Track, the plan is finalized as described above. During the public comment period, individuals and organizations not directly involved in the planning process have the opportunity to review and provide feedback on the plan. The comment period should be at least 60 to 90 days to allow ample time for review and the submission of comments.

Once the comment period closes, the Climate Preparedness Team reviews and considers all relevant comments and makes changes to the draft plan where appropriate. After concluding this process, the Climate Preparedness Team releases the final version of the state's climate preparedness plan and begins working toward implementation.

Moderate Track

In the Moderate Track, each sector work group's draft reports are initially circulated to the other work groups for review and comment. Ensuring that perspectives from other work groups are taken into account can help to eliminate strategies that may have significant or previously unknown consequences. Reviewers carefully examine the drafts, with particular attention paid to any unaddressed climate risks or additional cross-cutting strategies that may have been overlooked by the Climate Preparedness Team and work group chairpersons. In addition, reviewers should scrutinize the recommended strategies for potential unintended consequences or impacts in other sectors that may not have been considered. After comments are received from the other work groups, each work group revises its draft report with careful consideration of any comments or suggestions made by members of other sector work groups.

After each sector work group report is finalized, the reports are forwarded to the Climate Preparedness Team for review and the plan is finalized as described in the Basic Track.

The final preparedness plan also contains an entire chapter dedicated to cross-cutting strategies, the importance of collaboration, and how collaboration among agencies, governing bodies and external stakeholders helps to move implementation along.

Robust Track

The Robust Track builds on the Moderate Track with an additional review of the draft plan by climate experts and experienced preparedness practitioners. Prior to the final draft plan's release for public comment, an external group of climate experts (e.g., university faculty and staff, research scientists) and preparedness practitioners (e.g., municipal staff, consultants,) reviews the report for accuracy and suitability. The Climate Preparedness Team reviews these expert comments in consultation with the sector work groups and makes any necessary revisions before releasing the plan for public comment.

LIVING SHORELINE PLANTING, ANNAPOLIS, MD | CHESAPEAKE BAY FOUNDATION

STEP 6
Implementing and Updating the Plan

Once a final state climate preparedness plan has been released, the state begins implementing the strategies it recommends. The identification of discrete tasks, time frames and lead agencies during the planning process facilitates strategy implementation after the plan is completed. Case studies are provided at the end of this section to demonstrate how various states have implemented strategies to build resilience to current challenges while also providing benefits in anticipation of future climate impacts.

Preparing for climate change may require an iterative approach in which the development and implementation of a plan of action is followed by monitoring and evaluation of progress. Monitoring and reevaluating strategies as they are implemented is necessary to determine whether they are effective and whether preparedness goals are being achieved.

6.1 Implementation Mechanisms and Funding Sources

Many existing state climate preparedness plans are high-level strategic documents that provide a policy framework for state agencies but lack detail on concrete projects or actions that can be readily implemented. Given the importance and critical nature of preparing for the impacts of climate change, this guide recommends that implementation mechanisms be considered during the plan development process. The identification of mechanisms, tasks, actions and responsible parties facilitates timely implementation of the state's climate preparedness plan. Depending on a state's approach, the implementation process may start with translating planning strategies to on-the-ground actions. As states develop detailed work plans to achieve the objectives outlined in the climate preparedness plan, they may need to consider whether new programs, regulations or legislation are needed. Additionally, outreach initiatives may be necessary to educate the public about climate impacts and build public support for strategy implementation.

Climate Implementation in Massachusetts[130]

In 2011, Massachusetts released its climate change adaptation report, which was required under the state's Global Warming Solutions Act (GWSA). This report contains more than 200 potential strategies to address climate impacts in the state. To advise state agencies and the executive office on the implementation of climate strategies, Massachusetts established a GWSA adaptation subcommittee. The subcommittee has developed a work plan that contains all of the strategies from the report along with the responsible agency and a time line, and it is currently working on priority projects, such as development of climate change visualization tools, that will help to facilitate strategy implementation by state agencies.

There are numerous federal funding programs to support the implementation of preparedness strategies that may not have funding sources. These include programs within NOAA, the Economic Development Administration, FEMA, EPA and the Departments of Defense, the Interior, Housing and Urban Development, and Agriculture, among others. In addition, funding for projects implemented in partnership with nonprofit organizations may be available from private and charitable foundations. Some states also have developed funding mechanisms to support the implementation of climate preparedness strategies. Modifying eligibility criteria for existing state funding programs, such as the State Revolving Fund (SRF), also can be used to support the implementation of strategies, such as green infrastructure and water conservation and efficiency measures, by funding recipients.

For a detailed list of potential funding sources for implementation, refer to Appendix II.

6.2 Tracking Progress

To facilitate and track progress on implementation, it may be helpful for the Climate Preparedness Team to create and maintain a matrix that includes:

- tasks;
- lead state agencies and specific subunits;
- funding sources; and
- target completion dates.

A generic example of a matrix outlining tasks, lead agencies, funding sources and target dates for completing climate preparedness goals is given in Table 5.

Climate Implementation in California[131]

An appendix to California's 2009 Climate Adaptation Strategy included a table that contained specific short-term strategies, slated for completion by November 2010, that were necessary to ensure the achievement of larger strategy goals. Not only did this allow California to outline greater details on implementation, but it also assigned responsibilities for implementation to specific state agencies.

Table 5. Example of a matrix to track completion of climate preparedness goals.

Goal	Task	Lead Agency/ Subunit	Funding Source	Target Completion Date	Status
Require water suppliers and local governments to develop and implement water conservation programs	Determine if statutory authority exists	Department of Water Resources/ Rules Division	Existing DWR program funding	June 2013	In Progress
	Initiate water conservation rulemaking	Department of Water Resources/ Rules Division	Existing DWR program funding	September 2013	Scheduled
	Develop draft guidance document for suppliers and local governments	Department of Water Resources/ Planning and Outreach Division	State Water Resources Board grant	January 2014	Scheduled
	Finalize water conservation rulemaking	Department of Water Resources/ Rules Division	Existing DWR program funding	September 2014	Scheduled
	Conduct public workshops to educate stakeholders about new requirements	Department of Water Resources/ Planning and Outreach Division	State Water Resources Board grant	December 2014	Scheduled

As tasks are completed and strategies are implemented, the performance indicators and metrics developed during the planning process will be critical components of gauging effectiveness. Strategies can be modified if these indicators and metrics suggest that strategies are not having the intended effect or goals are not being met.

An annual progress report on statewide climate change preparedness ensures transparency and accountability. For each strategy contained in the state's plan, the Climate Preparedness Team and associated sector work groups should determine the status and progress achieved. In addition, a discussion of annual achievements as well as planned actions for the coming year helps to keep the public and interested parties informed and engaged.

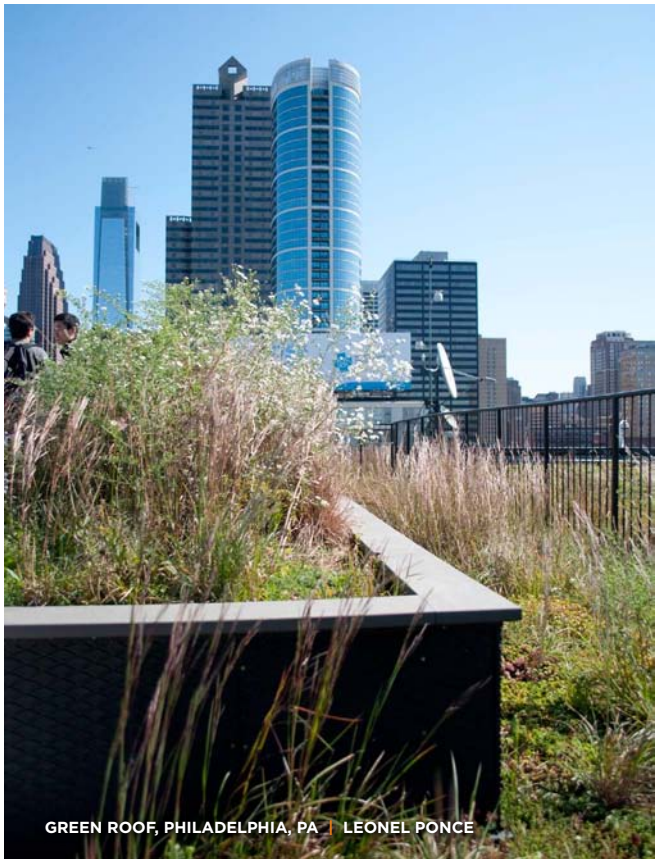
6.3 Updating the Plan Regularly

Scientists' monitoring capabilities and understanding of the earth's climate system are continuously improving. As a result, climate models also will continue to improve. The Climate Preparedness Team should regularly reevaluate climate change projections and the effectiveness of preparedness strategies. Changes in the state's priorities and resources also may impact the types of preparedness strategies available for consideration. After an assessment of strategy effectiveness and performance, if strategies selected are not performing as expected, they should be modified. The state climate preparedness plan should be updated on a regular basis, such as every five years, to incorporate these new developments. The state should ensure the update process is open and inclusive, with ample opportunities for public engagement.

Implementation Case Studies

Philadelphia—Green City, Clean Waters[132]

As in many older cities, much of Philadelphia is served by combined sewers, which collect and transport both stormwater runoff and municipal sewage for treatment before being discharged to nearby waterways. However, wet-weather events can introduce greater volumes of stormwater into these systems than the collection system or wastewater treatment plant can handle, leading to releases of untreated sewage and stormwater directly into nearby water bodies. These events, known as combined sewer overflows (CSOs), pose significant public health and water quality problems. In some areas of Philadelphia, CSOs occur up to 85 times a year.[133] To reduce stormwater runoff and CSO volume, the city is increasingly focusing on green infrastructure. Philadelphia recognizes the benefits that green infrastructure provides in the face of more frequent and intense precipitation events from climate change.[134]



GREEN ROOF, PHILADELPHIA, PA | LEONEL PONCE

As part of the city's recently approved Green City, Clean Waters plan, Philadelphia is requiring the retrofit of impervious areas to manage runoff onsite; relying on green infrastructure to reduce CSOs; investing more public funds in green infrastructure than in traditional gray approaches; and leveraging private investments by applying a one-inch stormwater retention standard for new development and redevelopment projects. To fund the city's share of the costs, Philadelphia has implemented a stormwater fee based on impervious area and is encouraging private landowners to employ green infrastructure by offering incentives such as reduced stormwater fees, free design assistance, low-interest loans, green roof tax credits, free rain barrels and expedited permit reviews.

Over the next 25 years, the city will invest at least $1.67 billion in green infrastructure with an anticipated focus on streets and sidewalks, which account for a substantial amount of impervious cover.[135] For streets undergoing capital improvements or routine repaving, the city intends to install tree trenches, tree pits, stormwater bump-outs, sidewalk planters, porous pavement and other green infrastructure features to manage stormwater. Philadelphia also has prioritized the use of green infrastructure at schools, including green roofs, rain gardens, permeable pavers and rainwater harvesting, and is aiming to retrofit up to half of all schools over a period of 20 years. In addition to its stormwater management benefits, the city recognizes the numerous other benefits that green infrastructure provides, including improved recreation, improved air quality, higher property values, enhanced ecosystems, opportunities for green jobs and energy savings resulting from the cooling and insulating effects of vegetation. These cooling effects will become more important as temperatures increase due to climate change.

Preparing for Sea Level Rise in California[136]

In California, the ocean and 1,100 miles of coastline are integral parts of the state's identity and economy, providing resources and opportunities for tourism and recreation, marine habitat, and transportation and commerce. In fact, almost 85 percent of the state's total population can be found in the 19 coastal counties, which also support 86 percent of California's gross state production. However, these benefits are not without significant risks. Over the 20th century, sea level along the California coast rose approximately 7 inches. According to a recent report by the National Research Council, sea level is projected to further rise 5 to 24 inches by 2050 and 17 to 66 inches by 2100.[137] A 100-year flood event after a 55-inch sea level rise would put at risk an estimated 480,000 people, $100 billion worth of property, nearly 4,000 miles of roadway and railway, 30 power plants and 28 wastewater treatment facilities.[138]

In response to the significant risks that sea level rise poses, California has developed a range of policies and tools. In October 2010, the Sea-Level Rise Task Force of the Coastal and Ocean Working Group of the California Climate Action Team released an interim guidance document to assist state agencies with incorporating sea level rise into planning and decision-making.[139] The guidance recommends that state agencies utilize sea level rise ranges of 5 to 8 inches by 2030, 10 to 17 inches by 2050, and 31 to 69 inches by 2100 and that they consider time frames, adaptive capacity and risk tolerance when selecting sea level rise estimates. Following on the heels of this guidance document, the Ocean Protection Council, which coordinates the activities of ocean-related agencies in California, adopted a resolution in March 2011 requiring that state agencies and private entities implementing projects either funded by the state or on state property must consider potential risks from sea level rise.[140] Similarly, the Strategic Growth Council, which assists local communities in sustainability planning, and the State Coastal Conservancy, which funds coastal

CLIFF PERCHED HOME, CALIFORNIA COAST | WONDERLANE

resource and shoreline access projects, require grant applicants to consider potential sea level rise impacts.[141] The Department of Water Resources also requires grant applicants to consider sea level rise in its billion-dollar Integrated Regional Water Management Program. In addition, to assist local communities in planning for climate change impacts, California has developed the Cal-Adapt website, which contains visualization tools that map coastal flooding projections and changes in temperature, snowpack and wildfire risk.[142]

In addition to statewide initiatives, local efforts also are under way to address sea level rise risks. The Bay Conservation and Development Commission, a state agency charged with regulating San Francisco Bay fill and shoreline development, amended its Bay Plan in October 2011 to address climate change. With the new climate change amendment, sea level rise risk assessments are required when planning shoreline areas or designing larger shoreline projects. Further, if public safety risks from sea level rise and storms are expected during the project's lifetime, the project must be designed to handle these risks through at least the middle of the century.[143] Additional policies require that any hard shoreline protection measures (e.g., levees, seawalls) be designed to withstand projected sea level rise and be integrated with soft protection measures, such as wetlands, where possible.

FLOODING IN DOWNTOWN GAYS MILL | USDA

Relocating Out of Harm's Way—Soldiers Grove and Gays Mills, Wisconsin[144]

Originally settled on the banks of the Kickapoo River in the 1850s, the community of Soldiers Grove thrived thanks to southwestern Wisconsin's abundant forests and fertile soils. However, extensive logging, agriculture and urbanization stripped the watershed of its vegetation, and the Kickapoo began to flood the communities that had sprung up along its banks. Flooding soon became a serious and permanent problem, inundating Soldiers Grove in 1907, 1912, 1917, 1935 and 1951.[145] Nearly the entire business district was located within the floodplain, making floods especially disastrous to the community. The Corps of Engineers created plans for a flood-control dam and levees to protect the town, but they were subsequently canceled when it became apparent that the project was not economically viable, would endanger rare plants and would cause water quality problems.[146]

After the Corps of Engineers project was canceled, residents turned to relocation as the only viable alternative. That choice was reinforced when a record flood struck in July 1978, leaving two dead and inflicting half a million dollars in damages while destroying several buildings. Due to a state law passed in 1975, new development and major repairs on buildings within floodplains were prohibited, leaving the village with few options for recovery. The town spent years planning its relocation and securing the necessary funding, completing the process in 1983. The business district, made up of 39 businesses, was moved half a mile to the south to ground 55 feet above the old town center.[147] In addition, 10 families moved to homes outside of the floodplain, and 12 homes were elevated to protect them from high water. Other residential neighborhoods remained outside the floodplain. The vacated area was planted with native vegetation and converted into a municipal park that now offers basketball and tennis courts, picnic areas, baseball fields, a skateboard park and a playground.[148]

The relocation of Soldiers Grove rescued the town from the recurring floods that threatened residents' lives and the town's existence. In August 2007, more than a foot of rain caused the Kickapoo to crest at more than 19 feet.[149] While floodwater inundated the park located on the site of the old downtown, the rest of the town sustained little damage beyond a partially collapsed road.[150] Unfortunately, just 10 miles downstream, the neighboring village of Gays Mills was not so lucky. Seventy-five homes in Gays Mills were evacuated during the flood.[151] Many residents lost cars, furnishings and other belongings. Electricity and gas services were out for days.

Ten months later, while the region was still recovering from the previous year's disaster, a new flood record was set as the Kickapoo crested at nearly 21 feet. In Soldiers Grove, floodwaters overwhelmed an old levee, damaging the riverside park and 30 homes that had been flood-proofed but not relocated in 1978. None of the relocated homes flooded. Elsewhere the damage was far worse. Approximately 175 homes and businesses were damaged in Gays Mills alone.[152] Some residents of the town gave up following the 2008 flood, and 30 to 45 homes remained vacant months later. The June 2008 flood affected more than 90 percent of Gays Mills' downtown, including almost all of the businesses along Main Street.

Gays Mills is now starting the relocation process that Soldiers Grove chose in the 1970s. The widespread damage in 2008 along with the region's long history of flooding convinced the residents that only a large-scale mitigation action would address their risk and that they should consider relocating the portion of the village located in the floodplain. In response to the Presidential Disaster Declaration for the 2008 flooding, FEMA activated the Long-Term Community Recovery (LTCR) program, which integrates assistance from state and federal partners to address recovery needs for communities experiencing particularly devastating losses.

After reviewing multiple plans on how best to address the flooding situation, it was determined that a "no action" response was unacceptable and that building a levee was not feasible for financial, safety and technical reasons. Although the community was ready to accept LTCR's recommendation to relocate, financing remained an obstacle. However, since 2008 Gays Mills has acquired and demolished more than fifteen flood-damaged structures in the floodplain, elevated structures for those not wishing to relocate, acquired land for the relocated village at two sites about a mile north of the original downtown and built new residences, commercial structures, public buildings and infrastructure. Plans for the North Mills site include homes and townhouses, a Mercantile Center owned by the village, and a Community Commerce Center that includes a library, village offices, a community room and a community kitchen.

The relocation of Soldiers Grove, and now Gays Mills, has helped revitalize and stabilize communities in decline, ensuring a viable future in a changing climate. Severe precipitation events in southern Wisconsin are expected to become 10 to 40 percent stronger by the end of the century.[153] If the floods of 2007 and 2008 foreshadow future conditions, the relocations will save lives and prevent the repeated loss of homes and businesses. The value of preserving floodplains in a changing climate is not confined to an immediate reduction in flood damage, however. Large floods also undermine community cohesiveness, drive families away and weaken the local economy. The measures that Soldiers Grove and Gays Mill have taken will make them more resilient and enable quicker recovery. Rather than leaving themselves at the mercy of Mother Nature, these villages have decided to play an active role in determining their future and will reap the benefits for years to come.

Conclusion

Recent extreme weather events like Superstorm Sandy and the summer drought of 2012 (and the related loss of life and tens of billions of dollars' worth of damage) serve as vivid reminders of the nation's vulnerability to weather and climate. Without action, warmer temperatures, changing precipitation patterns and rising seas will exact an increasingly heavy toll on human health, communities, the economy and the environment. However, local communities and states can and should take steps to plan and prepare for these impacts. Many have already begun to do so by reducing the carbon pollution that fuels climate change and implementing strategies to prepare for climate impacts. Yet many more are not acting and remain woefully unprepared.

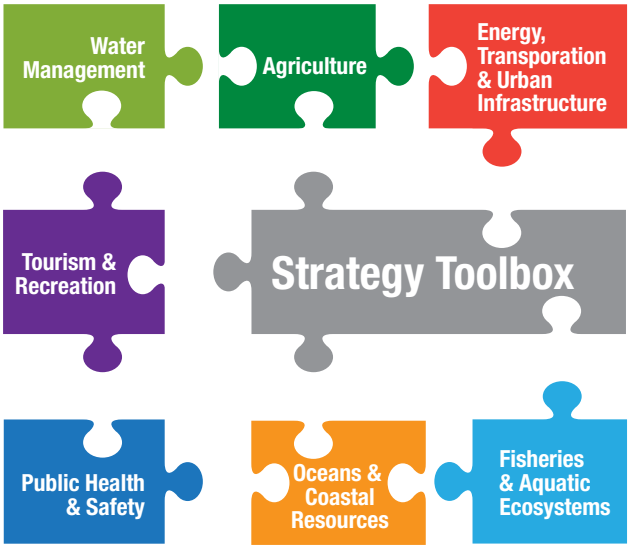
As climate change continues to alter historical temperature and precipitation patterns, it is critical that all states develop and implement climate preparedness plans. The planning process described in this guide provides state governments, water managers and other stakeholders with the information necessary to begin addressing the risks that climate change poses for people, communities and ecosystems. By following these steps, states will be better positioned to tackle the inevitable challenges that climate change presents and better prepared for future climate variability. With increasingly extreme weather, preparing for a changing climate and the new normal cannot wait. There is far too much at stake.

Strategy Toolbox

The preparedness strategies listed here have been identified from an extensive literature review and have been evaluated by subject matter experts to ensure they will help to build the resilience and reduce the vulnerability of both people and ecosystems to climate change impacts.

The strategies are organized first according to sector (agriculture; energy, transportation and urban infrastructure; fisheries and aquatic ecosystems; oceans and coastal resources; public health and safety; tourism and recreation; and water management), and then grouped by what goal or outcome the strategy achieves. Because water resources are utilized by multiple sectors, management decisions are inherently complex and must take into account many objectives. The goal of water resource management should be to consider these objectives in an integrated and holistic fashion. However, for the sake of simplicity and ease of use, strategies are organized according to sector. Although many of the preparedness strategies contained in the toolbox provide multiple benefits and address numerous climate risks, most strategies are listed only within the most relevant sector to eliminate redundancy.

The seven sectors included in the Strategy Toolbox.



Specific strategies are generally listed from less intensive (in lighter color) to more intensive (in darker color), recognizing that state-specific circumstances will determine the feasibility and applicability of each strategy listed. Less intensive strategies are generally lower in cost, beneficial under all climate change scenarios and achievable in the short term, and they often also provide long-term benefits. More intensive strategies may require the creation of new institutions, system-wide retrofits or comprehensive regulatory changes. Yet these strategies are likely to be the most effective at reducing long-term vulnerability to climate impacts. Given differences in terms of resources, governance and regulatory structures, and the ability to compel or incentivize local actions, states will need to consider how to adapt the strategy ideas presented here to their specific circumstances.

