

Adaptation Planning for the National Estuary Program

Elements of an Adaptation Plan

Successful adaptation in estuaries requires plans that respond to both the unique vulnerabilities and the priorities of the places they protect. The plans also need to be realistic assessments of the degree of risk and cost that can be sustained, and flexible enough to respond to changing conditions and information.

This document describes five critical elements of adaptation planning, and provides examples of these elements and suggestions for additional resources. Any estuary in the National Estuary Program (NEP) should incorporate these elements in an adaptation plan to achieve recognition as a Climate Ready Estuary (CRE)¹. While specifically developed for the NEPs, this document can be used as a resource for other coastal communities as a starting point for planning to adapt to climate change. The CRE program intends to periodically revisit and update this document as EPA and the NEPs gain greater experience with adaptation planning and implementation. It is not intended to provide a detailed set of step-by-step instructions for adaptation planning. Each program will have to select the best order and process to develop an adaptation plan that fits the estuary's unique circumstances. For example, NEPs may decide to develop a stand-alone plan or incorporate climate change as an additional/new element in an existing management plan, such as a comprehensive conservation management plan (CCMP).

Regardless of the overall approach, there are five critical elements that an adaptation plan should include to earn CRE recognition:

- Assessment of vulnerability to climate change
- Summary of considerations used to set priorities and select actions
- Description of specific adaptation actions for implementation
- Plan for communicating with stakeholders and decision makers
- Plan for monitoring and evaluating results.

For an estuary to be recognized as "Climate Ready," an adaptation plan including these critical elements must be approved by the estuary's management committee after consultation with EPA as well as other appropriate reviewing organizations, such as state or local oversight programs.

Finally, in the style of adaptive management,² any climate strategy or plan needs to be seen as a "living document"—one that allows for relatively easy revisiting and updating in response to changing conditions and lessons learned from monitoring and evaluating results. Because of uncertainties regarding the rate and severity of climate-related effects and the rapidly-changing science and tools that will underlie any climate plan, climate change adaptation will require more frequent reassessment and perhaps realignment of plans and actions than most accepted planning approaches anticipate. Unlike conventional approaches to restoration or protection plans, the initial plans will need to be updated and enhanced as information changes regarding socioeconomic and ecological vulnerability, uncertainty, management priorities, technology, ecosystem health, and outcomes of adaptation efforts undertaken. Central to the fifth critical element of this guidance, "Plan for monitoring and evaluating results," appropriate periodic reviews and updates should be incorporated into the plan for monitoring and evaluation.

The following pages describe the five critical elements in more detail, and provide examples of these elements along with resources for additional information. In addition, a sample adaptation plan can be found in Appendix A.

¹ Additional information on the Climate Ready Estuaries program can be found at www.epa.gov/cre.

² Adaptive management is defined as "a process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. It also recognizes the importance of natural variability in contributing to ecological resilience and productivity." From the US Climate Change Science Program Synthesis and Assessment Product 4.4 - *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources*, 2008.

Critical Elements

Assessment of Vulnerability to Climate Change

The vulnerability of an estuary is a function both of the estuary's *sensitivity* to changes in climate as well as its *adaptive capacity* to adjust to changes in climate (either reactively to events or changes, or proactively through planning decisions). To assess its vulnerability, each estuary program should describe the specific effects from climate change (and interactions of climate change with existing stressors) that are likely to affect key management goals.

Climate change impacts will vary regionally, as will the approach taken to identify the most significant vulnerabilities. There are many different approaches to completing an assessment, from simple risk screening of existing effects on high-value habitat and infrastructure, to more sophisticated approaches that examine the links between multiple effects with analytical tools to help project changes. A general understanding of vulnerability may be enough of a basis to inform adaptation actions in coastal areas. However, some NEPs may need to develop estuary-specific information that better characterizes the spatial distribution, intensity, and frequency of projected impacts. A more-detailed and descriptive assessment may also be necessary to better inform stakeholders and gain support for action and to prioritize actions. Also, the time frame for effects will vary according to the selected planning horizon for the estuary.

