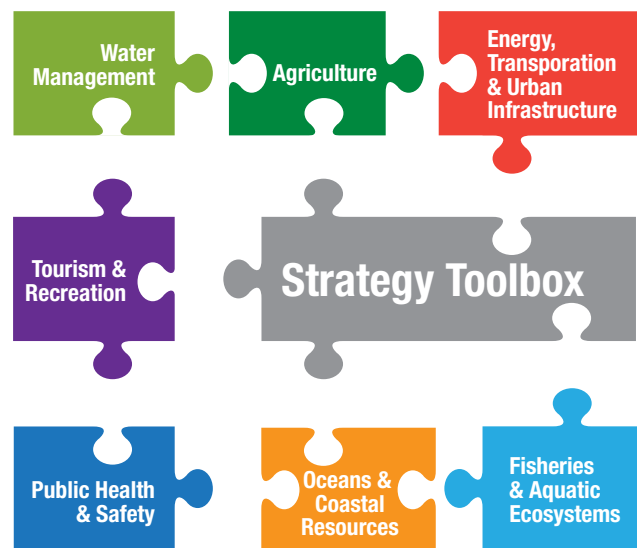

Strategy Toolbox

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.

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

The seven sectors included in the Strategy Toolbox.



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
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ 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)
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ Backfill irrigation ditches and install tide gates to prevent brackish water from infiltrating coastal farmland
<ul style="list-style-type: none"> ■ Use improved LIDAR elevation data and information to guide farmers considering relocation of vulnerable farming operations
Manage Emerging Threats from Pests/Weeds/Diseases
<ul style="list-style-type: none"> ■ Integrate potential climate change impacts (e.g., changes in weeds, diseases, pests) into current detection, monitoring and integrated pest management efforts
<ul style="list-style-type: none"> ■ Increase chemical-free forms of pest control
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ Provide information to the agricultural community to enable farmers and growers to modify agricultural practices and to adapt to new pests and diseases
<ul style="list-style-type: none"> ■ Increase monitoring, detection and control measures for pest insects and plant diseases
<ul style="list-style-type: none"> ■ Improve understanding of how climate change will affect the intensity and distribution of weeds, insects and diseases
<ul style="list-style-type: none"> ■ Increase adoption of techniques that replicate natural systems' mechanisms for pest control, windbreaks, and disease management
<ul style="list-style-type: none"> ■ Maintain the genetic diversity of crops
Conduct Emergency Response and Preparedness Planning to Improve Agricultural Resilience
<ul style="list-style-type: none"> ■ Support research and development of agricultural emergency response plans for severe drought and other extreme events
<ul style="list-style-type: none"> ■ 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: <ul style="list-style-type: none"> ■ 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-INFRA-STRUCTURE-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 from 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/slr/finalrep.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/aboutcrp/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
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ 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
<ul style="list-style-type: none"> ■ 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.nyscrda.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 snow-making 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/uploaded-Files/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-INFRA-STRUCTURE-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