Many of these strategies are traditional best management practices because proper and effective management of existing threats to water resources is essential to building long-term climate resilience. As the climate changes further and impacts on water resources intensify nationwide, states and cities must be proactive in adopting flexible and adaptive management strategies to protect people, livelihoods, communities and natural resources.

Agriculture

EXPAND AND DIVERSIFY AGRICULTURAL WATER SUPPLY
■ Reduce water loss in existing irrigation systems through maintenance and repair
■ Harvest and store rainwater for agricultural use
■ Capture runoff from barns and outbuildings for reuse
■ Provide incentives for farmers to increase storage capacity by using farm ponds/large cisterns to capture runoff for irrigation needs, animal wash water and cooling water
■ Use efficient irrigation technology (e.g., drip or pulse irrigation)
■ Increase agricultural use of recycled urban water, where appropriate
■ Treat saline drainage water to expand available water supplies
■ Foster voluntary intrabasin transfers of water
■ Expand current resources by developing regional intrabasin water connections to allow for water trading in times of service disruption or shortage

REDUCE WATER DEMAND
■ Require agricultural water suppliers and districts to track water deliveries and prepare and adopt a water conservation plan
■ Use crop idling/fallowing where appropriate
■ Promote awareness of low- or no-cost loans available from the USDA Farm Services Agency's Conservation Loan Program for infrastructure adaptation (e.g., irrigation, livestock facilities)
■ Adjust the selection of planting dates (e.g., earlier planting and harvesting dates to avoid arid late-summer conditions)
■ Employ direct seeding for field crops to eliminate greenhouse/nursery water usage
■ Eliminate the practice of using water to leach salt from crop root zones
■ Construct improvements (lining and piping) to control seepage from ditches and canals
■ Construct and operate properly lined spill-water and tailwater recovery systems
■ Use soil conservation techniques (e.g., terraces) to reduce field tillage and maintain soil moisture
■ Employ conservation tillage methods (e.g., no-till, mulching, strip till) to increase water infiltration and soil organic matter
■ Use cover crops and water-holding crops to enhance soil water retention
■ Improve water use efficiency in agricultural buildings and processing facilities
■ Develop incentives for and promote dry farming opportunities (e.g., wine grapes, apples)
■ Develop incentives (e.g., sales or property tax exemptions, rebates) for the use of advanced irrigation systems such as GIS, GPS, and satellite crop and soil moisture sensing systems
■ Plant a diverse variety of crops to reduce water consumption and defend against drought
■ Review and adopt standard water-use efficiency approaches to meet water needs during dry years, including alfalfa summer dry-down and regulated deficit irrigation
■ Retire farmland requiring irrigation or cap water withdrawals in areas where groundwater is being depleted
■ Use dry-year options to temporarily transfer water rights to other users

REDUCE WATER DEMAND (continued)
■ Establish minimum streamflow requirements in conjunction with minimum water-quality requirements
■ Allow carryover of unused water allocations into future crop years to eliminate conservation disincentives
■ Use incentives to facilitate agricultural water transfers for other beneficial uses within the same basin
■ Establish or increase prices for agricultural water
■ Implement pricing systems that reward conservation (e.g., seasonal pricing)

MANAGE WATER QUALITY IMPACTS
Reduce Erosion and Polluted Runoff
■ Use buffer strips of riparian vegetation/vegetated swales to slow bank erosion and filter drainage water from fields
■ Employ slow-forming terraces, constructed from a combination of infiltration ditches, hedgerows and earth or stone walls, to decrease runoff and increase infiltration
■ Ensure that manure is land-applied only at agronomic rates (see University of Wisconsin's Extension program for an example of specific guidelines)
■ Increase efforts to monitor the use and occurrence of pesticides in the environment
■ Ensure sufficient storage capacity for manure generated at farms in lined lagoon
■ Restore wetlands to filter pollutants and sediments
■ Employ conservation tillage
■ Employ cover crops to reduce erosion and improve water quality
■ Use runoff containment reservoirs
■ Retrofit filtration devices to existing drainage systems to reduce water quality impacts
■ Use variable-rate technology for chemical (pesticide/nutrient) applications
■ Handle manure through alternative management techniques (e.g., manure biodigester), ensuring that leftover waste is handled properly to avoid pollution problems
■ Use carefully prescribed pesticide/nutrient application practices, such as no winter nutrient application and application at agronomic rates
■ Employ organic farming techniques
■ Maintain aquaculture systems separate from natural water bodies to reduce impacts on natural systems and reduce aquaculture's exposure to climate-driven variability

BUILD CROP RESILIENCE TO CLIMATE RISKS
Enhance Information/Research/Outreach
■ Expand collection and dissemination of local weather information for irrigation planning
■ Increase climate change education and outreach to agricultural producers and enable delivery of applied research and decision-making tools
■ Establish an information clearinghouse for growers on water conservation technology
■ Improve accuracy of existing real-time weather warning and forecasting systems for drought and extreme events
■ Reestablish/establish a network of agro-meteorological stations statewide to collect climate observations, including estimates of evapotranspiration, to support research and development of agricultural practices
■ Develop and disseminate seasonal climate forecasts
■ Expand technical assistance programs to help farmers make decisions about sustainable crops and production practices
■ Create or enhance existing networks to facilitate the rapid transfer and adoption of new knowledge and technologies to help farmers adapt to a changing climate, promote sustainability and provide benefits for the environment, rural communities and farmers
■ Enhance water conservation and efficiency activities at the farm and district levels in highly drought-vulnerable basins by expanding technical and financial cost-share assistance programs
■ Expand the role of mobile irrigation labs or extension services to increase support for improved water stewardship practices
■ Support research and development of more crop rotations and crop mixtures
■ Support research on practices (e.g., cover cropping, conservation tillage, soil fertility) to enhance soil's water-holding capacity
■ Research innovative and cost-effective new strategies for improved water management systems and design
■ Model agricultural water demand under future scenarios of climate change and projections of cropping types
■ Develop decision support tools to assist farmers in determining the optimal timing and magnitude of investments to cope with climate change
Transfer Risks Through Insurance and Other Innovative Risk Distribution
■ Analyze drivers of current crop planting behaviors (e.g., crop prices, insurance availability) to determine ways to modify behaviors
■ Determine and establish economic and cooperative structures that can transfer risk away from the bank and farmer, such as Community Supported Agriculture (CSA), where risk is shared between the community and the farmer
■ Incentivize conservation best management practices (e.g., conservation planning) with reduced agricultural insurance (crop/index-based) rates
■ Require agricultural insurance (crop/index-based) to factor climate risk reduction benefits of best management practices in rates
Manage Flooding Risks
■ Promote agriculture that is compatible with periodic flooding
■ Change planting dates to avoid wet periods
■ Promote measures that capture rainfall by improving soil moisture retention and groundwater infiltration (e.g., conservation tillage)
■ Use voluntary floodplain corridor protection easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance
■ Research the benefits of periodic fallowing for active floodplain acres to maximize floodplain storage, nutrient processing and sediment capture (or to prevent major scour damage)

BUILD CROP RESILIENCE TO CLIMATE RISKS (continued)
Manage Flooding Risks (continued)
■ Purchase wetland easements on marginal and flood-prone agricultural lands to diversify grower income, buffer productive lands from flood events, and improve the environmental services provided by these lands
■ Backfill irrigation ditches and install tide gates to prevent brackish water from infiltrating coastal farmland
■ Use improved LIDAR elevation data and information to guide farmers considering relocation of vulnerable farming operations
Manage Emerging Threats from Pests/Weeds/Diseases
■ Integrate potential climate change impacts (e.g., changes in weeds, diseases, pests) into current detection, monitoring and integrated pest management efforts
■ Increase chemical-free forms of pest control
■ Develop and enhance emergency response plans to manage significant pest outbreaks that harm human health, the environment and the economic viability of the agriculture sector, including streamlined approval mechanisms for new biological and chemical tools and monitoring
■ Provide information to the agricultural community to enable farmers and growers to modify agricultural practices and to adapt to new pests and diseases
■ Increase monitoring, detection and control measures for pest insects and plant diseases
■ Improve understanding of how climate change will affect the intensity and distribution of weeds, insects and diseases
■ Increase adoption of techniques that replicate natural systems' mechanisms for pest control, windbreaks, and disease management
■ Maintain the genetic diversity of crops
Conduct Emergency Response and Preparedness Planning to Improve Agricultural Resilience
■ Support research and development of agricultural emergency response plans for severe drought and other extreme events
■ Establish regional coordination capabilities for early-warning systems and early detection and rapid-response approaches to emerging threats

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
California Department of Water Resources, U.S. EPA Region 9, U.S. Army Corps, Resources Legacy Fund	Climate Change Handbook for Regional Water Planning	www.water.ca.gov/climatechange/CCHandbook.cfm
California	2009 California Water Plan Volume 2	www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c02_agwtruse_cwp2009.pdf
California	California Climate Change Adaptation Planning Guide: Identifying Adaptation Strategies	resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf#page=60
California	2009 Climate Adaptation Strategy	www.climatechange.ca.gov/adaptation/documents/Statewide_Adaptation_Strategy_-_Chapter_8_-_Agriculture.pdf
Massachusetts	Massachusetts Climate Change Adaptation Report	www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf#page=97
NRDC	In Hot Water: Water Management Strategies to Weather the Effects of Global Warming	www.nrdc.org/globalwarming/hotwater/hotwater.pdf
Pacific Institute	More With Less: Agricultural Water Conservation and Efficiency in California	www.pacinst.org/reports/more_with_less_delta/more_with_less.pdf
Pennsylvania	Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations	www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf
U.S. Department of Agriculture	Climate Change and Agriculture in the United States: Effects and Adaptation	www.usda.gov/oce/climate_change/effects_2012/CC%20and%20Agriculture%20Report%20(02-04-2013)b.pdf
United Nations Environment Programme	Technologies for Climate Change Adaptation—Agriculture Sector	ncsp.undp.org/sites/default/files/TNA_Guidebook_AdaptationAgriculture.pdf
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004k.pdf
Wisconsin	Wisconsin's Changing Climate: Impacts and Adaptation	www.wicci.wisc.edu/report/WICCI-Chapter-5.pdf

Energy, Transportation and Urban Infrastructure

MANAGE FLOOD RISKS
Assess Existing and Future Risks
■ Adopt updated FEMA flood insurance rate maps
■ Inventory past flood conditions and assess future flooding risks and impacts on infrastructure
■ Update flood insurance rate maps and other regulatory tools that rely on FEMA maps to reflect evolving risks from climate change
■ Develop or update floodplain mapping using the best available science (including LIDAR surveys, climate models, stream migration, etc.) to identify flood-prone areas and especially at-risk facilities
■ Use climate/flood forecast information to manage risks
■ Systematically identify and map landslide-prone areas statewide
■ Implement a scientific floodplain mapping program that uses the best available science for use in local land use planning
Protect Developed Areas
■ Reduce impervious surface and implement green infrastructure to promote infiltration, evapotranspiration and reuse
■ Provide incentives and tools including funding, technical assistance and complementary state policies to aid in the implementation of on-site stormwater management practices
■ When retrofitting existing development and designing new development, use green infrastructure to capture and direct water away from buildings (see Water Management section for additional details)
■ Promote voluntary floodplain corridor protection easements on agricultural lands
■ Encourage development of structures and infrastructure in areas that are unlikely to be eroded or flooded by more intense and frequent storms, instead of in vulnerable areas
■ Use natural floodwater bypasses
■ Identify and map potentially restorable wetlands (PRWs) in floodplain areas
■ Direct water to groundwater infiltration basins from urban streams during high flows
■ Enhance infiltration in headwater areas and near watershed divides, and protect recharge/infiltration buffers from overland flow of runoff
■ Prioritize natural floodplain restoration by reconnecting rivers with their floodplains
■ Use setback levees and bypasses to retain and slowly release floodwaters
■ Enhance dam and levee safety inspections, and evaluate where fortification of existing dams and levees is necessary to withstand increased flooding and extreme storm events or where design improvements or removal of structures would improve flood risk management
■ Manage runoff to minimize high-flow impacts rather than sediment removal during high storm flows with consideration of impacts on local wildlife and water quality
■ Establish buffers and setbacks for development
■ Prevent wetland loss and restore prior-converted wetlands in upland areas to provide storage and filtration and to mitigate storm flows and nutrient loading downstream
■ Use existing reservoirs to impound floodwater and reduce flows by updating operational parameters to improve their ability to help manage floods

MANAGE FLOOD RISKS (continued)
Protect Developed Areas (continued)
■ Flood-proof existing critical structures at risk
■ Acquire land along waterways to prevent flooding, improve water quality and reduce combined sewer overflows
■ Set aside floodplain land to accommodate the safe conveyance of higher flood heights in the future
■ Conserve and restore riparian zones, estuaries, wetlands, and floodplains
■ Enhance natural flood management capacity by developing regulations and incentives to encourage development projects to restore or create flood storage
■ Relocate or remove infrastructure from vulnerable areas
■ Upgrade or implement design improvements for flood-control structures (e.g., levees, flood walls) that protect existing critical infrastructure
■ Repair or remove high-hazard dams and dams that cause localized flooding
■ Remove unnecessary dams, coastal levees, and other infrastructure to allow for wetland advancement zones, natural buffers and the protection of public safety against increased precipitation and extreme events
Use Funding, Financing and Insurance Mechanisms to Reduce Risk
■ Encourage insurance providers to work with lending sources to encourage development outside vulnerable floodplains and coastal zones
■ Consider new mortgage products similar to PACE loans to incorporate the costs of adaptation into private property transactions (PACE allows a local government to provide loans to homeowners for renewable energy and efficiency retrofits, with the loans paid back via tax bills)
■ Revise state Clean Water Revolving Fund criteria to require green infrastructure (as in Maryland's Stormwater Act of 2007), where appropriate
■ Develop a stormwater billing system to create a more equitable fee structure that more closely reflects the costs of managing stormwater for individual properties (e.g., the Philadelphia Model)
■ Provide tax credits for green infrastructure implementation, reduced stormwater fees to reward greater site permeability and rebates for downspout disconnection
■ Establish a committee to investigate data adequacy on climate risks for insurers, adaptive options to mitigate insured losses, and whether insurance rates structures can provide incentives for early adoption
■ Adopt insurance mechanisms and other financial instruments, such as catastrophe bonds, to protect against financial losses associated with infrastructure losses
■ Implement insurance rates that accurately reflect risk
■ Require the purchase of flood insurance for properties protected by levees
Use Regulatory Mechanisms to Reduce Risk
■ Work with federal agencies to reduce new development in areas at high risk from flooding
■ Examine utilization of state statutes and regulations to ensure that new buildings are sited and built in a manner that reduces their vulnerability to climate impacts, especially those on inland and coastal floodplains and other current and future threatened areas
■ Restructure disaster-recovery policies to ensure that redevelopment efforts strive to reduce long-term risk
■ Implement new or modified policies (e.g., zoning regulations, tax incentives, rolling easements) that encourage appropriate land use and reduce repetitive losses

MANAGE FLOOD RISKS (continued)
Use Regulatory Mechanisms to Reduce Risk (continued)
■ Change property tax structures to provide incentives for setbacks, rolling easements and covenants to preclude building and reconstruction in vulnerable areas
■ Change zoning ordinances to discourage development in flood-prone areas, thereby designing communities in ways that proactively mitigate risks
■ Update building codes to require more flood-resistant structures in floodplains (e.g., mandate that buildings or bridges be raised above current and future flood levels, or require that first floors be "floodable")
■ Relocate development out of floodplains as buildings, infrastructure and flood-protection structures age and must be rebuilt
■ Undertake long-term managed relocation or elevation of existing structures in vulnerable areas
Enhance Public Awareness
■ Develop public education and outreach on landslide risks and how to adapt to them
■ Educate property owners about flood inundation levels and rates of failure of flood-control structures
■ Provide individual landowners with better information about their ecologically based flood-proofing options and the rapidly changing location of floodplains as shifts in land use and climate affect erosion and flooding
■ Improve the accuracy and technological capabilities of flood forecasting, early-warning and emergency-preparedness systems

INTEGRATE CLIMATE CHANGE INTO PLANNING FOR EXISTING AND NEW INFRASTRUCTURE
■ Evaluate ability and need to harden or relocate transfer stations and related solid waste infrastructure located within areas likely to be affected by sea level rise or inland flooding
■ Engage local and municipal stakeholders to determine the needs of local jurisdictions and to convey the importance of climate resilience
■ Determine critical public buildings that will be impacted by coastal and inland flooding and recommend appropriate adaptation strategies that will not adversely impact natural resources
■ Work with local jurisdictions to incorporate consideration of climate change into ongoing land use planning efforts (e.g., growth management, development planning)
■ Launch a climate-smart growth and infrastructure education campaign
■ Use elevation assessment tools such as LIDAR to help inform decisions on siting
■ Develop decision tools to evaluate replacement, modification and design life for infrastructure
■ Design buildings to maximize resilience by placing on higher floors those assets and services most likely to be impacted by flooding or those most expensive to replace (e.g., electrical and HVAC systems)
■ Design infrastructure to accommodate projected changes in natural conditions over the life of the project
■ Incorporate evaluation of climate change impacts into permitting processes to facilitate consideration of these impacts in the development/redevelopment process
■ Develop best management practices, policies and incentives for land management that reduces landslide risk
■ Ensure adequate insurance for levels of risk with the state insurance commission and insurance industry to address defined risk where it occurs

INTEGRATE CLIMATE CHANGE INTO PLANNING FOR EXISTING AND NEW INFRASTRUCTURE (continued)

- Collaborate with trade associations and the insurance industry to develop specification improvements that ensure building and infrastructure designs are more resilient to climate change
- Limit new development in floodplains and coastal areas vulnerable to sea level rise or flooding, and, where feasible, return coastal and floodplain areas to natural conditions
- Promote practices (e.g., buyouts and relocations of flood-prone properties) that eliminate flood risk by removing property from the floodplain and restoring land to naturally functioning ecosystems
- Update aging solid waste infrastructure, with consideration of green practices that may be more resilient to climate change impacts, especially precipitation and stormwater effects

MANAGE CLIMATE RISKS TO TRANSPORTATION INFRASTRUCTURE

- Accelerate use of green infrastructure in local capital improvement plans (see Water Management section for additional details)
- Elevate subway ventilation grates above ground level
- Coordinate planning with other stakeholders (e.g., energy utilities, natural resources agencies) to improve preparedness for increases in extreme events
- Assess emergency response systems, the sufficiency of emergency shelters, and the evacuation capacity of communities and transportation access bottlenecks
- Assess infrastructure elevation, state of repair, capacity of culverts, land development trends and natural resource conditions to identify vulnerable infrastructure
- Identify state investments necessary to prepare for future weather emergencies (e.g., snow, rain, floods) that impact transportation
- Prioritize transportation planning that reduces congestion and minimizes greenhouse gas emissions (e.g., improved public transit, transit-oriented development)
- Determine vulnerable transportation routes and transportation infrastructure that may adversely impact natural resources and human mobility under future climate change scenarios
- Work with ports to determine short- and long-term strategies to protect port infrastructure and transportation linkages to prevent disruption of commerce and international trade
- Determine what transportation infrastructure to protect, retrofit or relocate according to a clear framework of priorities for capital resources by considering the following:
  - Water dependence and vulnerability to flooding and scour
  - Importance as an evacuation/emergency route
  - Environmental and economic benefits from incorporating green infrastructure or other innovative approaches to reduce flooding and protect clean water
  - Major opportunities for ecological restoration by removing, elevating, improving or relocating the asset
  - Ability to serve as a levee protecting valuable land and development, if retrofitted
- Require more frequent inspections of transportation routes and mechanisms based on their age, condition, vulnerability and location
- Conduct extended and more detailed/comprehensive inspections of transportation infrastructure, such as roads and bridges, after high-impact events in areas that are subject to erosion
- Adjust routine operations, maintenance and inspection, and capital budget expenses to prepare for more frequent and intense storms, floods, landslides, etc.