Regardless of the specific approach, the general components of a vulnerability assessment could include: a description of the approach used, a summary of the most significant effects, the timeframe for the predicted effects, and consideration of uncertainty or other factors needed to set planning priorities.

Examples of Vulnerability Assessment Techniques in the Context of Adaptation Planning

- *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. ICLEI, 2007. Pp. 67-86, "Conduct a Climate Change Vulnerability Assessment." (<http://www.iclei.org/action-center/planning/adaptation-guidebook>).
- *Climate Adaptation: Risk, Uncertainty and Decision-making*. United Kingdom Climate Impacts Programme, 2003. Pp. 70-87, "Key Aspects of Climate Change Risk Assessment." (http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).
- *King County Climate Plan*. King County, WA, 2007. Pp. 20-52, "Impacts of Climate Change to the Pacific Northwest." (<http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf>).

Summary of Considerations Used to Set Priorities and Select Actions

Planning typically requires some narrowing of the scope to focus efforts on areas or resources that are most at risk, have the greatest chance of success, and feasible given an NEP's capabilities. Determining the greatest needs for a particular estuary will likely entail both qualitative and quantitative analyses of risk and vulnerability, as well as discussion and agreement among key estuary managers, stakeholders, and collaborators. Quantitative and qualitative climate change risk and vulnerability assessments need to be balanced with the estuary's management goals and objectives. In many cases, climate change may not require new management goals or initiatives, but rather consideration of how existing programs will be affected by a changing climate. In developing an adaptation plan or modifying existing plans to include adaptation, NEPs will want to consider how existing management goals, priorities, and actions will be affected by climate change. In some cases, additional climate change-focused goals and objectives will need to be developed. However, in most cases climate change will become a critical context within which ongoing decisions must be made.

The summary of considerations used to set priorities and select actions could include a description of the approach taken, decisions regarding priorities, and identification of uncertainty or other considerations that may affect the selection of specific activities.

Key considerations in assessing management priorities and risk, as well as selecting actions, may include:

1. Timing of projected impacts (e.g., short-term, mid-term, long-term) relative to the timing of management decisions and actions.
2. Severity of projected impacts (e.g., catastrophic, severe, major, minor, insignificant), and geographic scale (i.e., localized vs. estuary-wide).
3. Probability of occurrence of different impacts.
4. Economic or social significance/value of endpoints of concern (e.g., ecosystem services that are being protected).
5. Capacity of the community to undertake the action compared to the scale of the impacts, which could include:
 - a. Costs associated with implementing adaptation actions (e.g., budget availability, funding opportunities);
 - b. Information availability, including ongoing monitoring and research or future needs (e.g., LIDAR, GIS, mapping, indicators);
 - c. Availability of adaptation options suitable for addressing risks;
 - d. Timing and time horizon (e.g., decision frequency, planning horizon, implementation period);
 - e. Linkage to other decisions (i.e., how adaptation actions will impact other decisions within the estuary or externally);
 - f. Regulatory, operational, political, or legal constraints;
 - g. Public awareness, support, and concern about the issue; and
 - h. Ability to act under uncertainty (e.g., regarding likely impacts or the effectiveness of the actions).

Examples of Approaches to Consider Risk and Select Priorities

- *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. ICLEI, 2007. Pp. 87-91, "Conduct a Climate Change Risk Assessment." (<http://www.iclei.org/action-center/planning/adaptation-guidebook>).
- *Climate Adaptation: Risk, Uncertainty and Decision-making*. United Kingdom Climate Impacts Programme, 2003. Pp. 21-38, Stages 3-6 "Assess Risk → Make Decision." (http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).
- *Preparing for Climate Change: A Guide for Local Government in New Zealand*. New Zealand Ministry for the Environment, 2008. Pp. 26-36, "Responding to the Effects of Climate Change." (<http://www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt/preparing-for-climate-change-guide-for-local-govt.pdf>).