MANAGE CLIMATE RISKS TO TRANSPORTATION INFRASTRUCTURE (continued)

- Conduct a comprehensive analysis of the vulnerability of transportation infrastructure and prioritize network repair, replacement, improvement or decommissioning
- Move portable assets (e.g., buses, railcars) out of vulnerable areas in advance of extreme weather events
- Prioritize the retrofit of transportation infrastructure while undergoing maintenance and repair
- Ensure proper pumping and drainage capacity for underground transportation networks
- Strengthen building and infrastructure design standards to emphasize both energy and water efficiency and climate preparedness benefits by:
  - Changing design standards of roadways and other structures, including those that may be prone to flooding as a result of dam from ice dams or other debris blocking water flow
  - Coordinating culvert and fish passage upgrades with natural resource agencies engaged in fish passage
- Consider applying floodplain-level standards to areas vulnerable to flooding that may not be in the existing 100-year floodplain
- Utilize climate models to help with planning, design, siting, construction, operations and maintenance
- Require sea level rise and changes in heavy rainfall events to be factored into the design of all transportation projects and major repairs in vulnerable areas
- Develop transportation design and engineering guidance to minimize climate change risks when siting and designing new transportation infrastructure and project-related infrastructure, such as stormwater treatment and flow control, wetlands protection and mitigation, and fish passages
- Require all new and redeveloped transportation projects to meet objective, performance-based retention standards designed to protect, restore and replicate natural hydrology
- Create emergency transportation alternatives for corridors that may suffer from extreme events or prolonged closures
- Enhance the preparedness of transportation, utilities and emergency service providers to respond to weather-related emergencies (e.g., heavy rain and snow events, heat extremes, and other emerging public concerns) through increases in funding and emergency training
- Investigate the impacts of development on the whole watershed and downstream effects on transportation infrastructure to determine design criteria (e.g., culvert and drainage system sizing)
- Require stream simulation design and/or stream meander mapping to be factored into the design of road-stream crossings
- Reduce flood damage resulting from small culvert failure by facilitating replacement with larger, more resilient culverts
- Relocate vulnerable roadways located in floodplains

MANAGE CLIMATE RISKS TO COMMUNICATIONS AND ENERGY INFRASTRUCTURE

Reduce Risks to Communications Systems

- Assess communications infrastructure operations and maintenance plans with respect to changing climate conditions
- Improve reliability of communications systems for use during and after extreme events
- Revise building codes to allow positioning of emergency generators and fuel supplies at higher levels
- Evaluate options for underground energy and communications infrastructure to increase protection from storms, including use of fiber-optic materials for replacement

MANAGE CLIMATE RISKS TO COMMUNICATIONS AND ENERGY INFRASTRUCTURE (continued)
Reduce Risks to Energy Production Facilities and Infrastructure
■ Adopt the most up-to-date water conservation technologies and water-efficient practices and use alternative water supplies whenever possible
■ Encourage designs that make buildings more resilient to energy-supply interruptions and droughts (e.g., passive heating and cooling, daylighting, gray water reuse, water recycling, distributed generation)
■ Monitor and encourage reduction of thermal discharges from power plants, which can have significant harmful impacts on aquatic ecosystems
■ Develop operational contingency plans for critical infrastructure, including energy supply and distribution networks
■ Monitor instream flows and water temperature with a robust stream gauging program in basins with thermal and hydropower generation facilities
■ Conduct vulnerability assessments of energy-system assets at risk of climate impacts and, over time, improve the reliability of energy infrastructure and equipment that is identified as most likely to fail during extreme events or as a result of sea level rise
■ Identify energy infrastructure and production facilities vulnerable to potential climate impacts including drought and water scarcity
■ Assess vulnerability of electricity conduits and communication lines to flooding, salt intrusion and more frequent and stronger storm events
■ Encourage owners and operators of critical energy infrastructure to evaluate vulnerability to the impacts of climate change, including the risk of damage and the potential for disruptions and outages from flooding, sea level rise, extreme heat, drought, erosion and other extreme weather events
■ Explore opportunities to coordinate water treatment and energy generation (for instance, locating power plants next to wastewater treatment facilities could partly displace freshwater needs for cooling purposes)
■ Replace or retrofit the building stock over time with resource-efficient, climate-adaptive buildings that are energy and water efficient
■ Monitor and model temperature and precipitation patterns to understand how changing weather patterns will affect hydropower generation in both drought and flood situations
■ Alter the timing of hydropower generation to more closely mimic a river's natural ebb and flow
■ Stabilize lake levels and dam releases to protect lake shoreline and riverbanks from erosion
■ Allow fish to safely pass around hydroelectric dams, such as by using fish ladders
■ Replace outdated turbines and generators with more efficient equipment at hydropower facilities to generate more electricity per unit of water and generate more efficiently across a range of flow conditions
■ Provide incentives for the use of less water-intensive renewable energy sources
■ Design new facilities to be resilient to sea level rise through the end of their service lives
■ Develop and implement drought-resistant cooling technologies as drought could cause curtailments at nuclear, coal and natural gas power plants, potentially impacting electric grid reliability
■ Enhance the resilience of electric grid and communications infrastructure (e.g., towers, lines) in coastal and inland flood zones
■ Seek to reduce water use in energy production by considering alternative technologies since peak water use in energy production often coincides with periods of high heat and low water availability
■ Require closed-cycle or dry cooling instead of once-through cooling in power plants to reduce water withdrawals and thermal stress on waterways
■ Require the use of reclaimed water for cooling, where appropriate

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
California	California Climate Change Adaptation Planning Guide: Identifying Adaptation Strategies	resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf#page=63
Center for Clean Air Policy	The Value of Green Infrastructure for Urban Climate Adaptation	ccap.org/assets/THE-VALUE-OF-GREEN-INFRASTRUCTURE-FOR-URBAN-CLIMATE-ADAPTATION_CCAP-February-2011.pdf
Environmental and Energy Study Institute and the Center for Clean Air Policy	Climate Adaptation & Transportation: Identifying Information and Assistance Needs	files.eesi.org/Climate_Adaptation_Transportation.pdf
Federal Transit Administration	Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation	www.fta.dot.gov/documents/FTA_0001_-_Flooded_Bus_Barns_and_Buckled_Rails.pdf
ICLEI-USA	San Diego Bay Sea Level Rise Adaptation Strategy	www.icleiusa.org/static/San_Diego_Bay_SLR_Adaptation_Strategy_Complete.pdf
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea-level Rise and Coastal Storms	www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf#page=15
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic and Ecological Resilience	www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf#page=61
Massachusetts	Massachusetts Climate Change Adaptation Report	www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf#page=58
New York State	Response to Climate Change in New York State	www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Environmental-Reports/EMEP-Publications/Response-to-Climate-Change-in-New-York.aspx
Pennsylvania	Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations	www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf
Union of Concerned Scientists	Freshwater Use by U.S. Power Plants	www.ucsusa.org/clean_energy/our-energy-choices/energy-and-water-use/freshwater-use-by-us-power-plants.html
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004m.pdf

Fisheries and Aquatic Ecosystems

PROTECT AND RESTORE CRITICAL HABITAT
Protect and Restore Critical Marine and Anadromous Fisheries Habitat
■ Remove dams and other stream barriers where the adverse ecological harm outweighs any benefits provided by the structure or where the structure is dilapidated, outdated or no longer in use
■ Build fish passage structures where technically feasible for dams that need to stay in place
■ Modify or replace road crossings and culverts where necessary to provide fish passage
■ Restore riverine habitat essential to supporting healthy, self-sustaining populations of native fish
■ Protect and restore nearshore habitat
Protect and Restore Riparian and Freshwater Habitat
■ Protect existing, headwater, riparian and freshwater habitat form further degradation
■ Promote planting of native species and prevent the sale of invasive species in nursery trade for riparian plantings
■ Remove barriers (e.g., dams/culverts) to improve connectivity/fish migration and improve habitats (flow), particularly those that are no longer needed or are a barrier to fish passage
■ Manage cold-water resources in large reservoirs to provide suitable water temperatures at critical times of the year, particularly during heat waves
■ Replace undersized and/or perched culverts or those acting as aquatic species barriers with open-bottom designs (such as bottomless archway culverts) and bridges that are less restrictive, to allow for aquatic passage and to support natural ecological processes
■ Restore riparian habitat and natural features that provide overhead cover and shade, particularly those that mimic undercut banks
■ Prevent excessive urban runoff by reducing existing impervious surfaces, or limiting creation of additional impervious surfaces, in critical watersheds and through restoration of riparian buffer zones
■ Promote use of native vegetation to restore stream banks and encourage channel stability, reducing erosion and improving water quality
■ Restore beneficial native aquatic plants and improve fish habitat throughout lakes and watersheds
■ Identify areas experiencing significant tree loss and develop a plan for restoring these areas with native species
■ Expand or revise current minimum riparian buffer zones to better protect thermal conditions in all streams but especially in headwater/small streams
■ Protect strongholds of fish habitat by increasing available habitat and reestablishing stream connectivity to allow fish to move to suitable habitat
■ Increase resilience of aquatic ecosystems to climate change impacts by ensuring adequate habitat availability and limiting population-level impacts of human activities
■ Where appropriate, improve flood management systems by setting back or breaching levees, dikes, berms and other structures to reconnect rivers to their floodplains, and replace armoring with nonstructural alternatives
■ Maintain and restore streamflow, protect recharge areas and avoid excessive withdrawals of groundwater
■ Adopt regulations that provide streamflow levels necessary to ensure the resilience and ecological integrity of both warm-water and cold-water streams
■ Re-operate reservoirs to increase flows if necessary to provide suitable habitat for fish and support for riverine ecosystems
■ Increase on-the-ground implementation of existing stream restoration practices (e.g., riparian buffers, stormwater management, sediment control)
■ Where appropriate, restore or enhance stream channels to create cold-water refuges, including areas near downed logs, root wads, large boulders, deep pools, undercut banks, side-channel or alcove habitats and spring flow areas

PROTECT AND RESTORE CRITICAL HABITAT (continued)

Protect Critical Habitat from Agricultural Impacts

- Utilize best management practices (BMPs) on agricultural lands and barnyards to limit polluted runoff
- Ensure conservation compliance on farms, including the proper protection of highly erodible soils and nutrient management plans
- Protect environmentally sensitive agricultural land through enrollment in the Conservation Reserve Program (CRP) or other, similar programs
- Work with farmers and ranchers to develop and implement livestock management practices to reduce and reverse habitat degradation and to protect regeneration of vegetation
- Favor intensive rotational grazing over continuous grazing in upland areas of watersheds
- Provide native habitat buffers between agricultural lands and waterways
- Reduce nutrient loads through minimized fertilizer applications
- Limit agricultural "drainage improvements" that rapidly remove water from farmlands and convey it to stream channels
- Restore wetlands in agricultural areas

IMPROVE FISHERIES MANAGEMENT

Integrate Climate Change into Fisheries Management

- Increase monitoring of stocks and maintain basic fish sampling
- Ensure that fisheries' interests, including the need for conservation of resources, are taken into account in the multiple uses of coastal zones and are integrated into coastal area management, planning and development
- Conduct climate change risk assessments for native fisheries to identify species and populations that are at risk, and include potential economic losses and the costs of adaptation measures
- Ensure that land and water resource managers at the state and local levels integrate adaptation options into planning, programs and practices

Improve Management of Individual Fisheries and Ecosystems to Build Climate Resilience

- Use a science-based approach to better target protection and management actions by establishing temperature ranges and maximums and other water quality ranges for resource management
- Review existing legal, regulatory and policy frameworks that govern protection and restoration of fisheries habitats, and identify opportunities to improve their ability to address climate change impacts
- Base conservation and management decisions for fisheries on the best scientific evidence available, and consider traditional knowledge of the resources and their habitat, including current and future environmental, economic and social factors
- Integrate sustainable fisheries management into local land planning and development regulations
- Support initiatives to reduce recreational and commercial fishing in already stressed fisheries; lightly fished stocks are likely to be more resilient to climate change impacts than those heavily fished
- Strengthen and enforce laws that govern groundwater, particularly those critical to protecting cold-water streams and fisheries
- Identify water-rights options that protect fish and wildlife
- Manage fish populations to increase resilience to interdecadal environmental variability by determining the minimum number of age classes needed for resilience and then managing age structure accordingly
- Prevent overfishing and rebuild depleted fisheries by maintaining fisheries above biomass levels that produce maximum sustainable yield, to ensure more resilient populations under changing environmental conditions

IMPROVE FISHERIES MANAGEMENT (continued)
Reduce the Impact of Invasive Species
■ Promote the health of native populations, which gives them a better chance to compete successfully
■ Strengthen rules for cleaning and transporting boats and recreational fishing gear to reduce invasive species outbreaks
■ Increase research into new techniques for controlling/managing invasive species
■ Increase monitoring and control of invasive plant and aquatic species
■ Develop regulations aimed at preventing future incursions of exotic and invasive species
■ Ban the sale of invasive plant and aquatic species that have shown to be a problem elsewhere and are not benign in character
■ Sever man-made hydrologic connections between distinct basins (Great Lakes and Upper Mississippi; Great Lakes and St. Lawrence Seaway; Santee River and Cooper River; etc.)
Reduce Impacts on Marine Fisheries
■ Address stormwater and pollutant flows from mainland
■ Initiate a dialogue among all affected interests about opportunities to improve the utility of existing legal, regulatory and policy frameworks to address impacts of sea level rise on coastal habitats
■ Restore sediment flows to estuaries, and protect and restore estuary habitats
■ Limit harvests for selected fisheries, particularly those that are unsustainably harvested

ENHANCE INFORMATION AND OUTREACH
Increase Research to Improve Fisheries Knowledge
■ Use best available science regarding projected climate changes and trends as well as vulnerability and risk assessments
■ Assess overall range, combination, likelihood and potential impacts of climate-related effects in fishery contexts
■ Collect data on fish distribution, abundance and recruitment and use a science-based approach to inform fishery management strategies to maintain appropriate levels of abundance, age and recruitment as environmental conditions change
■ Identify how climate change may affect or be affected by decisions about land use and energy development, and how this might impact species, habitat and connectivity across the state
■ Prioritize research and data collection needed to improve management of fisheries, including consideration of their interaction with the ecosystem
■ Improve knowledge of key factors that promote recolonization by extirpated fish and mussels
■ Locate existing data or collect new data to establish baseline conditions for vulnerable species, and establish a central database for vulnerable and ecologically valuable species/habitats
■ Increase monitoring of species and habitats, particularly those that are vulnerable, against an established baseline over the long term
■ Work with local and regional water resource management agencies to evaluate historical flows and recent base flows, and develop water management options to protect or restore aquatic habitats
■ Work with water resource managers to enhance design and siting criteria for water resources infrastructure to reduce impacts and restore connectivity in floodplains and aquatic habitats
■ Encourage bilateral and multilateral cooperation in research for transboundary fisheries, recognizing the transboundary nature of many aquatic ecosystems, and establish binding fisheries laws
■ Model/project how species will move across a state or region in response to climate change and factor in their relative vulnerability to climate change stresses

ENHANCE INFORMATION AND OUTREACH (continued)
Improve Outreach and Public Awareness
■ Inform sport fishermen and other stakeholders about the importance of climate change impacts on freshwater aquatic systems
■ Identify subsistence fishing communities and develop a plan that both increases awareness and addresses the need for sustenance
■ Conduct channel migration zone (CMZ) mapping and other activities to support education of landowners on setbacks from rivers, maintenance of connectivity, ecosystem integrity and personal safety

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
California	2009 Climate Adaptation Strategy	www.climatechange.ca.gov/adaptation/documents/Statewide_Adaptation_Strategy_-_Chapter_5_-_Biodiversity_and_Habitat.pdf
Food and Agriculture Organization (FAO) of the United Nations	Building Adaptive Capacity to Climate Change: Policies to Sustain Livelihoods and Fisheries	ftp.fao.org/docrep/fao/010/a1115e/a1115e00.pdf
Food and Agriculture Organization (FAO) of the United Nations	Code of Conduct for Sustainable Fisheries	www.fao.org/docrep/005/v9878e/v9878e00.HTM
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic and Ecological Resilience	www.dnr.state.md.us/climatechange/pdfs/climatechange_phase2_adaptation_strategy.pdf#page=41
Massachusetts	Massachusetts Climate Change Adaptation Report	www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf#page=40
Pennsylvania	Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations	www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004g.pdf
Wisconsin	Wisconsin's Changing Climate: Impacts and Adaptation	www.wicci.wisc.edu/report/WICCI-Chapter-4.pdf

Oceans and Coastal Resources

MANAGE COASTAL CLIMATE RISKS
Protect and Restore Coastal and Marine Ecosystem Habitat
■ Reduce water pollution by using innovative strategies like green infrastructure (see Water Management section for additional details)
■ Reestablish assemblages of coral reef species to prior natural states by decreasing pollution in coastal areas, using approaches such as green infrastructure
■ Manage forests and wetlands to enhance ecological services and storm impact reduction
■ Identify priority conservation and restoration areas that can increase natural resilience and protect vulnerable communities
■ Preserve ecological buffers to allow inland migration of beaches, wetlands and salt marshes
■ Implement reef restoration projects
■ Expand priorities for existing land conservation to promote horizontal marsh migration or vertical accretion
■ Enhance and protect wildlife corridors, and maintain the connectivity of vegetated areas
■ Direct state agencies to develop guidelines that incorporate sea level rise into state-managed and supported coastal restoration and protection projects
■ Develop and provide state and local jurisdictions with green shoreline design manuals for different types of shoreline
■ Perform a comprehensive modeling assessment of the extent of inland migration of tidal marshes to inform adaptation decisions
■ Restore coastal ecosystems (e.g., salt marshes and coastal mangroves) to reduce erosion and flooding
■ Restore coastal ecosystems (e.g., wetlands) for runoff storage and flood management, to reduce pollution, sequester carbon, increase open space and provide critical habitat for diverse species
■ Restore coastal ecosystems (e.g. wetlands) to protect both aquatic and terrestrial organisms by removing invasive plants and replanting native vegetation
■ Map potential locations of wetland migration corridors, areas where accretion may keep pace with sea level rise, and areas that are not suitable for migration and need active management to be sustained
■ Offer financial incentives that encourage private forest, waterfront and riparian landowners to preserve wetlands instead of developing those areas
■ Acquire land and conservation easements to provide upslope “advancement zones” adjacent to tidal marshes
Reduce Property Damage and Public Safety Risks
■ Reduce development in coastal hazard areas
■ Use more stringent building codes, elevation and/or lateral setbacks for new buildings and infrastructure, in addition to rebuilding disaster-damaged buildings and infrastructure that cannot be relocated
■ Consider climate change in flood hazard mapping to identify at-risk areas
■ Allow natural sediment-soil accretion in coastal areas to occur
■ Incorporate climate change impacts into design requirements for coastal structures
■ Protect and restore naturally occurring storm barriers, like dunes and wetlands
■ Develop or improve coastal flood warning systems
■ Use wet and dry flood-proofing measures to make structures more resilient to flood damage (Dry flood-proofing: use of special sealants or components that make lower floors watertight; Wet flood-proofing: allowing lower floors to flood but using materials less susceptible to damage)

MANAGE COASTAL CLIMATE RISKS (continued)
Reduce Property Damage and Public Safety Risks (continued)
■ Consider managed retreat to reduce flooding and erosion by allowing the flooding of presently defended areas
■ Prevent shoreline hardening by adopting regulations or easements (e.g., rolling, conservation)
■ Identify incentives and regulatory tools to reduce exposure to risk, and discourage new public development in coastal areas
■ Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas with regard to elevation, foundation design, long-duration flood impacts, debris impact, building envelope and capital project design
■ Remove government subsidies for development in vulnerable areas
■ Facilitate the landward relocation of roads and other infrastructure
■ Relocate or remove shoreline infrastructure to minimize human suffering from severe events
■ Establish regulations to control floodplain development
■ Do not permit new development in areas identified by local risk assessments and inundation maps as vulnerable to projected end-of-century sea level rise, unless project design and construction are compatible with sea level rise
Consider Climate Risks in Existing Policies and Programs
■ Coordinate state agencies' coastal adaptation strategies and actions to help prioritize actions across state agencies
■ Adopt uniform sea level rise estimates or ranges for planning purposes
■ Update planning guidelines to provide incentives for local governments to consider climate change impacts and relevant adaptation actions when amending shoreline master programs, land use management plans and other planning documents
■ Require coastal municipalities to conduct a sea level rise vulnerability assessment and update regularly as new and improved scientific information becomes available
■ Incorporate sea level rise and associated impacts into relevant local and regional plans and projects, including ecosystem restoration planning
■ Develop an inventory of dikes, levees, tide gates, hazardous waste cleanup sites, nearshore fuel storage facilities and other facilities located in vulnerable areas
■ Identify essential public infrastructure at risk and develop a decision-making process to determine when to protect, retrofit, relocate or retreat
■ Require all projects that the state funds, permits or approves to consider the effects of sea level rise and other coastal hazards
■ Evaluate and propose revisions of laws/rules that govern land use, shoreline management and other programs to effectively address sea level rise and other climate change impacts
Enhance Public Awareness
■ Update and maintain statewide sea level rise mapping, modeling and monitoring products
■ Inform prospective coastal property purchasers of likely climate impacts to the property by notifying potential buyers in property listing; disclosure notice settlement; as well as recording the impacts on the plat maps, zoning maps, or with the title and deed
■ Work with FEMA to include projected sea level rise scenarios in flood insurance rate maps (FIRMs) to help participating communities understand future risks of developing in low-elevation coastal areas

MANAGE AND IMPROVE UNDERSTANDING OF OCEAN ACIDIFICATION
Reduce the Impact of Ocean Acidification
■ Reduce land-based sources of both point and nonpoint pollution (e.g., polluted runoff, leaking septic systems) that contributes to decreases in pH of coastal and ocean waters, particularly in estuaries with high freshwater inflow
■ Integrate threats from ocean acidification into new and existing climate change programs and planning
■ Update fisheries management plans to include acidification for potentially impacted species
■ Reduce atmospheric carbon dioxide concentrations
■ Establish seagrass beds near corals to provide a short-term local buffer from the effects of ocean acidification
■ Identify and protect high-biodiversity coral reefs in areas where water is beneficial to coral growth with respect to parameters related to ocean acidification
Increase Monitoring and Research
■ Support the development of tools to predict and forecast low pH and corrosive conditions
■ Collaborate with NOAA Fisheries, other federal agencies, nonprofit organizations, academic groups and the shellfish industry to enhance monitoring of biological, hydrologic, hydraulic and chemical conditions
■ Increase research to help commercially important species that are known to be vulnerable, such as oysters, adapt to effects of seawater acidity on marine organisms and ecosystems
■ Increase participation in the National Estuarine Research Reserve System (NERRS) to obtain funding for research
■ Explore how Clean Water Act authorities can be used to prevent or reduce localized effects of ocean acidification (e.g., total maximum daily load programs)

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
Georgetown Climate Center	Adaptation Toolkit: Sea Level Rise and Coastal Land Use	www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea-level Rise and Coastal Storms	www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf
New York State	New York State Sea Level Rise Task Force Report	www.dec.ny.gov/docs/administration_pdf/slrtffinalrep.pdf
NRDC	Ocean Acidification: The Other CO_2 Problem	www.nrdc.org/oceans/acidification/
The Nature Conservancy	Honolulu Declaration on Ocean Acidification and Reef Management	coralreef.noaa.gov/aboutcrcp/strategy/reprioritization/wgroups/resources/climate/resources/oa_honolulu.pdf
U.S. EPA	Rolling Easements	water.epa.gov/type/oceb/cre/upload/rollingeasementsprimer.pdf
United Nations Environment Programme	Technologies for Climate Change Adaptation—Coastal Erosion and Flooding	www.unep.org/pdf/TNAhandbook_CoastalErosionFlooding.pdf
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004h.pdf

Public Health and Safety

ENHANCE EXISTING EMERGENCY PREPAREDNESS AND RESPONSE PROGRAMS

- Assess and, as necessary, enhance the capacity of existing emergency preparedness, response, recovery and regulatory programs (e.g., identify potential institutional/legal barriers to effective response, expand emergency response workforce)
- Facilitate greater cooperation and sharing of resources and expertise among the business community, public health organizations, health-care sector, forestry sector, and tourism industry to increase capacity to address emergencies
- Evaluate the adequacy/effectiveness of current early-warning systems for extreme events
- Assess the effectiveness of existing community evacuation plans in at-risk areas (with input from affected community groups and individuals), including plans for nursing home facilities and public housing, to identify what elements require improvements
- Require that emergency preparedness plans include coordination and communication among critical stakeholders, such as community organizations, local businesses, local health departments, hospitals and other health-care delivery facilities, utilities and local government
- Include in existing emergency response/preparedness/management plans events that will become more likely with climate change (e.g., floods, wildfires, sea level rise, extreme heat, saline intrusion); consider the most updated estimates of likely levels of precipitation, flooding and extreme storm events
- Conduct exercises to enhance preparedness for events likely to increase with climate change and to test early-warning systems and response plans (including prevention of vector-borne and water-borne diseases following floods and storms, response training, and best practices for safe cleanup after a disaster)
- Determine how existing telecommunications technology and social networking systems can be better integrated into early-warning and evacuation systems
- Assist at-risk communities with the development, adoption, practice and evaluation of response, evacuation and recovery plans

BUILD COMMUNITY RESILIENCE

Enhance Public Awareness

- Incorporate climate change and public health messages into existing education and outreach efforts, targeting vulnerable populations, clinicians and health professionals
- Use community-based groups and business/trade organizations to conduct outreach and education about risks and prevention and to connect individuals and families to appropriate services
- Develop a web-based resource hub to provide information and technical resources on public health and climate change preparedness
- Conduct education and outreach on emergency preparedness and response, including mental health needs following a disaster
- Expand public outreach and education efforts concerning the negative impacts of stormwater on flooding, water quality and public health risks following floods; the hazards of building in flood-prone areas; and the importance of sanitary sewer inflow and combined sewer overflow prevention
- Increase real-time reporting to educate the public regarding vector-borne disease, harmful algal blooms and waterborne diseases
- Disseminate information on appropriate individual behavior to avoid exposure to vectors, including eliminating vector breeding sites around residences
- Provide alerts regarding potential health risks (e.g., prediction of when/where harmful algal blooms and pathogen events may occur) through communications and early-warning systems that convey information to vulnerable communities

BUILD COMMUNITY RESILIENCE (continued)

Manage Water Quality Risks

- Continue to support funding for municipal infrastructure to reduce CSOs
- Use green infrastructure to reduce stormwater runoff volume and to filter pollutants (see Water Management section for additional information)
- Develop statewide standards for blue-green and red algal toxins
- Strengthen recreational water quality standards
- Develop more stringent regulations for shellfish advisories and recreational advisories, taking into account climate change impacts
- Modify safe water regulations to take climate change into account, and enforce accordingly

Protect Critical Public Health Facilities

- Identify vulnerable health-care facilities
- Set higher flood protection standards for all critical health facilities and infrastructure that could be exposed to flooding during their life span
- Develop strategies and incentives for the relocation of at-risk critical public health infrastructure to inland non-advancement zones for wetlands

Address Threats to Vulnerable Populations

- Consider the public health needs of vulnerable populations, such as the elderly and those of low socioeconomic status, in climate change preparedness planning
- Assess the vulnerability of schools in flood-prone locations to water and moisture damage, and adopt guidance for retrofit or remediation policies to reduce risks of flooding, moisture incursion, mold growth and exposures among schoolchildren and staff
- Work locally with vulnerable groups, including senior citizens, people with impaired mobility, and people with limited English-language proficiency, by engaging existing community networks to increase their response capacity; work to understand these groups' concerns and solicit potential solutions from members
- Improve capacity to conduct vector and human surveillance in order to identify high-risk groups and geographic areas to better target outreach, education and prevention efforts

BUILD PUBLIC HEALTH CAPACITY

Build Institutional Capacity at Local, Regional and State Levels

- Institutionalize consideration of health in land use; transportation; environmental quality; parks and recreation; urban; food; and water planning
- Facilitate and enhance regional coordination efforts among local boards of health
- Expand training and education at state and local agencies to build capacity to respond appropriately to the public health risks of climate change and to educate community members about their risks
- Enhance education of health-care professionals to understand the health risks of climate change, including diagnosis and treatment for health outcomes that may become more prevalent
- Increase funding resources for local public health departments to plan and prepare
- Incorporate climate vulnerabilities into existing public health planning, programs, policies and regulations
- Help local health departments assess their capacity to respond to health threats and to integrate climate preparedness into their hazard response plans and daily operations
- Expand the scope of the state hazard mitigation plan to factor in expected vulnerabilities from climate change impacts

BUILD PUBLIC HEALTH CAPACITY (continued)

Improve Disease Prevention

- Evaluate the capacity of existing disease prevention programs, enhance surveillance of disease and disease-causing agents, and enhance the capacity of public health programs that control disease-causing agents
- Work to improve capacity to respond to vector-borne diseases, streamline and automate reporting mechanisms, and stockpile supplies for prevention (e.g., insect repellent, repellent-impregnated work clothing)
- Enhance prevention (e.g., vaccination) and treatment capabilities
- Expand analytical laboratory capacity to support essential environmental monitoring, disease surveillance and outbreak investigation/control activities

ENHANCE INFORMATION AND RESEARCH

Improve Surveillance and Control Programs

- Increase monitoring of water quality reports, toxicology reports, epidemiologic reports and the impacts of storms and hurricanes on water-borne diseases
- Develop surveillance and control programs for vector-, water- and food-borne diseases (e.g., harmful algal blooms) that are likely to become more prevalent, in order to inform effective and timely responses to emerging public health threats
- Implement electronic surveillance systems to manage disease reporting and water quality concerns that pose a risk for human health (e.g., web-based)
- Provide funding and personnel, possibly through research partnerships with universities, to monitor for new pathogens that are likely to expand their ranges

Assess Sanitation Infrastructure and Practices and Occupational Safety Standards at Risk

- Review occupational health and safety standards to identify occupations at risk due to climate change, and revise as necessary
- Assess sanitation infrastructure and practices at risk from climate-related impacts so that program and facility design can be modified to adequately address current and anticipated environmental changes (for instance, the capacity of rural sanitation and solid waste management systems could be improved to respond to and/or control anticipated new and exacerbated disease and toxic exposures)

Expand Research on Human Health Impacts

- Improve understanding of human health impacts of climate change and extreme weather (e.g., health risks, areas and populations at greatest risk, new methods to address identified risks) through research and education
- Formulate a research agenda that includes making use of health impact assessments, developing appropriate health indicators and assessing the effectiveness of adaptation technologies
- Screen recommended adaptation and mitigation strategies to determine whether there may be associated health benefits or harms and to identify additional actions to maximize benefits and reduce potential adverse impacts

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
Alaska	Alaska's Climate Change Strategy: Addressing Impacts in Alaska	www.climatechange.alaska.gov/aag/docs/aag_Ch7_27Jan10.pdf
American Rivers	Growing Green: How Green Infrastructure Can Improve Community Livability and Public Health	www.americanrivers.org/assets/pdfs/green-infrastructure-docs/growing-green-how-green-infrastructure-can-improve-community-livability.pdf
California	California Climate Change Adaptation Planning Guide: Identifying Adaptation Strategies	resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf#page=24
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic and Ecological Resilience	www.dnr.state.md.us/climatechange/pdfs/climatechange_phase2_adaptation_strategy.pdf#page=11
Massachusetts	Massachusetts Climate Change Adaptation Report	www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf#page=79
New York State	New York Climate Action Council Interim Report	www.dec.ny.gov/docs/administration_pdf/irchap11.pdf#page=40
New York State	Response to Climate Change in New York State	www.nyserda.ny.gov/Publications/Research-and-Development/Environmental/EMEP-Publications/~/media/Files/Publications/Research/Environmental/EMEP/climaid/11-18-response-to-climate-change-in-nys-chapter11.ashx
NRDC	Preparing for Global Warming: A Framework for Protecting Community Health and the Environment in a Warmer World	www.nrdc.org/globalwarming/preparedness.pdf
Resources for the Future	Public Health: Adapting to Climate Change	www.rff.org/rff/documents/RFF-IB-10-06.pdf
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004f.pdf

Tourism and Recreation

MANAGE IMPACTS ON RECREATIONAL AREAS

Protect Water-Based Tourism and Recreation

- Reduce beach closings by using green infrastructure and other best management practices to reduce combined sewer overflows and polluted runoff into recreational waters
- Use rapid test methods to provide timely notification to beachgoers of water quality conditions
- Protect and maintain public access to shorelines, inclusive of streams, lakes and oceans
- Increase and maintain access points (e.g., walking trails) in and around lake and river recreation areas to be resilient to climate impacts
- Relocate or redesign docks, boat launch sites, boardwalks and other at-risk infrastructure as water levels change, taking into account potential future climate impacts, best management practices and green infrastructure principles
- Site non-recreational development so as to minimize conflict with recreational resources along streams, lakes and seashores during climate impacts such as flooding, drought, extreme weather and sea level rise

Protect Winter Sports

- Consider the energy, water and infrastructure costs of making snow, as well as the ecological and cultural implications
- Encourage ski resorts to consider natural snowfall, temperature and skier visits when determining the timing of ski area openings
- Improve climate forecasting to enhance risk assessment and strategic business assessment for season openings and weather insurance
- Strategically plant and retain trees to capture moving snow and to shade ski slopes to reduce snowmelt, thereby reducing snowmaking needs
- Take into account water withdrawals when making snow, and establish a mean flow so that snowmaking can be prohibited when natural watercourses are at or below average mean flow

Reduce Water Demand for Golf Courses

- Encourage golf courses and parks to capture and store rainwater from impervious surfaces for use throughout the year
- Utilize native plants and xeriscaping (use of native landscaping) to decrease water consumption, lessen impacts on groundwater and nearby streams, and decrease fertilizer use and carbon emissions from lawn maintenance
- Encourage golf course management to expand use of water conservation measures
- Require use of recycled/reclaimed water golf course irrigation

Consider Climate Risks in Park Planning

- Utilize green infrastructure measures and riparian buffers to reduce polluted runoff from park facilities into lakes and rivers (see Water Management section for additional information)
- Manage water on-site at all parks and recreational centers using green infrastructure and conservation mechanisms
- Retrofit existing parks and create new parks to strengthen the community, improve habitat connectivity and offer an environmentally sound remedy to stormwater/flooding problems in surrounding neighborhoods and along urban river corridors (floodplain and channel migration buffers make great parks)
- Use recycled and water- and energy-efficient building materials and fixtures for construction
- Consider potential climate change impacts in determining the life expectancy of infrastructure components

DEVELOP NEW RECREATIONAL AREAS

- Improve monitoring for lake, groundwater and river flows to determine potential effects of climate impacts on recreation
- Conserve and enhance fish and wildlife habitat (e.g., remove small dams and restore riparian buffers to conserve and enhance connectivity, temperature and quality)
- Use riverfront lands with buffers for flood-tolerant recreation (e.g., walking paths, bike lanes, soccer fields, parks and natural areas) to help communities limit flood damage and connect residents to the river
- Restore wetlands and riparian areas for natural flood abatement and to provide breeding habitat for waterfowl and fish/amphibian species
- Provide new access to rivers so that people can fish, boat and swim
- Release water back into rivers to mimic natural flows so that people can fish, boat and swim
- Invest in riverfront improvements and recreation to spark downtown economic revitalization and boost tourism with consideration of climate and environmental impacts

ENHANCE OUTREACH AND PUBLIC AWARENESS

Assist Recreational Facilities in Preparing for Climate Change

- Educate facilities about diversification opportunities for more warm-weather or cold-weather activities (e.g., ski slopes can maintain mountain bike trails for summer/warm weather) with consideration of environmental impacts
- Establish a technical assistance center for recreational industries affected by climate change, and establish a source of grant funding or tax incentives to help industry and municipalities make adjustments

Increase Public Awareness of Climate Impacts on Recreation

- Educate park visitors and recreational participants about green technologies that are being used and how they can implement these technologies at home
- Educate the public about easements to support recreation access, to buffer critical lands and rivers and to maintain ecological health in a changing climate
- Increase public education and outreach around algae blooms in lakes and rivers, explaining the cause and the human health effects
- Educate the public regarding the causes, impacts and prevention of invasive species proliferation and its connection to climate change
- Build strategic collaborative partnerships to engage citizens and communities in adapting and conserving special places in a changing climate

ADDITIONAL RESOURCES

AUTHOR	TITLE	WEBLINK
Mitigation and Adaptation Strategies for Global Change	Climate Change Adaptation in the Ski Industry	www.ataland.com/files/articles/c1.pdf
Pennsylvania	Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations	www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf#page=68

Water Management

ADDRESS WATER SUPPLY RISKS
Protect and Expand Existing Water Supplies
■ Protect headwaters of rivers and streams through withdrawal/permit applications or other means
■ Require efficient water use through administrative code revisions or rulemakings
■ Integrate green infrastructure requirements into planning and zoning regulations to promote recharge through infiltration
■ Bank excess surface water underground during wet years for use during dry years, where appropriate and considering adequate environmental protections
■ Use previously banked groundwater (direct or indirect) for intra-basin use
■ Protect natural/high-quality groundwater recharge areas
■ Implement forest management practices that improve water-holding capacity in watersheds
■ Acquire and manage ecosystems (such as forested watersheds, vegetation strips and wetlands) to regulate runoff
■ Enhance existing groundwater supplies through aquifer recharge, where appropriate and considering adequate environmental protections
■ Support aquifer storage to capture winter and spring runoff, where appropriate and considering adequate environmental protections
■ Integrate surface water diversions and groundwater pumping to prevent groundwater overdraft and related environmental impacts, while reducing pressure on surface water resources at times of low flow and high environmental sensitivity
■ Limit groundwater extraction to prevent groundwater depletion and reduce saltwater intrusion into coastal aquifers
■ Reduce diversions from coastal rivers in order to prevent saltwater intrusion into estuaries
■ Implement aquifer recharge (through such methods as injection of reclaimed water) to limit effects of saltwater intrusion into groundwater
■ Provide assistance to landowners to restore wetlands, uplands and riparian zones to increase the capacity for natural water storage
■ Restore headwaters of rivers and streams (through corridor restoration, daylighting of headwater streams, etc.)
■ Use existing setback levees and bypasses to facilitate groundwater recharge in floodplain areas as part of a comprehensive regional flood-control plan
■ Renegotiate trans-boundary water agreements
Diversify Water Supply Sources
■ Use natural or constructed means (e.g., green roofs, rain barrels, cisterns) to harvest rainwater
■ Require local governments and water utilities to minimize or eliminate the need for additional capacity through water efficiency/conservation measures before considering a new water supply project
■ Require drought pricing or seasonal pricing for water before considering a new water supply project
■ Enhance capabilities to adequately treat water of marginal quality from new sources
■ Increase public water supply hookups for private wells subject to saltwater intrusion, with the cost of new connections paid for by new users
■ Use temporary intra-basin water transfers, including dry-year option contracts and spot market purchases; transfers should be linked to carefully documented reductions in current consumptive use and should include programs to minimize local economic impacts and avoid environmental impacts
■ Remediate degraded groundwater sources

ADDRESS WATER SUPPLY RISKS (continued)
Diversify Water Supply Sources (continued)
■ Provide incentives for the installation and use of gray water and rainwater harvesting
■ Require the use of gray water in new development with adequate public health safeguards
■ Consider guidelines (such as International Green Construction Code [IGCC] or IAPMO Green Code Supplement [GCS]) for increased reclaimed/recycled/gray water use for non-potable applications (e.g., irrigation, toilet flushing)
■ Connect regional water systems to allow increased reliability in times of service disruption or shortage
■ Use water banks, water pools and water markets to facilitate the reallocation of water rights
■ Develop long-term agreements for reciprocal sharing of water within the same basin
■ Require the use of reclaimed wastewater in new development with adequate public health safeguards

REDUCE WATER DEMAND
■ Adopt a water hierarchy that includes water conservation, capture, storage and reuse, similar to the well-known solid waste management "reduce, reuse, recycle" hierarchy
■ Implement public awareness campaigns on water conservation aimed at specific groups
■ Encourage xeriscaping (use of native landscaping) as a form of water conservation by issuing ordinances restricting residential/commercial landscape irrigation
■ Prohibit wasting of water (for instance, by requiring water utilities to prohibit runoff of irrigation water onto impervious surfaces or off-site)
■ Require water suppliers and local governments to develop and implement water conservation programs
■ Require water suppliers to meet water conservation targets (such as a 20 percent reduction in per capita use by 2020)
■ Adopt regulations for water utilities regarding water loss in the distribution system (e.g., % non-revenue water, required system audits)
■ Reduce non-revenue water losses by detecting leaks and updating/repairing aging distribution infrastructure where necessary
■ Incorporate measures that address climate change mitigation and adaptation (e.g., water conservation, energy efficiency) into existing programs, business plans and operations as both cost savings and ancillary benefits measures
■ Allow water efficiency measures to be funded through Clean Water and Drinking Water State Revolving Funds (SRFs)
■ Use increasing block, tiered and/or seasonal water rates
■ Meter all water uses (including submetering for multifamily housing), and bill by volume of use in both new and existing construction
■ Require water conservation offsets for new projects; under such an arrangement, a developer seeking approval for a proposed project must implement or financially contribute to actions that will save water at or above the demand level of the project
■ Integrate water conservation and efficiency standards for industries and businesses in permitting processes
■ Implement volumetric wastewater pricing
■ Establish a water efficiency rating program for new construction so that builders who do not meet new standards could find it more difficult to connect to the water system
■ Conduct water audits of homes before they are sold, and require the replacement of leaking or inefficient plumbing fixtures

REDUCE WATER DEMAND (continued)
■ Adopt water consumption regulations in mandatory building/plumbing codes for fixtures in new development (e.g., showerheads, urinals, toilets, landscape irrigation systems) that are more stringent than federal regulations (see International Plumbing Code 2015 or the Unified Plumbing Code 2015)
■ Develop and implement a rebate program for the installation or upgrade of water-efficient irrigation systems
■ Provide financial assistance to utilities (e.g., revolving loan fund, grants, bonds, appropriations) to provide incentives for the installation of conservation measures (e.g., landscape water conservation, low-flow devices, rainwater harvesting tanks)
■ Use non-potable water sources/reclaimed water for non-potable uses (e.g., industrial cooling, landscape irrigation) with adequate public health safeguards
■ Develop water reuse guidelines for industry
■ Increase water recycling in industrial processes
■ Implement rate structures to accommodate routine maintenance and long-term system improvements
■ Install smart water meters that allow different rates to be charged when overall system demand is higher
■ Develop a water withdrawal permitting program for all users that integrates water conservation measures (urban, agricultural, industrial, commercial)
■ Use ambient information systems to alter consumer behavior (e.g., real-time monitoring)
■ Price water to reflect its true cost by allowing rate decoupling
■ Establish a tax credit program for projects that save at least 10 percent of the water used in an industrial, agricultural or commercial process
■ Propose and adopt a framework for managing groundwater withdrawals that is consistent with healthy surface water quality
■ Establish minimum streamflow requirements using biology-based criteria to determine the maximum amount of water that can be withdrawn from a water body during different times of the year.

PREVENT WATER QUALITY DEGRADATION
Protect Source Water Quality
■ Utilize land use planning and open space conservation to protect water supply areas
■ Ensure that existing drinking-water wells are adequately protected from potential contamination by conducting sanitary surveys and source-water assessments that consider climate change impacts
■ Decrease pharmaceutical and other emerging toxic chemical concentrations in water supplies that might be exacerbated by climate change by implementing a pharmaceutical take-back program
■ Modify waste discharge permits as decreased streamflows and higher water temperatures decrease assimilative capacity of water bodies receiving waste
■ Seal abandoned wells to prevent contamination of groundwater
■ Designate all eligible high-quality waters as Tier III waters under the Clean Water Act
■ Relocate potentially problematic pollution sources from floodplains

PREVENT WATER QUALITY DEGRADATION (continued)
Reduce Polluted Runoff and Discharges
■ Use green infrastructure (e.g., green roofs, rain gardens, porous pavements, bioswales, blue roofs) to manage stormwater and reduce CSOs
■ Develop erosion control and stormwater management plans for all construction sites
■ Reduce existing pollution and contamination of freshwaters by tightening existing NPDES permit limits
■ Educate the public about ecologically sound landscaping practices, which reduce reliance on chemical fertilizers that can enrich freshwater systems with ecosystem-disrupting nutrients
■ Mandate that public projects incorporate green infrastructure to demonstrate viability and value
■ Develop and enforce a stormwater retention standard for new development and redevelopment
■ Maximize infiltration of stormwater on-site at existing developed sites
■ Ensure that industrial and municipal wastewater treatment best management practices and standards consider climate change impacts
■ Provide direct incentives to property owners for green infrastructure installation
■ Institute laws, regulations and local ordinances requiring implementation of green infrastructure with new development or substantial redevelopment, building on retention standards
■ Implement a fee for impervious surfaces to reduce stormwater runoff
■ Establish urban forests or plant street trees to reduce stormwater volume and pollutants
■ Restore riparian wetlands and forests to filter runoff and prevent erosion
■ Revise State Revolving Fund (SRF) state ranking criteria to require a thorough analysis and maximization of the use of green infrastructure, where appropriate
■ Promote and require preservation of natural features that treat and infiltrate runoff, such as buffers, wetlands and related landscapes
■ Require the installation of road and parking lot buffers and vegetated filters for all transportation and related projects
■ Practice fire management plans in watersheds, such as mechanical thinning, weed control, selective harvesting, controlled burns and creation of fire breaks
Reduce Water Temperatures
■ Plant shade trees and riparian buffers to protect against higher water temperatures
■ Retrofit existing surface storage with temperature control curtains (i.e., flow curtains), or install flow outlets at a range of elevations within the reservoir to help meet water temperature needs downstream
■ Require the use of closed-loop cooling systems to reduce thermal stress on waterways from power plants
Build Regulatory and Institutional Capacity
■ Prevent inundation and overflow of on-site disposal systems by establishing a permit fee to fund permitting programs, enforcement and development of innovative technical solutions
■ Complete and implement total maximum daily load (TMDL) plans for impaired waters, which take into account climate change impacts
■ Enhance state and local groundwater pollution prevention capacity
■ Increase state and local funding for water quality regulation and remediation monitoring and assessment