Description of Specific Adaptation Actions for Implementation

An adaptation plan should specify a limited set of essential actions and a preliminary schedule and approach to achieving those actions. Identifying actions needed to achieve adaptation planning objectives involves considering options that fit within existing policies and/or programs, as well as options that may require new initiatives. In some cases, plans can easily fit into or will overlap with existing management actions. In other cases, however, existing actions may need to be revised using climate change as a new context for decision making, or new management actions and goals may need to be established. In either event, identifying specific actions helps to understand stakeholder needs, and can assist in gaining political, public and financial support for the actions.

The crucial need is to select realistic actions to address known risks and identify the needs to implement those actions (including public support for the action and necessary institutional changes, funding, and timing). In the style of adaptive management, the plan should recognize the need to proceed without complete information and acknowledge the need to revisit and update the plan as better information and experience with adaptation become available. Throughout this process, NEPs may choose to identify no-regret or low-regret adaptation actions that are easy to implement and, therefore, appropriate for near-term action, or may identify a more long-term and substantial set of actions that include no- or low-regret options.

Adaptation actions can be categorized into two groups:

- *Proactive* measures to preserve and protect resources in anticipation of climate change impacts (i.e., anticipatory actions before impacts occur); and
- *Reactive* measures that are implemented as a result of: observing climate change impacts (e.g., through monitoring established to identify changes); rebuilding after a natural disaster; achieving social willingness to act; availability of extraordinary or emergency resources; or crossing another type of threshold. Reactive measures can include:
 - Responses that are developed in the present but planned to be initiated once one of the above-mentioned thresholds is crossed.
 - Ad hoc responses to climate change impacts after one of the above-mentioned thresholds is crossed.

For more information regarding specific adaptation options, including brief summaries of benefits, constraints, and existing examples, please consult the *Synthesis of Adaptation Options for Coastal Areas* on the CRE Website (www.epa.gov/cre/adaptationoptions.html).

Examples of Adaptation Plans

- Keene, NH: *Adapting to Climate Change: Planning a Climate Resilient Community*, 2007. Pages 32-42 are an excellent example of listing adaptation-related goals then specific targets to help achieve each of those goals. (http://www.ci.keene.nh.us/planning/Keene%20Report_ICLEI_FINAL_v2.pdf).
- King County, WA: 2007 King County Climate Plan. Pp. 99-137, "Adaptation." Lists proposed adaptation actions for the County according to management goals. (<http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf>).
- Maryland: *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change: Sea level rise and coastal storms* (Chapter 5 of Maryland Climate Action Plan). Maryland Commission on Climate Change, 2008. (<http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>).

Additional Resources

- *Identifying Adaptation Options.* UK Climate Impacts Programme. This document outlines different categories of adaptation actions (e.g., "no-regrets") and gives numerous examples of each. (http://www.ukcip.org.uk/images/stories/Tools_pdfs/ID_Adapt_options.pdf).
- *Climate Adaptation: Risk, Uncertainty and Decision-making.* United Kingdom Climate Impacts Programme, 2003. Pp. 66-69, "Climate Change Adaptation Strategies and Options." (http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).

Communication with Stakeholders and Decision Makers

Adaptation actions will require understanding and support from the citizens who live near and use the estuary, as well as decision makers who provide approval, funding, or otherwise will be involved in carrying out the selected actions. NEPs are very experienced with appropriate communication tools for their locales, and should be well-equipped to incorporate climate change adaptation into ongoing information and education programs. In some cases, however, communicating the risks posed by climate change, the uncertainties surrounding those risks, and the options for addressing them may demand a different approach or new expertise. For example, some NEPs will be trying to build support for actions that prevent uncertain (or even unimagined) future outcomes. Other NEPs may more broadly need to overcome public skepticism about the likelihood or severity of climate change effects. NEPs may need to convince stakeholders and decision makers of the need to prepare for or reduce events that: (1) have not yet manifested themselves in the estuarine system, or (2) will force difficult trade-offs between important social and environmental objectives and the reality of potential losses due to climate change.

New communication techniques and strategies may be necessary to address some of these unfamiliar concerns, to provide specific information on the actions that will be necessary now or in the future, and to build support for adaptation actions.