MANAGE IMPACTS ON WATER, WASTEWATER AND STORMWATER INFRASTRUCTURE

Enhance Existing Infrastructure Capacity and Build Resilience

- Reduce stormwater system inflow through green infrastructure and water conservation
- Free up wastewater treatment and conveyance capacity by identifying and reducing infiltration and inflow from wastewater collection systems (e.g., downspout disconnection)
- Compile critical information on water and wastewater treatment infrastructure, including elevation data, location of pump stations and other affiliated structures and potential vulnerabilities (e.g., saltwater intrusion, flooding)
- Assess the impact of climate change on critical water supply and wastewater infrastructure, and encourage the development of facility-specific adaptation plans
- Evaluate flood-proofing vulnerable wastewater facilities by raising the elevation of structures, installing watertight doors and windows, replacing wet/dry well pumps with submersible pumps, increasing emergency power backup for all key equipment operations and relocating vulnerable equipment
- Update water and wastewater emergency response and maintenance procedures to prepare for more common and more extensive coastal flooding of vulnerable infrastructure
- Promote the use of supervisory control and data acquisition (SCADA) systems and training to assist in the monitoring and operation of water treatment plants during climate-changed conditions and extreme events
- Update drinking water, stormwater and wastewater management plans and capital improvement programs to prepare for climate change impacts, including strategic consideration of systemic reconstruction of water facilities in the later-century time frame
- Review NPDES permit limits and sewer design standards to identify potential impacts from climate change that might include higher maximum flows or alterations in pollutant treatment efficiency (e.g., nitrogen)
- Plan for alternative power supplies to support operations in case of loss of power
- Restore natural hydraulic features of watersheds to increase resilience and capacity redundancy in wastewater systems
- Upgrade urban storm drains and BMPs based on modeling and climate predictions, and implement throughout the watershed to mitigate high flows, reduce sanitary sewer overflows and protect water quality
- Install effluent pumping systems for wastewater treatment plants affected by sea level rise, and ensure the adequacy of emergency generator systems
- Require standby power for buildings with sump pumps to avoid system inflows caused by storm-related power outages
- Mandate insurance programs for dam owners, and require insurance companies to acknowledge and financially cover liabilities, anticipate future threats, address potential vulnerabilities and reduce the state's expense in emergency response and cleanup
- Coordinate risk assessment planning for high-hazard-potential dams, using worst-case assumptions of climate change impacts
- Implement or retrofit source control measures at treatment plants to deal with altered influent flow and quality and potentially increased water treatment needs
- Identify and protect vulnerable facilities, developing operational strategies that isolate these facilities and reroute flows
- Relocate high-risk facilities over the long term, but build berms as a short-term protective measure
- Upgrade the capacity of vulnerable and inadequate sewers and pumping stations
- Increase treatment capabilities and capacities to address more protective treatment requirements

Modify Infrastructure Operations

- Evaluate the need to extend seasonal effluent disinfection periods to accommodate a lengthened water recreation season
- Require public water suppliers to establish "rule curves" for reservoirs (a rule curve sets specific guidelines for reservoir releases given the amount of stored water at different times of the year) to provide a systematic, unbiased protocol for managing water supplies and instream flow under current and future drought

MANAGE IMPACTS ON WATER, WASTEWATER AND STORMWATER INFRASTRUCTURE (continued)
Modify Infrastructure Operations (continued)
■ Implement a training program for drinking water and wastewater treatment facility operators and other water professionals to educate them on how to prepare for climate change impacts (e.g., extreme storms, high temperatures)
■ Develop and implement wastewater treatment plant protocols to protect wastewater plants and minimize loss of treatment efficiency at times of high flow
■ Use dynamic rule curves to help guide the management of flood storage capacity and refill mountain reservoirs, thereby adjusting reservoir level targets based on real-time snowpack measurements, soil moisture conditions and climate forecasts
■ Integrate climate change and the potential for more frequent CSO events into existing long-term control plans for CSOs
■ Adjust reservoir operations (e.g., increase flood control/water storage) to reflect changing conditions, considering objectives for energy production, agriculture irrigation, flood management, fish flows and other needs
Change Siting and Design Practices for New Infrastructure
■ Design new infrastructure with consideration of climate change impacts
■ Ensure that new sewer mains and manholes are sealed against floodwater inflow and groundwater infiltration
■ Institutionalize new systems using constructed wetlands, which are cheaper and more effective than conventional advanced treatment facilities for small wastewater utilities when properly designed and operated
■ Incorporate climate resilience into drinking water and wastewater treatment design manuals
■ Assess current infrastructure siting, setback and design standards
■ Require consideration of climate impacts (e.g., extreme weather events) in permitting, planning, siting and designing of drinking water, wastewater and stormwater infrastructure and related facilities
■ Assess the feasibility of relatively simple siting modifications (e.g., avoiding floodplains) or the raising of facilities by several feet during construction to reduce risks from severe inundation
■ Implement energy management programs, incorporate efficient/renewable energy technologies and strategies, and introduce water conservation and water use efficiency practices in repair, replacement and new construction efforts
■ Increase design flood protection levels (i.e., beyond the 100-year flood)
■ Avoid building and rebuilding facilities in high risk areas
■ Reevaluate standards for the design and maintenance of septic systems, and implement guideline changes as necessary to offset climate change–related impacts
■ Update aging stormwater infrastructure by incorporating sizing and green infrastructure techniques
■ Develop planning standards for municipal water supply based on anticipated future hydrologic conditions
■ Modify the design standard for new dams and levees to accommodate increases in flooding and extreme storm events by updating modeling protocols and precipitation data for use in future reservoir safety analyses and design work
Integrate Climate Change into Existing Planning, Design and Investment Processes
■ Include climate change projections in water supply and water quality planning to enhance reliability, improve quality and improve instream flows and fish passage
■ Require utilities to consider potential climate change impacts in planning
■ Develop guidance for analyzing whether and how to incorporate projected climate information and preparedness actions into planning, policies and investment decisions—this may impact water allocation decisions, water delivery, water systems operations, water quality standards, stormwater and floodplain management and infrastructure safety, among other areas
■ Map the location of major capital infrastructure and areas of the state most vulnerable to climate stress to guide current and future investment in public infrastructure

MANAGE IMPACTS ON WATER, WASTEWATER AND STORMWATER INFRASTRUCTURE (continued)

Integrate Climate Change into Existing Planning, Design and Investment Processes (continued)

- Seek to ensure that state investments in infrastructure and development projects (direct or indirect via grants, loans, tax incentives or other funding mechanisms) reflect potential climate change impacts, especially future risk projections
- Identify lead times for adaptive construction so that time frames for infrastructure rehabilitation and replacement can be considered
- Review and potentially modify the State Revolving Fund (SRF) program to encourage communities to address climate change impacts by protecting vulnerable facilities and avoiding new investments in highly vulnerable areas

ENHANCE STATEWIDE WATER RESOURCES MANAGEMENT AND PLANNING

Enhance Information and Address Knowledge Gaps

- Monitor factors (e.g., snowpack, streamflow, atmospheric processes) that impact hydrology and water resources
- Increase monitoring of groundwater, aquifer and reservoir levels
- Increase monitoring of water quality parameters and pollution sources
- Conduct frequent monitoring of primary nutrients, turbidity and pathogen indicators on major rivers
- Support additional research on climate change impacts on water supply
- Conduct a statewide assessment of long-term changes to basin hydrology by using hydrologic models to project changes in surface runoff and groundwater due to climate change, and incorporate modeling results into water supply planning
- Study the impact of increased precipitation on the frequency of combined and sanitary sewer overflows and water quality
- Update fire models and fire management plans for water supply sources in fire-prone watersheds to incorporate any changes in fire frequency, magnitude and extent due to projected future climatic conditions
- Model groundwater conditions, including saltwater intrusion into aquifers associated with sea level rise
- Develop models to determine potential changes in water quality and resulting treatment costs

Build State Capacity for Water Management

- Increase institutional capacity for water supply planning and regulation (e.g., establish a water supply planning entity)
- Inventory statewide water withdrawals and identify those at risk
- Develop a statewide water supply plan
- Assess current and future needs for potable and non-potable water uses, and plan for infrastructure improvements to the public water system as part of a long-term infrastructure sustainability plan
- Update monitoring and accounting of water rights
- Develop a water management framework that supports cross-jurisdictional coordination and integration, effective priority setting, integrated water resource management and the establishment of effective risk management partnerships with critical interdependent actors
- Implement a comprehensive statewide water management program to better regulate the use and consumption of the state's water resources
- Create new water management commissions to oversee water allocations among multiple competing users, particularly in regions with large or growing populations (e.g., Delaware River Basin, Susquehanna River Basin)

ENHANCE STATEWIDE WATER RESOURCES MANAGEMENT AND PLANNING (continued)
Build Local/Regional Capacity for Climate Change Preparedness
■ Develop educational campaigns for climate change preparedness awareness targeted at multiple sectors
■ Identify champions to demonstrate preparedness strategies
■ Increase the capacity of local governments to prepare for climate change by providing education, leadership and funding
■ Build the capacity of rural water systems to be successful and sustainable to increase climate change resilience
■ Provide water resource utility owners and operators of water supply and wastewater treatment facilities statewide with climate preparedness information, strategies and training (e.g., materials from the EPA's Climate Ready Water Utilities initiative)
■ Implement a program to educate water resource utility owners and operators on how to incorporate climate impacts into models used in the planning and site design of water, wastewater and stormwater systems
■ Support the development of peer-to-peer information sharing to foster the adoption of climate preparedness practices
■ Disseminate current climate change preparedness research and technical resources to the appropriate stakeholders (e.g., planners, designers, regulators)
■ Support local mutual aid collaboration to develop contingency plans to respond to the impacts of climate change on water supplies
■ Provide local governments with technology and financial assistance to prepare for potential high-water conditions caused by climate change, such as by examining the adequacy of wastewater treatment systems
■ Provide communities and watershed groups with water forecast projections using best available data, tools and models, so they can assess watershed vulnerability and determine priority risks that require a response
■ Support the development and delivery of early-warning or rapid-response information to water utilities to address challenges and disaster risks from extreme climate events, such as devastating floods, droughts, fires and storms

ENHANCE DROUGHT PREPAREDNESS
■ Identify areas of the state most likely to be critically affected by drought
■ Assess the vulnerability of groundwater and surface water resources to prolonged drought conditions
■ Update/develop state drought management plans to expressly include climate change considerations
■ Require the preparation of drought emergency plans by water utilities or cities at least every 5 years
■ Require the development of local water use restriction ordinances or plans that implement conservation measures (e.g., limits on outdoor watering, a mandatory 10 percent reduction in public water supply, drought water pricing) during water shortages
■ Increase authority to implement water restrictions
■ Develop an automated gauging network (or, at a minimum, a formal reporting network) for the water in rivers, in public water supply reservoirs and in aquifers, to provide the basis for a statewide early-warning system for recognizing supply shortages
■ Consider establishing, updating or enlarging state stockpiles of drought emergency equipment (e.g., mobile pumps, water tanks, filters)
■ Modify regional water compacts to include drought contingency stipulations

ADDITIONAL RESOURCES		
AUTHOR	**TITLE**	**WEBLINK**
Alliance for Water Efficiency	The Water Efficiency and Conservation State Scorecard: An Assessment of Law and Policy	www.allianceforwaterefficiency.org/uploadedFiles/News/NewsArticles/NewsArticleResources/AWE-State-Scorecard-Report-Final-September-2012.pdf
American Rivers	Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide	www.americanrivers.org/assets/pdfs/reports-and-publications/banking-on-green-report.pdf
American Rivers	Green Infrastructure Portfolio Standard	www.americanrivers.org/assets/pdfs/reports-and-publications/upgrade-your-infrastructure.pdf
American Rivers	Hidden Reservoir: Why Water Efficiency Is the Best Solution for the Southeast	act.americanrivers.org/site/DocServer/SE_Water_Efficiency_Oct_2008_opt.pdf?docID=8421
American Rivers	Money Pit: The High Cost and High Risk of Water Supply Reservoirs in the Southeast	www.americanrivers.org/newsroom/resources/money-pit.html
California Department of Water Resources, U.S EPA Region 9, U.S. Army Corps, Resources Legacy Fund	Climate Change Handbook for Regional Water Planning	www.water.ca.gov/climatechange/CCHandbook.cfm
California	California Water Plan Update 2009, Volume 2	www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2_all_cwp2009.pdf
California	California Climate Change Adaptation Planning Guide: Identifying Adaptation Strategies	resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf#page=42
Center for Clean Air Policy	The Value of Green Infrastructure for Urban Climate Adaptation	ccap.org/assets/THE-VALUE-OF-GREEN-INFRASTRUCTURE-FOR-URBAN-CLIMATE-ADAPTATION_CCAP-February-2011.pdf
Maryland	Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic and Ecological Resilience	www.dnr.state.md.us/climatechange/pdfs/climatechange_phase2_adaptation_strategy.pdf#page=51
Massachusetts	Massachusetts Climate Change Adaptation Report	www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf#page=65
The National Academies	America's Climate Choices	dels.nas.edu/Report/Americas-Climate-Choices/12781
NRDC	A Clear Blue Future	www.nrdc.org/water/lid

ADDITIONAL RESOURCES (continued)		
AUTHOR	**TITLE**	**WEBLINK**
NRDC	Capturing Rainwater from Rooftops	www.nrdc.org/water/rooftoprainwatercapture.asp
NRDC	Financing Stormwater Retrofits in Philadelphia and Beyond	www.nrdc.org/greenbusiness/cmi/files/CMI-Report-GIFinance.pdf
NRDC	In Hot Water: Water Management Strategies to Weather the Effects of Global Warming	www.nrdc.org/globalwarming/hotwater/hotwater.pdf
NRDC	Looking Up: How Green Roofs and Cool Roofs Can Reduce Energy Use, Address Climate Change, and Protect Water Resources in Southern California	www.nrdc.org/water/pollution/files/GreenRoofs-Report.pdf
NRDC	Making Every Drop Work: Increasing Water Efficiency in California's Commercial, Industrial and Institutional (CII) Sector	www.nrdc.org/water/cacii/files/cii.pdf
NRDC	Pipe Dreams: Water Supply Pipeline Projects in the West	www.nrdc.org/water/management/files/Water-Pipelines-report.pdf
NRDC	Protecting a Shared Future: Assessing and Advancing the Sustainable Management of the Great Lakes Through Water Conservation and Efficiency	www.nrdc.org/water/greatlakescompact.asp
NRDC	Rooftops to Rivers II: Green Strategies for Controlling Stormwater and Combined Sewer Overflows	www.nrdc.org/water/pollution/rooftopsii/
Oregon	Oregon's Integrated Water Resources Strategy	www.oregon.gov/owrd/LAW/docs/IWRS_Final_2.pdf
Pennsylvania	Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations	www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf#page=59
U.S. EPA	Adaptation Strategies Guide for Water Utilities	water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf
Washington State	Washington State Integrated Climate Change Response Strategy	www.ecy.wa.gov/pubs/1201004i.pdf
Wisconsin	Wisconsin's Changing Climate: Impacts and Adaptation	http://www.wicci.wisc.edu/report/WICCI-Chapter-3.pdf

Endnotes

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[3] NCDC, NOAA, "State of the Climate: Wildfires—Annual 2012," revised January 7, 2013, www.ncdc.noaa.gov/sotc/fire/2012/13.

[4] NCDC, NOAA, "State of the Climate: National Overview—Annual 2012," revised January 10, 2013, www.ncdc.noaa.gov/sotc/national/2012/13.

[5] Natural Resources Defense Council (NRDC), *Ready or Not: An Evaluation of State Climate and Water Preparedness Planning* (2012), 3, www.nrdc.org/water/readiness/files/Water-Readiness-full-report.pdf.

[6] U.S. Global Change Research Program (USGCRP), "Water Resources," *Global Climate Change Impacts in the United States*, (2009a), 41, globalchange.gov/images/cir/pdf/water.pdf.

[7] Ibid.

[8] National Research Council (NRC), *America's Climate Choices: Advancing the Science of Climate Change* (2010), 27-82.

[9] Tom Meixner, "Wildfire Impacts on Water Quality," *Southwest Hydrology* 3, 5 (2004): 24-25.

[10] NRDC, note 5.

[11] California Department of Water Resources (DWR), U.S. EPA Region 9, U.S. Army Corps of Engineers and the Resources Legacy Fund, *Climate Change Handbook for Regional Water Planning* (2011), www.water.ca.gov/climatechange/CCHandbook.cfm.

[12] Personal communication with John Andrew, Assistant Deputy Director, California Department of Water Resources, January 2013.

[13] Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: *The Physical Science Basis. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, eds.), (2007a), www.ipcc.ch/publications_and_data/ar4/wg3/en/annex1-ensglossary-j-p.html.

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Appendix I

Types and Examples of State Commitments to Preparedness Planning

There are various types of instruments that can be utilized by states to formalize and affirm climate change preparedness planning. States should carefully consider which options will sustain preparedness actions at the state level and remain robust regardless of political and economic changes.

Staff-led directive: With this option, low- to mid-level agency staff lead efforts to develop agency-specific preparedness planning.

- **PROs**
  - staff-level engagement
  - likely strong enthusiasm
  - contributes to integration of climate preparedness into existing programs, planning and policies
- **CONs**
  - unlikely to spread to uninterested parties without high-level support or "buy-in"
  - lacks enforceability
  - voluntary participation
  - limits preparedness planning to areas that the particular agency has jurisdiction over
  - unlikely to provide additional resources (e.g., funding, staff)

Request by governor or agency executive: This option consists of a formal or informal memo by the governor or a state agency executive requesting the development of a preparedness plan.

- **PROs**
  - unilateral (not necessary to get buy-in from multiple parties)
  - relatively easy to accomplish
- **CONs**
  - often lacks enforceability
  - extremely vulnerable to leadership changes
  - possible low level of staff engagement/commitment
  - in the case of agency-specific memos, can contribute to management silos and fragmentation among state agencies
  - unlikely to consider additional resources (e.g., funding, staff)

Executive order: This option consists of the issuance of an executive order by a state's governor requiring the development of a preparedness plan. State constitutions, statutes, case law and sometimes implied powers granted to state chief executives give governors the authority to issue executive orders. Depending on the state, executive orders can be used to address public emergencies, disasters, executive branch organization and other initiatives.

- **PROs**
  - likely leads to the participation of all applicable state agencies
  - demonstrates strong support and leadership by the governor
  - typically unilateral
- **CONs**
  - may not be binding as force of law
  - extremely vulnerable to changes in governorship
  - depending on the state, may be subject to legislative or cabinet approval
  - may not address additional resources (e.g., funding, staff)

Legislative act: This option consists of passage of a bill requiring development of a preparedness plan by the state legislature. Legislative acts, if written appropriately (i.e., not as a proclamation or resolution), become law and are binding unless changed through legislative or judicial action.

- **PROs**
  - legally binding
  - demonstrates strong support and leadership by state government
- **CONs**
  - requires passage by legislature and approval of governor
  - potentially time-consuming process for passage

Comprehensive legislative act: This legislative act is more robust and complete, establishing benchmarks and deadlines and allocating funding for development of a preparedness plan. It also establishes procedures for implementation of the plan once developed.

- **PROs**
  - legally binding
  - demonstrates strong support and leadership by state government
  - allocates resources (e.g., funding) and establishes a time frame for plan development and implementation
- **CONs**
  - requires passage by legislature and approval of governor
  - potentially time-consuming process for passage
  - may require greater effort to garner support due to more specific provisions contained within the legislation

Office of the Governor

ARNOLD SCHWARZENEGGER
THE PEOPLE'S GOVERNOR

EXECUTIVE ORDER S-13-08

11/14/2008

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

ATTEST:
Debra Bowen
Secretary of State

By: Ellis S.B. No. 424

A BILL TO BE ENTITLED

AN ACT

relating to the development of a climate adaptation plan by certain entities.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. Subtitle C, Title 5, Health and Safety Code, is amended by adding Chapter 393 to read as follows:

CHAPTER 393. CLIMATE ADAPTATION PLAN

Sec. 393.001. PARTICIPATING ENTITIES. Not later than September 1, 2012, and before the end of each successive four-year period after that date, each of the following entities shall publish a climate adaptation plan that will assess the entity's role with respect to climate change:

(1) the Department of Agriculture;

(2) each independent organization certified under Section 39.151, Utilities Code;

(3) the Texas Commission on Environmental Quality;

(4) the General Land Office;

(5) the Texas Department of Housing and Community Affairs;

(6) the Texas Department of Insurance;

(7) the Parks and Wildlife Department;

(8) the Department of Public Safety of the State of Texas;

(9) the Public Utility Commission of Texas;

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(10) the office of the comptroller;

(11) the Texas Forest Service; and

(12) the Texas Water Development Board.

Sec. 393.002. PLAN. (a) For the purposes of this chapter, a climate adaptation plan is a strategy to identify, minimize, and adequately prepare for the effects of climate change on the social, economic, and ecological systems of this state and to manage the risks associated with a changing climate. A plan under this chapter must be based on current peer-reviewed climate science that identifies the likely impacts of rising ambient temperatures, rising sea levels, and changes in precipitation patterns on this state.

(b) Each climate adaptation plan must include:

(1) a climate change vulnerability assessment;

(2) a review of existing programs in the context of anticipated changing climate conditions;

(3) specific steps necessary for the entity to fulfill its mission during the anticipated climate change;

(4) an analysis of the effects implementing the steps identified under Subdivision (3) would have on the entity's budget during the next 5 and 10 years;

(5) potential sources of funding to support the entity's efforts to adapt to climate change;

(6) a statewide strategy to monitor the continuing effects that climate change may have on the entity's ability to fulfill the entity's missions; and

(7) a written statement by the Texas state

climatologist regarding the adequacy of the scientific basis of the plan.

(c) In developing a climate adaptation plan, each entity subject to this chapter shall:

(1) consider the most current assessment reports created by the United States Global Change Research Program; and

(2) consult with the Texas state climatologist or another climate expert employed at a Texas institution of higher education or nonprofit research institution.

(d) Not later than September 1, 2012, and before the end of each successive four-year period after that date, each entity subject to this chapter shall post the entity's climate adaptation plan on a publicly accessible Internet website and electronically submit a copy of the plan to:

(1) the governor, lieutenant governor, and speaker of the house of representatives;

(2) the presiding officer of each standing committee or subcommittee of the legislature with primary jurisdiction over environmental matters; and

(3) the executive director of the Texas Commission on Environmental Quality.

(e) Each climate adaptation plan is subject to audit by the state auditor in accordance with Chapter 321, Government Code.

SECTION 2. This Act takes effect immediately if it receives a vote of two-thirds of all the members elected to each house, as provided by Section 39, Article III, Texas Constitution. If this Act does not receive the vote necessary for immediate effect, this Act takes effect September 1, 2011.

GENERAL ASSEMBLY OF NORTH CAROLINA
SESSION 2009

H **1**

HOUSE BILL 1808*

Short Title:	NC Climate Change Adaptation Strategy.	(Public)
Sponsors:	Representatives Harrison, Underhill, Wilkins (Primary Sponsors); M. Alexander, Carney, Fisher, Gill, Glazier, Hughes, Insko, and Luebke.	
Referred to:	Environment and Natural Resources, if favorable, Appropriations.	

May 19, 2010

A BILL TO BE ENTITLED

AN ACT TO DIRECT THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES TO DEVELOP THE NORTH CAROLINA CLIMATE CHANGE ADAPTATION STRATEGY, AS RECOMMENDED BY THE LEGISLATIVE COMMISSION ON GLOBAL CLIMATE CHANGE.

The General Assembly of North Carolina enacts:

SECTION 1.(a) The North Carolina Climate Change Adaptation Strategy. – The Department of Environment and Natural Resources shall develop the North Carolina Climate Change Adaptation Strategy, a comprehensive strategy to adapt to the impacts to North Carolina associated with global climate change. The Strategy shall consist of an assessment as provided under Section 2 of this act and a comprehensive plan as provided under Section 3 of this act. The North Carolina Climate Change Adaptation Strategy shall include climate adaptation goals and principles that shall be reflected in the comprehensive plan. The Strategy shall identify a mechanism and process to assess whether any modification to the Strategy is needed based on the latest science or information as it becomes available over time, and, if modification is needed, a process to implement the modification. In developing the Strategy, the Department of Environment and Natural Resources shall seek the participation and cooperation of units of local government, the Department of Transportation, the Department of Crime Control and Public Safety, the Department of Insurance, the Department of Administration, the Department of Agriculture and Consumer Services, the Department of Commerce, the Department of Public Instruction, the Department of Cultural Resources, the North Carolina Wildlife Resources Commission, and any other State agency or commission that might have a role or be affected by global climate change. In developing the Strategy, the Department of Environment and Natural Resources may seek the input of any appropriate federal agency, such as the United States Army Corps of Engineers, the Federal Highway Administration, the Federal Emergency Management Agency, the United States Department of the Interior, the United States Environmental Protection Agency (USEPA), the United States Department of Commerce, the United States Department of Defense, or any other federal agency that might have a role or be affected by global climate change; any university; or any nongovernmental organization.

SECTION 1.(b) Coordination With Local Government and Public Outreach. – In developing the Strategy, the Department of Environment and Natural Resources shall seek input from units of local government regarding the development of the Strategy and shall coordinate with units of local government regarding local plans or programs pertaining to climate change. In developing the Strategy, the Department of Environment and Natural Resources shall seek input from the public and provide public outreach and education to inform

the general public of the impacts to North Carolina associated with global climate change and the State's strategy for adapting to these impacts.

SECTION 1.(c) Technical Advisory Committee. – In developing the Strategy, the Department of Environment and Natural Resources may establish a technical advisory committee to assist in developing the Strategy. The technical advisory committee shall consist of technical experts on North Carolina climate change selected from the scientific community and associated disciplines within the constituent institutions of The University of North Carolina. The technical advisory committee may also consist of technical experts on North Carolina climate change selected from units of local government or nongovernmental organizations.

SECTION 2. The North Carolina Climate Change Adaptation Assessment. – In developing the North Carolina Climate Change Adaptation Strategy, the Department of Environment and Natural Resources first shall conduct an assessment that, based on the best available science, accomplishes at least all of the following tasks:

(1) Identifies the projected impacts to North Carolina's ecosystems associated with global climate change, including at least all of the following potential impacts:
   a. Sea level rise.
   b. More frequent and intense heat waves.
   c. Increased air and water temperature.
   d. Increased intensity and frequency of storms.
   e. Altered rainfall patterns that may result in droughts, floods, and fires.
   f. Shoreline erosion that may result in land loss and other ecosystem change.
   g. Loss of biodiversity.

(2) Determines the range of projections of the impacts identified under subdivision (1) of this subsection and the degree of confidence in these projections.

(3) Identifies which resources of the State, including land, water, air, and biodiversity, are threatened by impacts identified under subdivision (1) of this subsection, giving consideration to at least all of the following resources:
   a. The natural resources of the coastal, Piedmont, and mountain regions of the State.
   b. Public, residential, commercial, and industrial buildings.
   c. Transportation and other essential infrastructure.
   d. Water supplies.
   e. Commercial activities, including agriculture and forestry.
   f. Public health.
   g. Recreational and conservation lands.

(4) Identifies which of the impacts identified under subdivision (1) of this subsection should receive the highest priority to be addressed with adaptation measures based upon the severity or certainty of the impact and the level of the threat to the public, natural resources, or the State or local economies.

(5) Initiates an economic cost and benefit analysis to determine the potential costs of maintaining the status quo compared with the costs of implementing the North Carolina Climate Change Adaptation Plan under Section 3 of this act.

SECTION 3.(a) The North Carolina Climate Change Adaptation Plan. – Concurrent with conducting the Assessment under Section 2 of this act, the Department of

Environment and Natural Resources shall develop the North Carolina Climate Change Adaptation Plan, a comprehensive plan to adapt to the most likely impacts and associated threats that are identified in the Assessment, for the purpose of maximizing the security of North Carolina's citizens, natural resources and biodiversity, essential infrastructure, and economic vitality. The Plan shall provide a strategy that accomplishes at least all of the following:

(1) Develops an inventory of existing federal, State, or local programs and plans that directly or indirectly address adaptation to climate change.

(2) Identifies needed changes to existing planning tools and identifies new planning tools that are needed in order to take into account projected impacts from climate change, including at least all of the following:
   a. Floodplain mapping.
   b. Steep slope mapping.
   c. Basinwide water planning.
   d. Coastal zone planning.
   e. Beach and shoreline planning.
   f. Transportation and other infrastructure planning.
   g. Planning regarding public health issues, including planning regarding increased mortality and morbidity from heat waves, additional disease vectors, and diminished air quality.
   h. Emergency response and disaster relief planning.

(3) Identifies needed changes to federal, State, and local policies, programs, statutes, and administrative rules in order to implement physical or ecological adaptation measures, stimulate market responses, provide appropriate incentives, and regulate future activities that may be affected by global climate change.

(4) Identifies adaptation measures as short-term, mid-term, and long-term adaptation measures and establishes a method by which adaptation measures are to be prioritized.

(5) Identifies methods to better coordinate and integrate State natural hazard planning and regulatory programs in the Department of Environment and Natural Resources and the Department of Crime Control and Public Safety.

(6) Directs the Department of Environment and Natural Resources or the Division of Emergency Management of the Department of Crime Control and Public Safety to integrate post-disaster planning requirements with hazard mitigation planning requirements into one plan that includes the latest scientific understanding of sea level rise, erosion, and other coastal hazards and environmental impacts of global climate change.

SECTION 3.(b) Considerations in Developing or Modifying the Plan. – When developing or modifying the Plan, all of the following policy approaches to adaptation may be considered:

(1) Developing plans that address how local governments in the coastal plain can adapt to potential changes in property tax revenue as sea-level increases lead to land loss.

(2) Directing the Coastal Resources Commission to increase protection of coastal wetlands and their ability to migrate inland by the Commission prohibiting new bulkheads and hardened structures in certain areas of environmental concern, as designated by the Coastal Resources Commission under G.S. 113A-113.

(3) Utilizing the consistency provisions of the Coastal Area Management Act (CAMA), Article 7 of Chapter 113A of the General Statutes, and the federal

Coastal Zone Management Act, 16 U.S.C. § 1451, et seq., to help resolve conflicts between existing State and federal policies and programs.

(4) Requiring the Division of Coastal Management of the Department of Environment and Natural Resources to report on the loss of coastal wetlands due to estuarine shoreline hardening and other uses to the Environmental Review Commission and any future legislative commission that directly and primarily addresses issues concerning global climate change.

(5) Requiring an applicant for a permit under CAMA to mitigate the applicant's impact on wetlands that may result from any hardening of the estuarine shoreline outside of areas of environmental concern.

(6) Authorizing coastal management grants to units of local government to be used for planning for, and adapting to, sea level rise.

(7) Making maps of sea level rise available on the Internet for the use of units of local government, realtors, conservation organizations, and the general public.

(8) In order to protect the public recreational beaches, identifying options for responding to shore zones that are most vulnerable to storms and sea level rise and develop options that provide for future changes and plans for the short-term and long-term use of public recreational beaches.

(9) Promoting the use of any of the following living shoreline management methods so that estuarine shorelines are able to evolve and migrate in response to rising sea level:

a. Restoring, enhancing, protecting, and mitigating existing wetland or riparian habitat and vegetation.

b. Constructing and managing new wetlands in upslope regions.

(10) Developing incentives and regulatory changes to encourage the use of the Climate Ready Estuaries program, a program developed by the USEPA to train coastal managers to implement economically viable and environmentally sound procedures for portions of the estuaries and barrier islands that are particularly vulnerable to climate variability and change; implement adaptation strategies; share information, and engage and educate the stakeholders and other coastal managers.

(11) Requesting the Albemarle. – Pamlico National Estuary Program, a cooperative program jointly sponsored by the Department of Environment and Natural Resources and the USEPA in cooperation with the Virginia Department on Conservation and Recreation, to review the USEPA's Climate Ready Estuaries program and plan for and adapt to climate change and sea level rise.

(12) Determining any funding needs related to adaptation and mitigation and considering possible funding resources to address such needs.

(13) Pursuing federal funding for a southeast regional adaptation study, a study to assist in the development of relocation and removal strategies that uses the existing authority of the United States Army Corps of Engineers.

(14) Developing plans for geo-zoning of the barrier islands and estuarine shore zone environments within coastal North Carolina.

(15) Identifying the reasons for and against adopting either a strategy of in situ management of adaptation measures as opposed to the strategy of retreating from the high hazard ocean and inlet shorelines and estuarine shorelines.

(16) Determining possible cost-sharing incentives with landowners for the costs of implementing ecologically beneficial adaptive strategies for managing estuarine shorelines in response to rises in sea level.

(17) Identifying new economic opportunities within the eastern North Carolina coastal system, the Piedmont, and the mountain regions of the State based upon the impacts identified under subsection (1) of Section 2 of this act and the resulting adaptations to these impacts.

(18) Directing the Coastal Resources Commission to delineate economically viable and environmentally sound ways to address various scenarios regarding potential sea level rise in each the short term, the midterm, and the long term, based on the information in its 2010 Science Panel report.

(19) Identifying mechanisms for purchasing land or conservation easements on portions of coastal and inlet hazard zones, as well as other portions of the low-lying coastal zone, that are identified as at risk.

(20) Developing and implementing a method of tracking ecosystem changes resulting from climatic shifts, with specific focus on those resources that have direct economic priorities, such as tourism, agriculture, silviculture, and marine fisheries.

(21) Evaluating the reasons for and against a requirement that sellers of coastal properties disclose potential hazards to buyers and a requirement that this disclosure accompany all real estate transfers of properties within coastal counties that either are directly on ocean, inlet, or estuarine shoreline frontage or are located within a 100-year floodplain.

(22) Evaluating the policy proposals, findings, and recommendations that resulted from the Beach Management Summit, held in 2009 in Beaufort, North Carolina, hosted by the North Carolina Coastal Federation and the UNC Center for the Study of Natural Hazards and Disasters, as these pertain to oceanfront communities adapting to climate change.

SECTION 4. Continued Coordination With Local Government and Public Outreach. – Once the North Carolina Climate Change Adaptation Strategy is developed initially under Section 1 through Section 3 of this act, the Department of Environment and Natural Resources shall continue to coordinate with units of local government regarding the implementation of the Strategy and shall continue to provide public outreach and education to inform the general public of the impacts to North Carolina associated with global climate change and the State's strategy for adapting to these impacts.

SECTION 5. Database Framework. – The Department of Environment and Natural Resources, the universities within The University of North Carolina, and the technical advisory committee, if a technical advisory committee is established under Section 1(b) of this act, jointly shall develop a framework for a database to provide to the general public and others information related to making economically and environmentally prudent adaptation decisions. This database may include maps, surveys, inventories, and other relevant, useful information. The Department of Environment and Natural Resources and the technical advisory committee, if a technical advisory committee is established, may recommend improving the current permanent monitoring stations and may install new permanent monitoring stations within the North Carolina coastal zone, as required to develop the database under this section.

SECTION 6. Report Requirement. – Beginning no later than October 1, 2010, the Department of Environment and Natural Resources shall submit quarterly progress reports to the Environmental Review Commission and to any future legislative commission that directly and primarily addresses issues concerning global climate. No later than January 1, 2013, the Department of Environment and Natural Resources shall submit a final report that shall include the North Carolina Climate Change Adaptation Strategy and any recommendations or legislative proposals to the Environmental Review Commission and to any future legislative commission that directly and primarily addresses issues concerning global climate change.

SECTION 7. Appropriation. – There is appropriated from the General Fund to the Department of Environment and Natural Resources the sum of fifty thousand dollars ($50,000) for the 2010-2011 fiscal year to implement the provisions of this act.

SECTION 8. Effective Date. – This act becomes effective July 1, 2010.

Appendix II

Funding for Plan Development and Implementation

Federal Funding Sources for Plan Development (as of August 2012)

PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Centers for Disease Control and Prevention (CDC) Climate-Ready States & Cities Initiative	This initiative provides CDC funding and technical support to city and state health departments to address the public health implications of climate change. Assistance is provided to anticipate health effects by applying climate science, predicting health impacts and preparing flexible programs.	not available (n/a)	www.cdc.gov/climateandhealth/climate_ready.htm
DOI State/Tribal Wildlife Grants	These federal grants provide funding for the development and implementation of programs that benefit wildlife and their habitats, with a particular emphasis on projects that address species of greatest conservation need. Funds can be used to conduct research, monitoring and surveys and for species and habitat management activities.	$61,323,000 (FY12)	wsfrprograms.fws.gov/Subpages/GrantPrograms/SWG/SWG.htm
FEMA Flood Mitigation Assistance (FMA)	Through FMA, communities are eligible for planning grants to prepare flood mitigation plans, which reduce or eliminate claims under the National Flood Insurance Program (NFIP).	$40,000,000 (FY12)	www.fema.gov/flood-mitigation-assistance-program
FEMA Hazard Mitigation Grant Program (HMGP)	HMGP provides grants to states and local governments to support measures to reduce the risk of loss of life and property from future disasters during the reconstruction process following a major disaster declaration.	$793,951,989 (FY11)— funding availability depends on the amount of FEMA disaster recovery assistance under a presidential major disaster declaration	www.fema.gov/hazard-mitigation-grant-program
FEMA Pre-Disaster Mitigation (PDM) Grant Program	The PDM program provides grants for hazard mitigation planning to reduce risks to populations and structures prior to a disaster event.	$35,500,000 (FY12)	www.fema.gov/pre-disaster-mitigation-grant-program
NIH Climate Change and Health: Assessing and Modeling Population Vulnerability to Climate Change	Funding is available for research projects that help inform climate change adaptation and public health interventions to reduce the vulnerability of various populations to health risks associated with climate change.	Limited to $275,000 per project over a two-year period	grants.nih.gov/grants/guide/pa-files/PAR-10-235.html#SectionIII1A
NOAA Climate Program Office— Climate and Societal Interactions (CSI) Program	CSI helps society adapt to a changing climate by providing funding for projects to better understand and anticipate changes in climate and, consequently, inform decision-making and climate risk management.	n/a	http://cpo.noaa.gov/ClimatePrograms/ClimateSocietalInteractionsCSI.aspx

Federal Funding Sources for Plan Development (continued)

PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
NOAA Coastal Zone Enhancement Program (CZMA Section 309)	This program encourages federally approved coastal management programs to develop programmatic changes or enhancements in one of nine areas: wetlands, coastal hazards, public access, marine debris, cumulative and secondary impacts, special area management plans, ocean/Great Lakes resources, energy and government facility siting, and aquaculture.	$10,000,000 (FY12)	coastalmanagement.noaa.gov/funding/welcome.html
NOAA Coastal Zone Management Administrative Grants (CZMA Section 306/306A)	The Office of Coastal Resource Management (OCRM) provides 1:1 matching funds for states to administer their coastal zone management programs.	$55,700,206 (FY12)	coastalmanagement.noaa.gov/funding/welcome.html
NOAA Coral Reef Conservation Program	This program was established to help protect important coral ecosystems through a multidisciplinary approach, which includes mapping, monitoring, research, training, management and outreach, to solve coral management issues. Further, the program facilitates and supports partnerships with scientific, private, government and nongovernmental groups to achieve this objective.	$26,700,000 (FY12)	coastalmanagement.noaa.gov/programs/coral.html
NOAA FY2012-2013 Broad Agency Announcement	Special projects and programs associated with NOAA's four main strategic goals (climate adaptation and mitigation, weather-ready nation, healthy oceans, and resilient coastal communities) that are not addressed through existing NOAA competitive funding opportunities are eligible to apply.	$2,296,811 (FY11)	www.csc.noaa.gov/funding/_pdf/current/baa_ffo_2012-2013.pdf
NPS Land and Water Conservation Fund (LWCF)	Planning grants are available through the LWCF for the development of State Comprehensive Outdoor Recreation Plans (SCORPs), which address the demand for recreation resources and identify needs and opportunities for recreation improvements within a state.	$45,000,000 (FY12)	www.nps.gov/ncrc/programs/lwcf/fed_state.html
NSF Science, Engineering, and Education for Sustainability (SEES)	NSF's SEES activities support interdisciplinary research and education on building a sustainable future that simultaneously consider social, economic and environmental systems. Research topics are wide-ranging and include coastal systems, biodiversity and ocean acidification, among numerous others.	$157,000,000 (FY12 est.)	www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707
USBR WaterSMART Grants	Grants have been available in the past to support the development of tools to understand climate impacts on water resources and inform water management decision-making.	$0 (FY12)	www.usbr.gov/WaterSMART/cat/index.html

Examples of Federal and Regional-Level Funding for Implementation (as of August 2012)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Centers for Disease Control and Prevention (CDC)	Climate-Ready States & Cities Initiative	This initiative provides CDC funding and technical support to city and state health departments to address the public health implications of climate change. Assistance is provided to anticipate health effects by applying climate science, predicting health impacts and preparing flexible programs.	n/a	www.cdc.gov/climateandhealth/climate_ready.htm
Chesapeake Bay Program	Chesapeake Bay Stewardship Fund	The fund issues grants and technical assistance to local communities to restore and protect water quality and habitats within the Chesapeake Bay watershed.	n/a	www.nfwf.org/Pages/chesapeake/home1.aspx
Department of Health and Human Services (HHS)	Improving the Capability of Indian Tribal Governments to Regulate Environmental Quality	Funds may be used to develop regulations, ordinances and laws to protect the environment on Indian land; to build the technical and program capability of the tribe or organization to perform essential environmental program functions to meet federal regulatory requirements; to inform the community about regulations and environmental stewardship; and to establish demonstration projects to exhibit technologies, which can lead to compliance with environmental regulations.	$1,801,052 (FY12 est.)	www.acf.hhs.gov/programs/ana/grants
Department of Housing and Urban Development (HUD)	Community Development Block Grant (CDBG) Program	The CDBG 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 by allocating funding to states and local jurisdictions. Projects must meet one of the following national objectives for the program: benefit low- and moderate-income persons, prevent or eliminate slums or blight, or address urgent community development needs because existing conditions pose a serious and immediate threat to the health or welfare of the community.	$3,408,000,000 (FY12)	portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Department of Housing and Urban Development (HUD)	Sustainable Communities Regional Planning Grants	The program supports metropolitan and multijurisdictional planning efforts that integrate housing, land use, economic and workforce development, transportation and infrastructure investments in a manner that empowers jurisdictions to consider the challenges of economic competitiveness and revitalization; social equity, inclusion and access to opportunity; energy use and climate change; and public health and environmental impact.	$0 (FY12), $45,080,000 (FY13)	portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities/sustainable_communities_regional_planning_grants
Department of Housing and Urban Development (HUD)	Community Challenge Grants	This grant program fosters reform and reduces barriers to achieving affordable, economically vital and sustainable communities. Such efforts may include amending or replacing local master plans, zoning codes and building codes, either on a jurisdiction-wide basis or in a specific neighborhood, district, corridor or sector, to promote mixed-use development, affordable housing, the reuse of older buildings and structures for new purposes, and similar activities with the goal of promoting sustainability at the local or neighborhood level.	$0 (FY12), $45,080,000 (FY13)	portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities/HUD-DOT_Community_Challenge_Grants
Department of Transportation (DOT)	Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grants	This grant program provides investments in innovative road, rail, transit and port projects.	$500,000,000 (FY12)	www.dot.gov/tiger
Environmental Protection Agency (EPA)	Clean Water State Revolving Fund (CWSRF)	The program distributes funding to states to provide low-interest loans for water quality protection projects, including wastewater treatment, nonpoint source pollution control and watershed and estuary management.	$1,468,806,000 (FY12)	water.epa.gov/grants_funding/cwsrf/cwsrf_index.cfm

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Environmental Protection Agency (EPA)	Drinking Water State Revolving Fund (DWSRF)	The program distributes funding to states to provide low-interest loans for investments in drinking water infrastructure, including the construction of new water treatment facilities, replacement of aging systems, and programs that prevent pollution of drinking water sources.	$919,363,000 (FY12)	water.epa.gov/grants_funding/dwsrf/index.cfm
Environmental Protection Agency (EPA)	Wetlands Program Development Grants	While these grants can be used for states' existing comprehensive wetland programs that address water pollution issues, priority will be given to projects that develop comprehensive monitoring and assessment programs, improve the effectiveness of compensatory mitigation and protect vulnerable wetlands and aquatic resources.	$15,143,000 (FY12)	water.epa.gov/grants_funding/wetlands/grantguidelines/index.cfm
Environmental Protection Agency (EPA)	National Estuary Program	The program provides financial assistance to protect and restore estuaries and associated watersheds that are deemed to be of national significance, of which there are currently 28 in the U.S. and Puerto Rico.	$27,014,000 (FY12)	water.epa.gov/type/oceb/nep/index.cfm
Environmental Protection Agency (EPA)	Nonpoint Source Implementation Grants	These grants, often referred to as Section 319 grants, are given to states to implement approved nonpoint source management programs that aim to reduce nonpoint source pollution.	$164,493,000 (FY12)	water.epa.gov/polwaste/nps/cwact.cfm
Environmental Protection Agency (EPA)	Beaches Environmental Assessment and Coastal Health (BEACH) Act Grants	Grants are awarded to eligible coastal and Great Lakes states, territories and tribes to develop and implement beach monitoring and notification programs.	$9,864,000 (FY12), $0 (FY13)	water.epa.gov/grants_funding/beachgrants/
Environmental Protection Agency (EPA)	Gulf of Mexico Program	The program facilitates collaboration among federal, state and local partners to protect, maintain and restore the health and productivity of the Gulf of Mexico. Priorities include water quality, habitat conservation and restoration, ecosystem integration and assessment, nutrient reduction and nutrient impacts, coastal community resilience and environmental education.	$5,455,000 (FY12)	www.epa.gov/gmpo/about/whatisgmp.html