Examples of Coastal Climate Change Fact Sheets

- *StormSmart Coasts*, Massachusetts Office of Coastal Zone Management. Provides a variety of tools and materials to communicate and manage for storm surge and climate-driven risks in coastal zones. (<http://www.mass.gov/czm/stormsmart/index.htm>).
- Miami-Dade County, FL: Three fact sheets that are mitigation-oriented, but still serve as good examples of the type of materials that can be produced to aid in communicating with the public:
 - “Climate Change and the Economy” (<http://www.sfrpc.org/data/ClimateChange/Economy%20Fact%20Sheet.pdf>).
 - “Climate Change and the Environment” (<http://www.sfrpc.org/data/ClimateChange/Environment%20Fact%20Sheet.pdf>).
 - “Climate Change and the Community” (<http://www.sfrpc.org/data/ClimateChange/Community%20Fact%20Sheet.pdf>).

Additional Resources

- *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. ICLEI, 2007. Chapter 5 (pp. 47-54), “Build and Maintain Support to Prepare for Climate Change.” Contains an excellent overview of building and executing a communication strategy to both stakeholders and decision makers. (<http://www.icleiusa.org/action-center/planning/adaptation-guidebook>).
- *Climate Resilient Cities: Reducing Vulnerabilities to Climate Change Impacts and Strengthening Disaster Risk Management in East Asian Cities*. World Bank, International Strategy for Disaster Reduction, 2008. Pp. 72-73, “Sound Practice 5: Generating Public Awareness.” (http://siteresources.worldbank.org/INTEASTASIAPACIFIC/Resources/226262-1217025557988/climatecities_fullreport.pdf).

Develop a Plan to Monitor and Evaluate Adaptation Actions

Adaptation plans should include an outline of the process that will be used to periodically monitor and evaluate: (1) climate-driven changes in the estuary, and (2) the effectiveness of adaptation actions in lessening the negative impacts of those climate-driven changes.

To monitor and evaluate climate-driven changes in the estuary, an NEP might develop a simple monitoring approach based on readily available information regarding changes in basic climate parameters (e.g., temperature, precipitation, storm intensity, etc.) and observed impacts (e.g., annual occurrence of reproduction for select species, spring flowering dates for plants, etc.). Alternatively, more-sophisticated sentinel systems could track changes in key indicator species or other measures of ecosystem health.

To assess the effectiveness of adaptation actions, it is useful to identify and measure desired outcomes before and after implementation (or as otherwise appropriate for the action).

Ideally, an adaptation plan will reflect the need for regular evaluation of adaptation effectiveness and incorporation of new or better information on climate effects. Rather than a static plan, authors of an estuary's climate change adaptation plan must consider the dynamic nature of information and climate interactions, and build in a regular process to revisit the plan's specified priorities and actions. This may require a standing or ad hoc workgroup consisting of stakeholders and decision makers, or some other ongoing structure or practice, to ensure that the plan stays up-to-date and effective.

Examples of Monitoring Plans

- *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. ICLEI, 2007. Pp. 113-120, "Measure Progress and Update Your Plan." (<http://www.iclei.org/action-center/planning/adaptation-guidebook>).
- *Climate Adaptation: Risk, Uncertainty and Decision-making*. United Kingdom Climate Impacts Programme, 2003. Pp. 39-40, "Monitor, Evaluate, and Review." (http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).

Adaptation Planning Resources

This section provides a list of additional websites, adaptation plans, and other valuable resources to assist in adaptation planning.

CRE Website

Climate Ready Estuaries Coastal Toolkit Adaptation Planning
<http://www.epa.gov/cre/adaptation.html>

This section of the Coastal Toolkit provides information on climate change adaptation options and other resources that can help coastal managers develop adaptation plans.

Guidance

Preliminary Review of Adaptation Options for Climate Sensitive Ecosystems and Resources. U.S. Climate Change Science Program, Synthesis and Assessment Product 4.4, 2008 (<http://www.climatescience.gov/Library/sap/sap4-4/final-report>).

Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Northeast Climate Impacts Assessment Team, July 2007 (<http://www.climatechoices.org/assets/documents/climatechoices/confronting-climate-change-in-the-u-s-northeast.pdf>).