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Environmental Protection Agency (EPA)	Water Pollution Control Program Grants	Grants are awarded to states, tribal entities and interstate agencies to develop and implement ground and surface water pollution control programs, including NPDES permitting, establishment of TMDLs and other water quality standards, monitoring and nonpoint source control activities.	$238,403,000 (FY12)	water.epa.gov/grants_funding/cwf/pollutioncontrol.cfm
Environmental Protection Agency (EPA)	Clean Water Indian Set-Aside (CWISA) Grant Program	The CWISA program provides funding to Indian tribes and Alaska Native villages for wastewater infrastructure.	$29,134,000 (FY12)	water.epa.gov/type/watersheds/wastewater/Clean-Water-Indian-Set-Aside-Grant-Program.cfm
Environmental Protection Agency (EPA)	Community Action for a Renewed Environment (CARE)	The CARE program helps communities address multiple sources of toxic pollutants in their environment.	$0 (FY12) $2,069,000 (FY13)	www.epa.gov/care/basic.htm
Environmental Protection Agency (EPA)	DWSRF Tribal Set-Aside Program	Community water systems and nonprofit non-community water systems that serve a tribal population are eligible for the funding of projects, including rehabilitation or development of a source of drinking water and installation or upgrading of treatment, storage and distribution facilities.	n/a	water.epa.gov/grants_funding/dwsrf/allotments/tribes.cfm
Environmental Protection Agency (EPA)	Environmental Education Grants	The Environmental Education Grants program offers funding to support environmental education projects that increase the public's awareness about environmental issues and provide participants with the skills to take responsible actions to protect the environment.	$2,160,000 (FY12 est.)	www2.epa.gov/education/environmental-education-ee-grants
Environmental Protection Agency (EPA)	Five Star Restoration Program	The program provides challenge grants, technical support and opportunities for information exchange to enable community-based projects to restore wetlands and streams.	$250,000 (FY12)	water.epa.gov/grants_funding/wetlands/restore/index.cfm

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Environmental Protection Agency (EPA)	Pollution Prevention (P2) Grant Program	The P2 grant program gives states and tribes the capability to assist businesses and industries in identifying better environmental strategies and solutions for complying with federal and state environmental regulations. P2 grants mostly fund state-based technical assistance, training, outreach, education, regulatory integration, data collection, research, demonstration projects and recognition programs.	$4,100,000 (FY13 est.)	www.epa.gov/p2/pubs/grants/index.htm#p2grant
Environmental Protection Agency (EPA)	Science to Achieve Results (STAR) Research Grants	The STAR program funds research grants and graduate fellowships in numerous environmental science and engineering disciplines through a competitive solicitation process and independent peer review. Current focus areas include the health effects of particulate matter, drinking water, water quality, global change, ecosystem assessment and restoration, human health risk assessment, endocrine disrupting chemicals, pollution prevention and new technologies, children's health and socioeconomic research.	n/a	www.epa.gov/ncer/rfa/#CurrentStar
Environmental Protection Agency (EPA)	Source Reduction Assistance (SRA) Grants	SRA awards are issued annually by the EPA at the regional level to support environmental projects that reduce or eliminate pollution at the source. Regions are interested in funding proposals that encourage greenhouse gas reduction, toxic and hazardous materials reduction, resource conservation, efficient business practices and pollution prevention (P2) integration activities. The program favors proposals that demonstrate new, innovative techniques, surveys or studies or that use research, investigations, experiments and/or training promoting P2/source reduction efforts.	$1,170,000 (FY12)	www.epa.gov/p2/pubs/grants/#srad

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Federal Emergency Management Agency (FEMA)	Hazard Mitigation Grant Program (HMGP)	The HMGP provides grants to states and local governments to take measures to reduce the risk of loss of life and property from future disasters during the reconstruction process following a major disaster declaration.	$793,951,989 (FY11)— funding availability depends on the amount of FEMA disaster recovery assistance under a presidential major disaster declaration	www.fema.gov/hazard-mitigation-grant-program
Federal Emergency Management Agency (FEMA)	Pre-Disaster Mitigation (PDM) Grant Program	The PDM program provides grants for hazard mitigation planning to reduce risks to populations and structures prior to a disaster event.	$35,500,000 (FY12)	www.fema.gov/pre-disaster-mitigation-grant-program
Federal Emergency Management Agency (FEMA)	Flood Mitigation Assistance (FMA)	Through the FMA, communities are eligible for planning and project grants to prepare flood mitigation plans, which reduce or eliminate claims under the National Flood Insurance Program (NFIP). Projects can include the acquisition, elevation or relocation of NFIP-insured structures.	$40,000,000 (FY12)	www.fema.gov/flood-mitigation-assistance-program
Federal Emergency Management Agency (FEMA)	Repetitive Flood Claims Program	Funds are available to states and communities to reduce flood damages to insured properties that have made one or more claims to the National Flood Insurance Program (NFIP).	n/a	www.fema.gov/repetitive-flood-claims-program
Federal Emergency Management Agency (FEMA)	Severe Repetitive Loss Program	The program provides funds to reduce or eliminate long-term risk of flood damage to severe repetitive loss structures (structures that have at least four NFIP claim payments or claim payments that exceed the market value of the structure).	$50,399,000 (FY12 est.)	www.fema.gov/severe-repetitive-loss-program
Federal Emergency Management Agency (FEMA)	Public Assistance Grant Program	Funds are available to assist state and local governments to respond to and recover from presidentially declared disasters. Assistance is available for debris removal, emergency protective measures, and repair, restoration, reconstruction or replacement of public facilities or infrastructure damaged or destroyed.	n/a	www.fema.gov/public-assistance-local-state-tribal-and-non-profit

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Federal Emergency Management Agency (FEMA)	Community Assistance Program—State Support Services Element (CAP-SSSE)	This program provides funding to states to give technical assistance to communities in the National Flood Insurance Program (NFIP) and to evaluate community performance in implementing NFIP floodplain management activities.	$10,000,000 (FY12 est.)	www.fema.gov/national-flood-insurance-program-1/community-assistance-program-state-support-services-element
Great Lakes Program	Great Lakes Restoration Initiative	The initiative involves a task force of 11 federal agencies that have developed an action plan focusing on five urgent issues: (1) cleaning up toxins and areas of concern, (2) combating invasive species, (3) promoting nearshore health by reducing pollution, (4) restoring wetlands and other habitats, and (5) tracking progress and working with strategic partners.	$299,520,000 (FY12)	glri.us/index.html
National Fish and Wildlife Foundation	Various grant programs	The foundation provides funding for projects that sustain, restore and enhance fish, wildlife and plants and their habitats.	n/a	www.nfwf.org/Pages/grants/home.aspx
National Oceanic and Atmospheric Administration (NOAA)	Coastal Zone Management Administration Awards	The Office of Coastal Resource Management (OCRM) provides 1:1 matching funds for states to administer their coastal zone management programs. Funds have been used for enhancing public access, protecting and restoring coastal habitat, mitigating coastal hazards, ocean planning, managing coastal community development and protecting coastal water quality.	$55,700,206 (FY12)	coastalmanagement.noaa.gov/funding/welcome.html
National Oceanic and Atmospheric Administration (NOAA)	Coastal Zone Enhancement Program (CZMA Section 309)	This program encourages federally approved coastal management initiatives to develop programmatic changes or enhancements in one of nine areas: wetlands, coastal hazards, public access, marine debris, cumulative and secondary impacts, special area management plans, ocean/Great Lakes resources, energy and government facility siting, and aquaculture.	$10,000,000 (FY12)	coastalmanagement.noaa.gov/enhanc.html

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
National Oceanic and Atmospheric Administration (NOAA)	Coral Reef Conservation Program	This program was established to help protect important coral ecosystems through a multidisciplinary approach that includes mapping, monitoring, research, training, management and outreach. Further, the program facilitates and supports partnerships with scientific, private, government and non-governmental groups to achieve this objective.	$26,700,000 (FY12)	coastalmanagement.noaa.gov/programs/coral.html
National Oceanic and Atmospheric Administration (NOAA)	Climate Program Office—Climate and Societal Interactions (CSI) Program	CSI helps society adapt to a changing climate by providing funding for projects to better understand and anticipate changes in climate and, consequently, inform decision-making and climate risk management.	n/a	cpo.noaa.gov/ClimatePrograms/ClimateSocietalInteractionsCSI.aspx
National Oceanic and Atmospheric Administration (NOAA)	Coastal Services Center (CSC)	CSC provides data, tools, training and technical assistance to state and local governments to address the challenges associated with flooding, hurricanes, sea level rise and other coastal hazards. Funding opportunities are posted on the CSC website as they are made available.	n/a	www.csc.noaa.gov/funding/
National Oceanic and Atmospheric Administration (NOAA)	National Estuarine Research Reserve System (NERRS)	Grants may be used to cover the costs of land acquisition, development, research, education, operation and facilities construction for the 28 federally designated National Estuarine Research Reserves.	$21,712,000 (FY12 est.)	www.nerrs.noaa.gov/Default.aspx
National Oceanic and Atmospheric Administration (NOAA)	Office of Habitat Conservation	Several times a year, funds are made available for individual coastal and marine habitat restoration and protection projects.	n/a	www.habitat.noaa.gov/funding/

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
National Oceanic and Atmospheric Administration (NOAA)	National Sea Grant College Program	Sea Grant is a university-based program that provides research and outreach to support greater understanding and conservation of coastal resources. Funding is available through the 33 state Sea Grant programs as well as National Strategic Investments (NSIs). Recent NSIs have supported research on sustainable marine aquaculture and aquatic invasive species.	n/a	www.seagrant.noaa.gov/funding/fundingfellowships.html
National Park Service	Land and Water Conservation Fund (LWCF)	Grants are available to state and local governments for the acquisition of park and recreation land, development of recreation facilities and redevelopment of older recreation facilities.	$45,000,000 (FY12)	www.nps.gov/ncrc/programs/lwcf/fed_state.html
NOAA/ U.S. Army Corps of Engineers	Estuary Habitat Restoration Program	The program provides technical assistance and federal funding for estuary habitat restoration projects.	n/a	www.era.noaa.gov/information/funding.html
U.S. Army Corps of Engineers	Beach Erosion Control Projects	The Corps of Engineers designs and constructs projects to control beach and shore erosion along public shores.	$5,000,000 (FY12 est.)	www.cfda.gov/index?s=program&mode=form&tab=step1&id=de50d106792bf01c0d24133395c1fd22
U.S. Army Corps of Engineers	Flood Control Projects	The Corps of Engineers designs and constructs projects to reduce flood damage.	$22,000,000 (FY12 est.)	www.cfda.gov/?s=program&mode=form&tab=step1&id=2216ee03c69db437c431036a5585ede6
U.S. Army Corps of Engineers	Aquatic Plant Control Projects	The Corps of Engineers cooperates with state and local government agencies to control invasive aquatic plants in rivers, harbors and allied waters.	$5,000,000 (FY12 est.)	www.cfda.gov/?s=program&mode=form&tab=step1&id=4b24f9623b731c7a4a2f375b2a476c02
U.S. Army Corps of Engineers	Protection of Essential Highways, Highway Bridge Approaches and Public Works	The Corps of Engineers designs and constructs projects to provide bank protection of highways, highway bridges, essential public works, churches, hospitals, schools and other nonprofit public entities endangered by flood-caused erosion.	n/a	www.cfda.gov/index?s=program&mode=form&tab=step1&id=7ba50e5ed3a412dce7c6187479c96a84

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
U.S. Army Corps of Engineers	Project Modifications for Improvement of the Environment	This program provides for modifications in the structures and operations of water resources projects constructed by the Corps of Engineers, to improve the quality of the environment. The Corps may undertake restoration projects at locations where an existing Corps project has contributed to degradation. The primary goal of these projects is ecosystem restoration, with an emphasis on projects benefiting fish and wildlife.	$7,910,000 (FY12)	ofmpub.epa.gov/apex/watershedfunding/f?p=116:2:0::NO::P2_X_PROG_NUM,P2_X_YEAR:109,2013
U.S. Army Corps of Engineers	Shore Damage Attributable to Federal Navigation Works	This program provides for the prevention or mitigation of erosion damage to public or privately owned shores along the coastline of the United States when this damage is the result of a federal navigation project.	$438,225 (FY12)	ofmpub.epa.gov/apex/watershedfunding/f?p=116:2:0::NO::P2_X_PROG_NUM,P2_X_YEAR:106,2013
U.S. Army Corps of Engineers	Small Flood Damage Reduction Projects	This program provides for local protection from flooding by the construction or improvement of structural flood damage reduction features such as levees, channels and dams. Nonstructural alternatives, such as installation of flood warning systems, raising and/or flood-proofing of structures and relocation of flood-prone facilities, also are considered.	$16,900,000 (FY12)	ofmpub.epa.gov/apex/watershedfunding/f?p=116:2:0::NO::P2_X_PROG_NUM,P2_X_YEAR:108,2013
U.S. Department of Agriculture (USDA)	Sustainable Agriculture Research and Education (SARE) Grants	SARE grants are distributed through four regions to fund agricultural research and education projects, including pest and weed management, livestock and rotational grazing, no-till and conservation tillage, nutrient management and crop and livestock diversity.	$12,577,923 (FY12)	www.sare.org/Grants

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
U.S. Department of Agriculture (USDA)	Water and Waste Disposal Loans and Grants	The Rural Utilities Service provides loans, guaranteed loans and grants for water, sewer, stormwater and solid waste disposal facilities in cities and towns of up to 10,000 people and in rural areas with no population limits.	$1,361,000,000 (FY13 est.)	www.rurdev.usda.gov/UWP-dispdirectloansgrants.htm
U.S. Department of Agriculture (USDA)	Conservation Reserve Program (CRP)	Through CRP, agricultural landowners can receive annual rental payments and cost-share assistance to convert highly erodible cropland or other environmentally sensitive land to long-term, resource-conserving cover on eligible farmland.	$2,201,694,000 (FY13 est.)	www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
U.S. Department of Agriculture (USDA)	National Integrated Water Quality Program (NIWQP)	The goal of NIWQP is to contribute to the improvement of the quality of surface water and groundwater resources through research, education and extension activities. It funds projects that (1) demonstrate conservation of water resources at the watershed scale to meet diminished water supply due to drought, climate variability, salinity and competing demand for water or (2) focus on biophysical, social, economic and behavioral practices needed to improve the adoption and maintenance of practices intended to improve water quality. Projects that address the use of recycled water in agriculture and the environmental impacts (positive or negative, including downstream effects) that result from application of recycled water are of particular interest.	$4,000,000 (FY12)	www.nifa.usda.gov/fo/waterqualitycgp.cfm
U.S. Department of Agriculture (USDA)	Farm Loan Programs	A variety of loan programs are available for farmers to implement soil and water conservation practices.	$4,577,254,000 (FY12)	www.fsa.usda.gov/FSA/webapp?area=home&subject=fmlp&topic=landing

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
USDA Natural Resources Conservation Service (NRCS)	Agricultural Management Assistance (AMA)	The AMA provides financial and technical assistance to agricultural producers to address issues such as water management, water quality and erosion control by incorporating conservation into their farming operations. Producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management or transition to organic farming. Funding is available in 16 states: Connecticut, Delaware, Hawaii, Maine, Maryland, Massachusetts, Nevada, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Utah, Vermont, West Virginia, and Wyoming.	$10,000,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ama
USDA Natural Resources Conservation Service (NRCS)	Environmental Quality Incentives Program (EQIP)	EQIP provides financial and technical assistance to agricultural producers through contracts that support practices addressing natural resource concerns. It also supports opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and nonindustrial private forestland.	$1,018,075,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
USDA Natural Resources Conservation Service (NRCS)	Conservation Technical Assistance (CTA)	CTA provides technical assistance to land users to address opportunities, concerns and problems related to the use of natural resources and to help land users make sound natural resource management decisions on private, tribal and other nonfederal lands. This assistance can help land users maintain and improve private lands and their management, implement better land management technologies, protect and improve water quality and quantity, maintain and improve wildlife and fish habitat, enhance recreational opportunities on their land, maintain and improve the aesthetic character of private land, explore opportunities to diversify agricultural operations, and develop and apply sustainable agricultural systems.	$473,527,866 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical
USDA Natural Resources Conservation Service (NRCS)	Agricultural Water Enhancement Program (AWEP)	AWEP provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land to conserve surface water and groundwater and improve water quality.	$48,024,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/awep/?&cid=nrcs143_008334
USDA Natural Resources Conservation Service (NRCS)	Farm and Ranch Lands Protection Program (FRPP)	FRPP provides matching funds to acquire conservation easements or other interests in land from landowners to keep productive farm and ranchland in agricultural use.	$142,909,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/farmranch
USDA Natural Resources Conservation Service (NRCS)	Conservation Stewardship Program (CSP)	CSP encourages producers to address resource concerns in a comprehensive manner by undertaking additional conservation activities and by improving, maintaining and managing existing conservation activities. Participants receive an annual payment for operation-level environmental benefits they produce, with payments based on conservation performance.	$695,534,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
USDA Natural Resources Conservation Service (NRCS)	Healthy Forests Reserve Program (HFRP)	HFRP assists landowners with restoring, enhancing and maintaining forest ecosystems on private lands through easements, contracts and restoration agreements.	$11,611,100 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/forests
USDA Natural Resources Conservation Service (NRCS)	Wetlands Reserve Program (WRP)	WRP provides technical and financial support to help landowners protect, restore and enhance wetlands on their property. These include permanent easements, 30-year easements or contracts, and restoration cost-share agreements.	$632,889,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands
USDA Natural Resources Conservation Service (NRCS)	Wildlife Habitat Incentives Program (WHIP)	WHIP is for landowners who want to develop and improve wildlife habitat on agricultural land, non-industrial private forestland, and Indian land. Priorities include native fish and wildlife habitats, habitats of at-risk species, reducing the impacts of invasive species, and wildlife migration and movement corridors.	$36,122,000 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/whip
USDA Natural Resources Conservation Service (NRCS)	Chesapeake Bay Watershed Initiative (CBWI)	Under CBWI, eligible landowners receive technical and financial assistance to address soil erosion, sedimentation and excess nutrients in streams and waterways, and other, related natural resource concerns such as air quality, wetlands, wildlife habitat and forestry.	$43,052,200 (FY12)	www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/farmbill/?&cid=stelprdb1047323
U.S. Economic Development Administration (EDA)	Public Works and Economic Adjustment Assistance Programs	The Public Works program provides funding to communities to upgrade physical infrastructure to enhance economic opportunities. The Economic Adjustment program provides funding to states and communities to design and implement strategies to change economies, particularly in areas that are under serious threat of structural damage to their economic base.	$161,700,000 (FY12)	www.eda.gov/PDF/FY_2012_EDAP_FFO_11-18-11_FINAL.pdf

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
U.S. Fish and Wildlife Service	State/Tribal Wildlife Grants	These federal grants provide funding for the development and implementation of programs that benefit wildlife and wild habitats, with a particular emphasis on projects that address species of greatest conservation need. Funds can be used to conduct research, monitoring and surveys and for species and habitat management activities.	$61,323,000 (FY12)	wsfrprograms.fws.gov/Subpages/GrantPrograms/SWG/SWG.htm
U.S. Fish and Wildlife Service	North American Wetlands Conservation Fund	This fund supports the conservation of North American wetland ecosystems for waterfowl, other migratory birds, fish and wildlife. Grants are available for projects that involve long-term protection, restoration, and/or enhancement of wetlands and associated upland habitats.	$35,497,000 (FY12)	www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm
U.S. Fish and Wildlife Service	National Coastal Wetlands Conservation Grant Program	This program provides funding to states for the acquisition, restoration, management or enhancement of coastal wetlands.	$20,500,000 (FY12)	www.fws.gov/coastal/coastalgrants/
U.S. Fish and Wildlife Service	Cooperative Endangered Species Conservation Fund	The fund provides grants to states to participate in a wide array of habitat conservation projects for candidate, proposed and listed species.	$33,000,000 (FY12)	www.fws.gov/endangered/grants/
U.S. Fish and Wildlife Service	Partners for Fish and Wildlife Program	The program provides technical and financial assistance to private landowners and tribes to help meet the habitat needs of federal trust species through conservation and restoration of native vegetation, hydrology and soils associated with imperiled ecosystems.	$22,000,000 (FY12 est.)	www.fws.gov/partners/aboutus.html

Examples of Federal and Regional-Level Funding for Implementation (continued)

NAME	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
U.S. Forest Service	Urban and Community Forestry Program	The program provides technical, financial, educational and research services to states, cities and non-profit groups so they can plant, protect, maintain and utilize wood from community trees and forests to maximize environmental, social and economic benefits.	$31,327,000 (FY12)	www.na.fs.fed.us/urban/
U.S. Forest Service	Forest Legacy Program (FLP)	The program supports state efforts to protect environmentally sensitive forests by encouraging the protection of privately owned forest lands. It encourages and supports acquisition of conservation easements, legally binding agreements transferring a negotiated set of property rights from one party to another, without removing the property from private ownership. Most FLP conservation easements restrict development, require sustainable forestry practices, and protect other values.	$53,303,000 (FY12)	www.fs.fed.us/spf/coop/programs/loa/flp.shtml

Examples of State Funding Sources for Implementation

STATE	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
California	Proposition 50: Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002	The Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 (Proposition 54) authorized general obligation bonds to fund a variety of water projects, including coastal protection, integrated regional water management, safe drinking water, water quality, and the CALFED Bay-Delta Program.	$3,440,000,000 bond	resources.ca.gov/bond/Prop_50_with_legislative_amendments-3.pdf
California	Proposition 84: Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006	The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) authorized general obligation bonds to fund safe drinking water, water quality and supply, flood control, waterway and natural resource protection, water pollution and contamination control, state and local park improvements, public access to natural resources and water conservation efforts.	$5,388,000,000 bond	bondaccountability.resources.ca.gov/p84.aspx
California	Proposition 1E: Disaster Preparedness and Flood Protection Bond Act	The Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1E) authorizes $4.09 billion in general obligation bonds to rebuild and repair California's most vulnerable flood-control structures to protect homes and prevent loss of life from flood-related disasters, including levee failures, flash floods and mudslides, and to protect California's drinking water supply system by rebuilding delta levees that are vulnerable to earthquakes and storms.	$4,090,000,000 bond	bondaccountability.resources.ca.gov/p1e.aspx

Examples of State Funding Sources for Implementation (continued)