Mitigating Shore Erosion along Sheltered Coasts. National Research Council, 2007 (http://www.nap.edu/catalog.php?record_id=11764).

Preparing for Climate Change: a Guidebook for Local, Regional, and State Governments. University of Washington, Climate Impacts Group, 2007 (<http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf>).

The Role of Coastal Zone Management Programs in Adaptation to Climate Change: Final Report of the CSO Climate Change Work Group. Coastal States Organization, 2007 (<http://www.coastalstates.org/documents/CSO%20Climate%20Change%20Final%20Report.pdf>).

Guidance from Other Countries

Australia

Climate Change Impacts & Risk Management: A Guide for Business and Government. Australian Greenhouse Office, 2006 (<http://www.greenhouse.gov.au/impacts/publications/pubs/risk-management.pdf>).

Climate Change in Australia: Regional Impacts and Adaptation – Managing the Risk for Australia. PMSEIC Independent Working Group, 2007 (<http://www.dest.gov.au/NR/rdonlyres/CE5D024E-8F58-499F-9EEB-D2D638E7A345/17397/ClimateChangeinAustraliareport.pdf>).

Climate Change Risk and Vulnerability: Promoting an Efficient Adaptation Response in Australia. Australian Greenhouse Office, 2005 (<http://www.greenhouse.gov.au/impacts/publications/pubs/risk-vulnerability.pdf>).

Canada

Adaptation to Climate Change: An Introduction for Canadian Municipalities. Canadian Climate Impacts and Adaptation Research Network (C-CIARN), 2006 (http://www.c-ciam.ca/pdf/adaptations_e.pdf).

Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Response to Adaptation Strategies. Mortsch, L., J. Ingram, A. Hebb, and S. Doka (eds.), 2006 (http://adaptation.nrcan.gc.ca/projdb/pdf/86b_e.pdf).

The Netherlands

Climate Change Scientific Assessment and Policy Analysis: Climate Adaptation in the Netherlands. Netherlands Environmental Assessment Agency, 2006 (<http://www.mnp.nl/bibliotheek/rapporten/500102003.pdf>).

New Zealand

Assessment of the Need to Adapt Buildings in New Zealand to the Impacts of Climate Change. Bengtsson, J., R. Hargreaves, and I.C. Page, 2007 (<http://www.branz.co.nz/branzltd/publications/pdfs/SR179.pdf>).

Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand. New Zealand Climate Change Office, 2004 (<http://www.mfe.govt.nz/publications/climate/coastal-hazards-may04/html/index.html>).

United Kingdom

Adapting to Climate Change: A Checklist for Development. Greater London Authority, London Climate Change Partnership, 2005 (http://www.london.gov.uk/climatechangepartnership/docs/adapting_to_climate_change.pdf).

Climate Adaptation: Risk, Uncertainty and Decision-making. UK Climate Impacts Programme, 2003 (http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).

The London Climate Change Adaptation Strategy. Greater London Authority, 2008 (<http://www.london.gov.uk/mayor/publications/2008/docs/climate-change-adapt-strat-summary.pdf>).

Research

Alternative Shoreline Stabilization Evaluation Project - Final Report. Puget Sound Action Team, 2006 (http://www.psp.wa.gov/publications/our_work/restore_hatitat/restore_resources/FinalPSAT9_15_06withphotos.pdf).

Cities Preparing for Climate Change: A Study of 6 Urban Regions. Clean Air Partnership, 2007 (http://www.cleanairpartnership.org/pdf/cities_climate_change.pdf).

Adaptation Resources

Assessments of Impacts and Adaptations to Climate Change in Multiple Regions and Sectors
<http://www.aiaccproject.org>

Center for Clean Air Policy – Urban Leaders Adaptation Initiative
<http://www.ccap.org/domestic/ULI.htm>

Clean Air Partnership
<http://www.cleanairpartnership.org>

Environmental Protection Agency – Adaptation
<http://www.epa.gov/climatechange/effects/adaptation.html>

International Council for Local Environmental Initiatives (ICLEI) Climate Resilient Communities
<http://www.iclei.org>

International Institute for Sustainable Development: Community-based Risk Screening Tool – Adaptation and Livelihoods (CRISTAL)
http://www.iisd.org/security/es/resilience/climate_phase2.asp

Natural Resources Canada – Climate Change Impacts and Adaptation Program
http://adaptation.nrcan.gc.ca/index_e.php

NOAA Regional Integrated Sciences and Assessments (RISA) Program
http://www.climate.noaa.gov/cpo_pa/risa

Pew Center on Global Climate Change
<http://pewclimate.org>

Tyndall Centre for Climate Change Research
<http://www.tyndall.ac.uk>

UK Climate Impacts Programme
<http://www.ukcip.org.uk>

UK Town and Country Planning Association
<http://www.tcpa.org.uk>

Adaptation Networks

AdaptNet
<http://gc.nautilus.org/gci/adaptnet>

Knowledge Network on Vulnerability and Adaptation to Climate Change Resource Centre
<http://ncsp.va-network.org/section/resources>

Linking Climate Adaptation Network
<http://www.linkingclimateadaptation.org>

Urban Climate Change Research Network (UCCRN)
<http://www.uccrn.org/>

Appendix A: Sample Adaptation Plan

This generic adaptation plan is intended to serve as an example for estuary managers seeking to develop their own adaptation plans. An adaptation plan could be incorporated as an additional/new element in an existing management plan, such as the CCMP. Specific elements of this sample plan may, thus, be more valuable as a guide to adaptation planning efforts than the sum of its parts.

Each estuary's adaptation plan will be distinct, since each estuary program faces unique challenges and has access to different resources. Successful adaptation in estuaries will require plans that respond to both the unique climate change vulnerabilities and the priorities of the places they protect. The plans will need to identify and assess risks and costs that can be sustained, and be designed with enough flexibility to respond to changing conditions and information.

This sample adaptation plan should not be viewed as a template to replicate exactly, but rather a skeletal adaptation plan that identifies key elements. Examples from existing climate action and adaptation plans from around the US were also included to assist in illustrating the various elements that may be included in an adaptation plan. These existing plans can also be consulted directly for more examples of "on the ground" adaptation planning.

Sample Table of Contents

- I. Plan authorship and acknowledgements
 - II. Reasons to develop this adaptation plan
 - III. Preparation for adaptation planning: assessing vulnerability
 - IV. Adaptation planning objectives
 - V. Adaptation actions
 - VI. Goals for implementation
 - VII. Monitoring and evaluation plan
 - VIII. Planned updates
- Appendix A: Related documents

I. Plan authorship and acknowledgements

This plan was developed by [*the NEP Director, climate change adaptation working group*] with assistance and input from [*resource managers, scientists, state agencies, federal agencies, local planning and zoning board, local municipal water agencies, NGOs, town councils, etc.*].

II. Reasons to develop this adaptation plan

The impetus for creating an adaptation plan was [*legislation, consensus of stakeholders, public concern, or key reports (e.g., Intergovernmental Panel on Climate Change Fourth Assessment Report, local or regional assessment of climate change impacts)*].

Climate change impacts such as [*sea level rise, marsh migration/dieoff, species shifts/dieoffs, increased storm activity, increased beach erosion, changes in hydrology, decreased water quality*] have already been observed in the estuary. These impacts are detailed in [*a recent study, report, or presentation on estuary-specific impacts*].

III. Preparation for adaptation planning: assessing vulnerability

The vulnerability of an estuary is a function both of the estuary’s sensitivity to changes in climate as well as its adaptive capacity to adjust to changes in climate (either reactively or proactively through planning decisions). To assess its vulnerability, each estuary should consider the specific effects from climate change that are likely to affect key management goals. There are many different approaches to completing an assessment of vulnerability, from simple back-of-the-envelope approaches based on effects that are already occurring to more sophisticated approaches that examine the links between multiple effects with predictive modeling or other tools to help project changes. Although a general understanding of vulnerability may be enough of a basis to inform adaptation actions in coastal areas, some NEPs may need to develop estuary-specific information that better characterizes the spatial distribution, intensity, and frequency of projected impacts. A more-detailed and descriptive assessment may also be necessary to prioritize actions and/or to better inform stakeholders and gain support for action.