STATE	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
California	Greenhouse Gas Reduction Fund, AB 1532/ SB 535	Signed into law in October 2012, AB 1532 requires that all revenues collected from the state's cap-and-trade program, which are deposited into the Greenhouse Gas Reduction Fund, be spent on greenhouse gas reduction projects. Applicable projects include but are not limited to energy efficiency, renewable energy, transportation, housing, and water and natural resources management. SB 535 requires that 25 percent of money in the fund be used on projects that benefit disadvantaged communities.	n/a	leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB1532
Hawaii	Act 73: Barrel tax on imported petroleum	Act 73 of 2010 was enacted to increase the per barrel tax on petroleum products under the environmental response, energy and food security tax, which supports critical investments in clean energy and local agricultural production in order to reduce the state's dependence on imported fossil fuels and food products. As currently apportioned, a combined $0.30 of the $1.05 per barrel tax is allocated to the energy security fund and the agricultural development and food security special fund.	n/a	www.capitol.hawaii.gov/session2010/bills/HB2421_CD1_.htm
Maryland	Chesapeake and Atlantic Coastal Bays Trust Fund	Established in November 2007, the Chesapeake and Atlantic Coastal Bays Trust Fund was created to provide a dedicated source of funding to accelerate Bay restoration. The fund finances a variety of practices that help reduce nutrients and sediment in the Bay and its tributaries. The fund allows Maryland to accelerate Bay restoration by focusing limited financial resources on the most effective nonpoint source pollution control projects.	Between FY09 and FY12, the fund provided $63.1 million, generated through motor fuel excise tax and rental car tax in Maryland. It is anticipated that when fully funded, the Trust Fund will distribute $50 million annually.	dnr.maryland.gov/ccp/funding/trust_fund.asp

Examples of State Funding Sources for Implementation (continued)

STATE	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Massachusetts	Community Preservation Act (CPA) Trust Fund	CPA is a smart-growth tool that helps communities preserve open space and historic sites, create affordable housing and develop outdoor recreational facilities. CPA also helps strengthen the state and local economies by expanding housing opportunities and construction jobs for the Commonwealth's workforce, and by supporting the tourism industry through preservation of the Commonwealth's historic and natural resources.	Between FY02 and FY12, the fund has distributed over $414 million.	www.communitypreservation.org/
Massachusetts	Coastal Pollutant Remediation (CPR) Grant Program	The CPR Grant Program was established in 1996 by the Massachusetts Legislature to help communities identify and improve water quality impaired by nonpoint source pollution. The CPR program provides funding to Massachusetts municipalities to assess and remediate stormwater pollution from paved surfaces or to design and construct boat waste pump-out facilities. Since 1996, more than $6 million in CPR grants has been awarded.	The maximum award for CPR is contingent on available funding. In 2013, about $400,000 in total funding is expected, with up to $125,000 granted for each project. The maximum award for each year is listed in the request for responses. Applicants must commit to matching 25 percent of the total project cost.	www.mass.gov/czm/cprgp.htm

Examples of State Funding Sources for Implementation (continued)

STATE	PROGRAM	DESCRIPTION	AMOUNT	ADDITIONAL INFORMATION
Wisconsin	Focus on Energy: Environmental and Economic Research and Development (EERD) Program	Focus on Energy works with eligible Wisconsin residents and businesses to install cost-effective energy efficiency and renewable energy projects. Focus on Energy information, resources and financial incentives help to implement projects that would otherwise not be completed, or to complete projects sooner than scheduled. Its efforts help Wisconsin residents and businesses manage rising energy costs, control the state's growing demand for electricity and natural gas, promote in-state economic development and protect the environment. Since 2002, more than 55 EERD grants have been awarded to ground-breaking research projects related to the environmental and economic impact of energy use.	A total of up to $400,000 was available for research projects in the 2012 funding cycle.	www.focusonenergy.com/rfp-postings

Appendix III

Additional Resources

For more information on preparedness planning or implementation, the authors suggest the following selected resources.

- Kate Boicourt and Zoë P. Johnson, (eds.), *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic, and Ecological Resilience,* Report of the Maryland Commission on Climate Change, Adaptation and Response and Scientific and Technical Working Groups (2010), www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf.

- Virginia R. Burkett and Margaret A. Davidson (eds.), *Coastal Impacts, Adaptation and Vulnerability: A Technical Input to the 2013 National Climate Assessment* (2012), downloads.usgcrp.gov/NCA/technicalinputreports/Burkett_Davidson_Coasts_Final_.pdf.

- California Department of Water Resources, U.S. EPA Region 9, U.S. Army Corps and the Resources Legacy Fund, *Climate Change Handbook for Regional Water Planning* (2011), www.water.ca.gov/climatechange/CCHandbook.cfm.

- California Emergency Management Agency and California Natural Resources Agency, *California Climate Change Adaptation Planning Guide* (2012), resources.ca.gov/climate_adaptation/local_government/adaptation_policy_guide.html.

- California Natural Resources Agency, *2009 California Climate Adaptation Strategy* (2009), resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf.

- Center for Climate Strategies, *Comprehensive Climate Action Planning: The Center for Climate Strategies Adaptation Guidebook* (2011), www.climatestrategies.us/library/library/download/908.

- The Climate Impacts Groups, University of Washington, King County, and ICLEI--Local Governments for Sustainability, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (2007), www.icleiusa.org/action-center/planning/adaptation-guidebook.

- Coastal-Marine Ecosystem-Based Management Tools Network, *Tools for Coastal Climate Adaptation Planning: A Guide for Selecting Tools to Assist with Ecosystem-Based Climate Planning* (2013), connect.natureserve.org/sites/default/files/documents/EBM-ClimateToolsGuide-FINAL.pdf.

- Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee, *Massachusetts Climate Change Adaptation Report* (2011), www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf.

- Michael B. Gerrard and Katrina Fischer Kuh (eds.), *The Law of Adaptation to Climate Change: U.S. and International Aspects* (2012), Chicago: American Bar Association.

- Patty Glick, Bruce A. Stein and Naomi A. Edelson (eds.), *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment* (2011), www.nwf.org/vulnerabilityguide.

- Jessica Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use* (2011), Georgetown Climate Center, www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf.

- Intergovernmental Panel on Climate Change, "Summary for Policymakers," In *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (2007), www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf.

- Intergovernmental Panel on *Climate Change, Climate Models and Their Evaluation* (2007), www.ipcc.ch/publications_and_data/ar4/wg1/en/ch8.html.

- Roger Jones and Rizaldi Boer, "Technical Paper 4: Assessing Current Climate Risks," Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures (2005), content.undp.org/go/cms-service/stream/asset/?asset_id=2200851.

- David C. Major and Megan O'Grady, *Adaptation Assessment Guidebook* (2010), New York City Panel on Climate Change, onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/pdf.

- National Oceanic and Atmospheric Administration (NOAA), *Voluntary Step-by-Step Guide for Considering Potential Climate Change Effects on Coastal and Estuarine Land Conservation Projects* (2012), coastalmanagement.noaa.gov/resources/docs/guidecelpapp.pdf.

- NOAA and U.S. Environmental Protection Agency (EPA), *Achieving Hazard-Resilient Coastal & Waterfront Smart Growth* (2012), coastalsmartgrowth.noaa.gov/pdf/hazard_resilience.pdf.

- Pennsylvania Department of Environmental Protection, *Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations* (2011), www.elibrary.dep.state.pa.us/dsweb/Get/Document-92911/27000-RE-DEP4303%20%20Pennsylvania%20Climate%20Adaptation%20Planning%20Report.pdf.

- U.S. Environmental Protection Agency, *Climate Ready Water Utilities: Adaptation Strategies Guide for Water Utilities* (2012), water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf.

- U.S. Global Change Research Program, *2009 Global Climate Change Impacts in the United States* (2009), downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

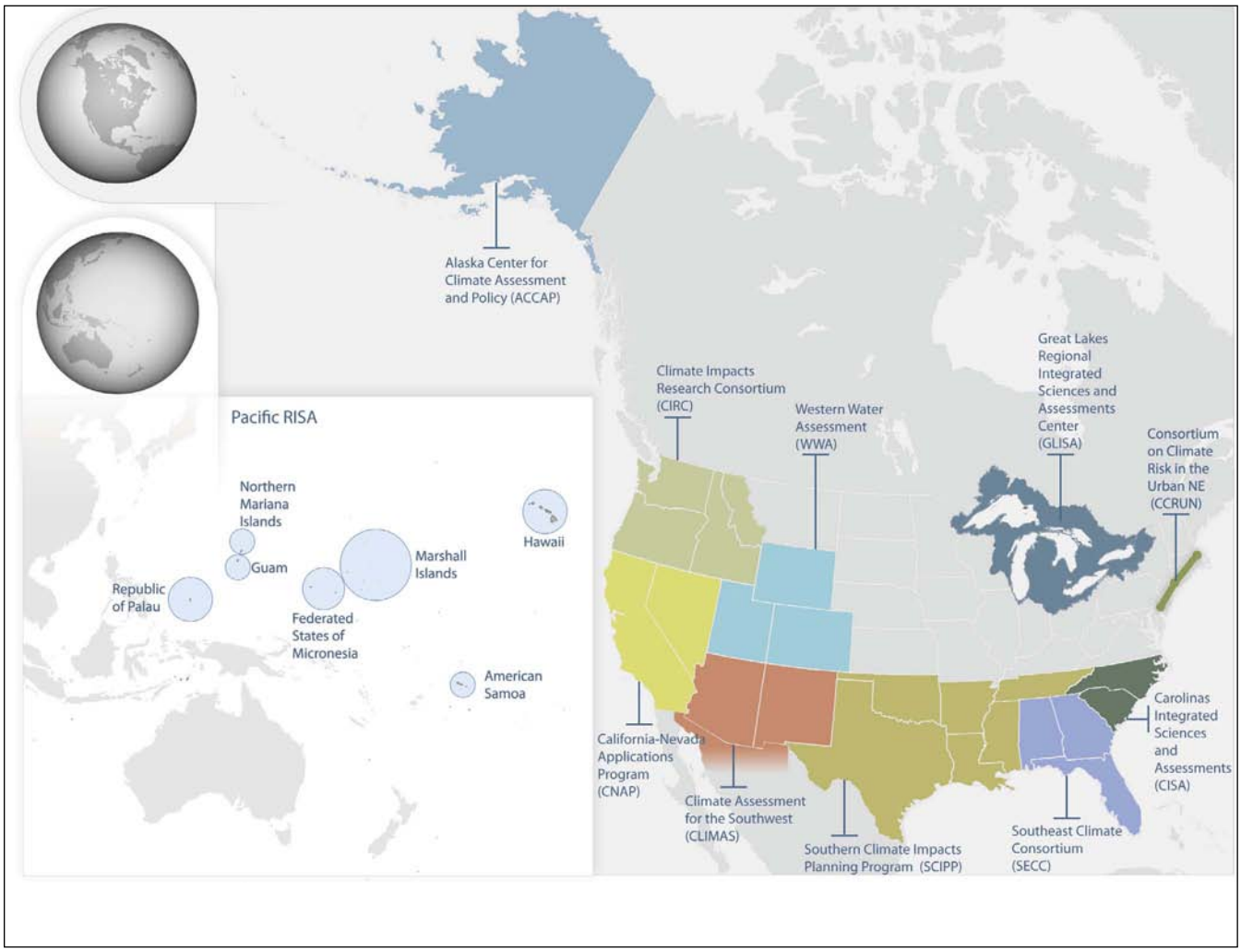
- Wisconsin Initiative on Climate Change Impacts (WICCI), Nelson Institute for Environmental Studies, University of Wisconsin--Madison and the Wisconsin Department of Natural Resources, *Wisconsin's Wisconsin's Changing Climate: Impacts and Adaptation* (2011), www.wicci.wisc.edu/publications.php.

- World Wildlife Fund (WWF), *Shifting Course: Climate Adaptation for Water Management Institutions* (2011), www.adaptiveinstitutions.org/Shifting_Course.pdf.

Information on the NOAA Regional Integrated Sciences and Assessments (RISA) Program and the Department of Interior's Climate Science Centers (CSCs) and Landscape Conservation Cooperatives (LCCs) is given below.

NOAA Regional Integrated Sciences and Assessments (RISA) Program Teams

cpo.noaa.gov/ClimatePrograms/ClimateSocietalInteractionsCSI/RISAProgram/RISATeams.aspx

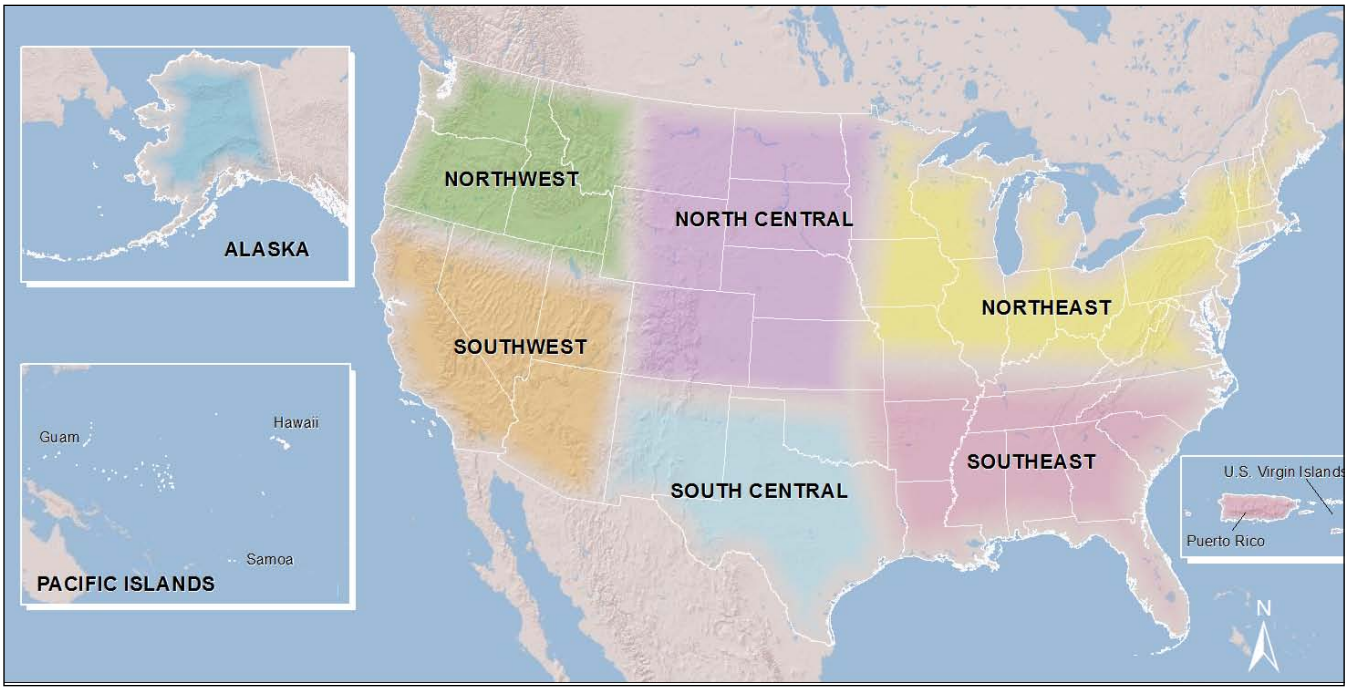


NAME	COVERAGE AREA	WEBSITE
Alaska Center for Climate Assessment and Policy (ACCAP)	Alaska	ine.uaf.edu/accap
California-Nevada Applications Program (CNAP)	California and Nevada	meteora.ucsd.edu/cap

NAME	COVERAGE AREA	WEBSITE
Carolinas Integrated Sciences and Assessments (CISA)	North and South Carolina	www.cisa.sc.edu
Climate Assessment for the Southwest (CLIMAS)	Arizona and New Mexico	www.climas.arizona.edu
Climate Impacts Research Consortium (CIRC)	Idaho, Montana, Oregon and Washington	www.pnwclimate.org
Consortium on Climate Risk in the Urban Northeast (CCRUN)	Connecticut, Massachusetts, New Jersey, New York, Pennsylvania and Rhode Island	www.ccrun.org
Great Lakes Regional Integrated Sciences and Assessments Center (GLISA)	Great Lakes region	glisa.msu.edu/about/index.php
Pacific RISA	Hawaii and the Pacific Islands	www.pacificrisa.org
Southeast Climate Consortium (SECC)	Alabama, Georgia and Florida	www.seclimate.org
Southern Climate Impacts Planning Program (SCIPP)	Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas	www.southernclimate.org
Western Water Assessment (WWA)	Colorado, Utah and Wyoming	wwa.colorado.edu

DOI Climate Science Centers (CSCs)

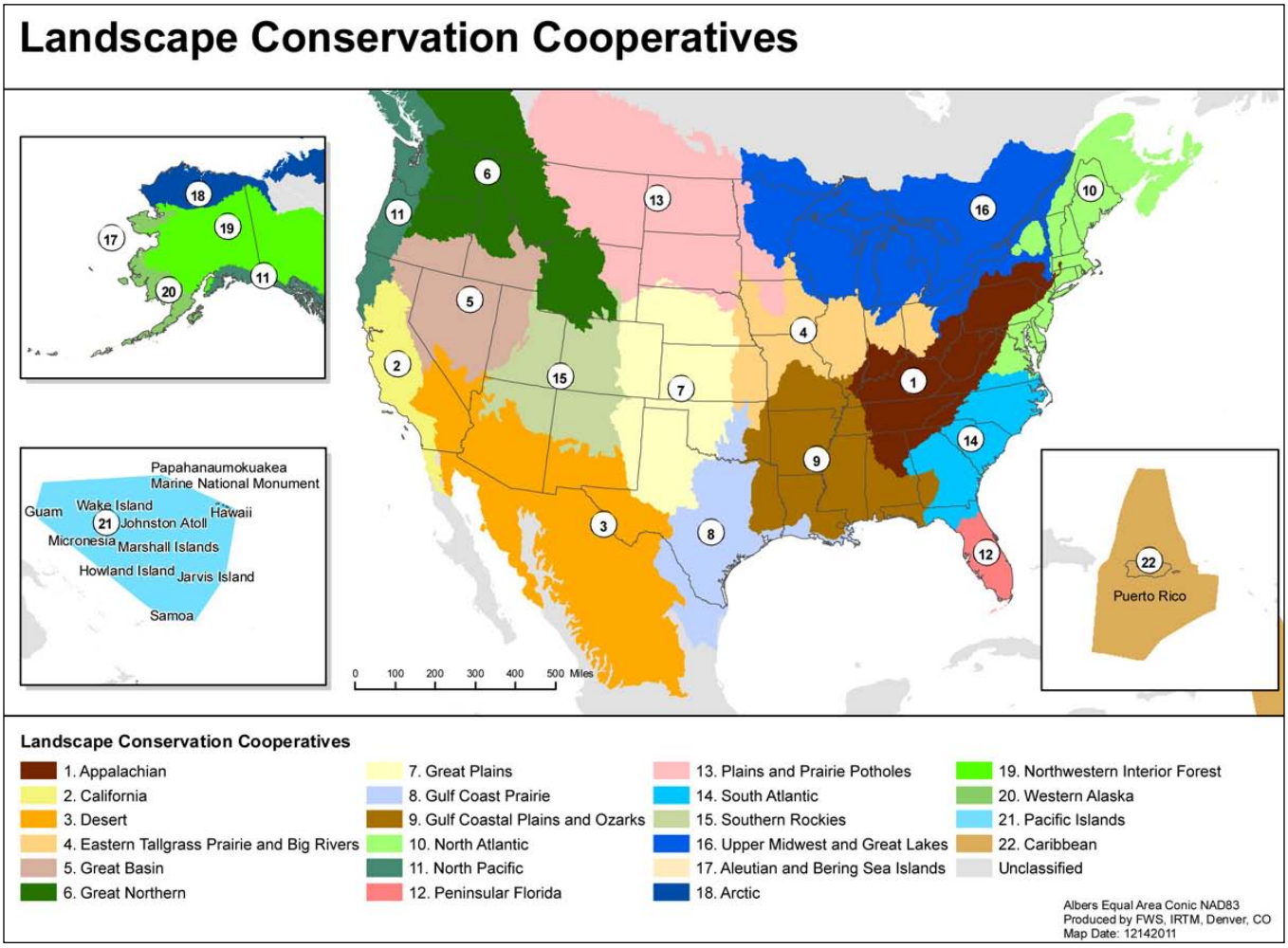
www.doi.gov/csc/index.cfm



NAME	WEBSITE
Alaska CSC	www.doi.gov/csc/alaska/index.cfm
North Central CSC	www.doi.gov/csc/northcentral/index.cfm
Northeast CSC	www.doi.gov/csc/northeast/index.cfm
Northwest CSC	www.doi.gov/csc/northwest/index.cfm
Pacific Islands CSC	www.doi.gov/csc/pacific/index.cfm
South Central CSC	www.doi.gov/csc/southcentral/index.cfm
Southeast CSC	www.doi.gov/csc/southeast/index.cfm
Southwest CSC	www.doi.gov/csc/southwest/index.cfm

DOI Landscape Conservation Cooperatives (LCCs)

www.doi.gov/lcc/index.cfm



NAME	WEBSITE
Appalachian	www.applcc.org
California	www.californialcc.org
Desert	www.usbr.gov/WaterSMART/lcc
Eastern Tallgrass Prairie and Big Rivers	www.tallgrassprairielcc.org
Great Basin	www.blm.gov/nv/st/en/prog/more_programs/GBLCC.html
Great Northern	greatnorthernlcc.org
Great Plains	www.greatplainslcc.org
Gulf Coast Prairie	www.gulfcoastprairielcc.org

NAME	WEBSITE
Gulf Coastal Plains and Ozarks	gcpolcc.ning.com
North Atlantic	www.northatlanticlcc.org
North Pacific	northpacificlcc.org
Peninsular Florida	peninsularfloridalcc.org
Plains and Prairie Potholes	www.plainsandprairiepotholeslcc.org
South Atlantic	www.southatlanticlcc.org
Southern Rockies	www.usbr.gov/WaterSMART/lcc
Upper Midwest and Great Lakes	www.greatlakeslcc.org
Aleutian and Bering Sea Islands	absilcc.org
Arctic	arcticlcc.org
Northwestern Interior Forest	nwblcc.org
Western Alaska	www.arcus.org/western-alaska-lcc
Pacific Islands	piccc.net
Caribbean	caribbeanlcc.org

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