A process of [vulnerability assessment, climate change working group meetings, expert workshops, literature review] was undertaken to identify and examine [vulnerabilities such as geomorphology, highly populated/developed areas, hydrology of the watershed, vulnerable species, invasive species; the most significant effects of climate change, timeframe for the predicted effects; uncertainty]. The results of this assessment guided the development of this adaptation plan by [identifying priority areas of most concern; identifying current management gaps; providing the basis for new management goals or initiatives; identifying which existing programs will be most affected by climate change; identifying information and research needs].

IV. Adaptation planning objectives

Adaptation planning objectives were identified at the outset of the planning process.

Examples

Objective 1	Give state and local governments the right tools to anticipate and plan for sea-level rise and climate change. [Comprehensive Strategy for Reducing Maryland’s Vulnerability to Climate Change: Sea level rise and coastal storms ³]
Objective 2	Build capacity for communities and their local leadership to mitigate and adapt to the effects of climate change through joint efforts. [Charlotte Harbor NEP CCMP 2008 Update ⁴]

Focus areas were then identified and agreed on to narrow the scope of the plan to focus on the priority known risks at this time. Consideration of critical resources to protect, existing management goals and strategies, and the climate stressors and impacts on both led to identification of strategic focus areas for adaptation planning:

Examples

Focus area 1	Public Health, Safety and Emergency Preparedness
Focus area 2	Surface Water Management, Freshwater Quality, and Water Supply
Focus area 3	Land Use, Buildings, and Transportation

³ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

⁴ <http://www.chnep.org/CCMP/CCMP2008.pdf>

Focus area 4	Economic Impacts
Focus area 5	Biodiversity and Ecosystems

Source: King County Climate Plan 2007⁵

V. Adaptation actions

A full list of possible adaptation actions that could assist in meeting the adaptation planning objectives was developed. This list was then narrowed by considering a number of factors [such as those listed below].

Examples

Timing of projected impacts relative to the timing of management decisions and actions	<i>e.g., short-term, mid-term, long-term</i>
Severity of projected impacts and geographic scale	<i>e.g., catastrophic, severe, major, minor, insignificant; localized vs. estuary-wide</i>
Probability of occurrence of different impacts	<i>e.g., virtually certain, very likely, likely</i>
Economic or social significance/ value of endpoints of concern	Natural resources within the coastal bays of Worcester County, Maryland have been estimated to have annual non-market use values (i.e., tourism and recreation) of over \$179 million (USD in yr. 2000) [An Assessment of the Economic Value of the Coastal Bays' Natural Resources to the Economy of Worcester County, MD, 2001 ⁶]. Climate change impacts to this region may reduce the availability of recreational opportunities (e.g., loss of marsh habitat due to sea level rise may lead to fewer migratory bird watchers), and have cascading effects on the local economy.
Costs associated with implementing adaptation actions	The costs of forest and wetland conservation and expansion are associated primarily with capital costs of land purchases and/or easements in areas identified as critical to buffering against the impacts of sea-level rise. Current state funding sources and incentives are limited and are not likely to be a leading instrument in executing this option. [Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change: Sea level rise and coastal storms ⁷]
Information availability	Baseline information regarding the impacts of climate change, including sea-level rise and associated coastal hazards, on the economics of varying sectors of resource-based trades and industries is lacking. [Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change: Sea level rise and coastal storms ⁸]
Availability of adaptation options	Adaptive responses to sea level rise fall into three categories: protection, retreat, and accommodation. When local water supply planners were asked about adaptation

⁵ <http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf>

⁶ <http://dnrweb.dnr.state.md.us/download/bays/cbassessment.pdf>

⁷ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

⁸ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

	options for increased saltwater intrusion, they listed both retreat and accommodation strategies: (1) development of inland well fields or surface water sources, (2) development of deeper brackish aquifers with attendant desalination, (3) desalination of water from existing well fields as salt water intrusion occurs, (4) constructing tide gates in water supply canals to prevent salt front migration upstream, and (5) increased use of wastewater reclamation. [Adaptive Response Planning to Sea Level Rise in Florida and Implications for Comprehensive and Public-Facilities Planning ⁹]
Timing/ time horizon	<i>e.g., decision frequency, planning horizon, implementation period</i>
Linkage to other decisions	The Charlotte Harbor NEP’s host agency, the Southwest Florida Regional Planning Council, has adopted a set of resolutions that have resulted in actions at the city and county levels to protect water quality. [Charlotte Harbor NEP CCMP 2008 Update ¹⁰]
Regulatory, operational, political, or legal constraints	Legislative action will be necessary to amend the Maryland Flood Hazard Management Act of 1976 (Environment Article, Title 5) to require that all counties adopt standards requiring two or more feet of freeboard in tidally influenced floodplains. [Comprehensive Strategy for Reducing Maryland’s Vulnerability to Climate Change: Sea level rise and coastal storms ¹¹]
Public awareness, support, or concern about the issue	Public education and outreach is vital to fostering a broad awareness of climate change issues and effects among the state’s citizens. Key uncertainties in developing a statewide public education and outreach effort are timing, the degree of federal and private sector recognition and support. [North Carolina Climate Action Plan ¹²]
Ability to act under uncertainty	In the context of evolving information, it is important to address that prudent planning would not ignore an area that could be greatly impacted by climate change simply because predictions are uncertain. When information about climate change impacts is relatively certain and impacts are anticipated to be great, King County should act with a degree of urgency. In cases of less certainty, planning can and should include early and low-cost provisions. [King County Climate Plan 2007 ¹³]

These factors were identified, discussed, and documented, where possible. In coordination with [resource managers, scientists, climate change adaptation working group, state agencies, federal agencies, local planning and zoning board, local municipal water agencies, NGOs, town councils, etc.], a priority-setting exercise was undertaken to identify the [3, 5, 10] best adaptation options. The selected actions fell into several categories: [actions to improve resilience of the estuary, actions to support adaptation in general (e.g., outreach efforts), actions to address the natural environment, actions to address the built environment].

For each selected adaptation action, the plan identifies: (1) who will be involved (including outside agencies or stakeholders), (2) the needs to implement those actions, including public support for the action, necessary institutional changes, and funding, (3) how the action will be taken, (4) necessary resources (both human and financial), (5) the steps for securing necessary resources (including who will be involved), (6) known barriers, (7) strategies identified to overcome those barriers, and (8) the timeline for action.

⁹ <http://www.dca.state.fl.us/fdcp/DCP/publications/AdaptiveResponsePlanningSeaLevelRise.pdf>

¹⁰ <http://www.chnep.org/CCMP/CCMP2008.pdf>

¹¹ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

¹² <http://www.ncclimatechange.us/ewebeditpro/items/O120F10923.pdf>

¹³ <http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf>

Examples

Adaptation action 1	Retain and expand forests, wetlands, and beaches to protect against coastal flooding
Short description	Identify high priority protection areas and strategically and cost-effectively direct protection and restoration actions.
Actors	Maryland Commission on Climate Change, Maryland Department of Natural Resources, Maryland Department of the Environment
Needs to implement action	Mapping and modeling data
Implementation	The state should establish a scientific and technical framework to develop and test new and existing criteria for identifying priority protection and restoration areas in the context of sea level rise. It is recommended that the framework be developed as a peer-reviewed model to graphically illustrate the potential location 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. Potential field sites should be identified in order to test site-scale suitability criteria for various restoration practices in response to sea level rise.
Necessary resources	Modelers, funding for developing framework
Steps to secure necessary resources	No listed steps for securing necessary resources <i>The key actors in identifying high priority protection areas—the Maryland Commission on Climate Change, the Maryland Department of Natural Resources, and the Maryland Department of the Environment—will be responsible for securing the necessary resources. If funding is not available within the state budget, the state could apply for grants through the federal government or non-profit organizations. If modeling resources are not readily available within state agencies, universities may be able to provide assistance.</i>
Known barriers	Potential mapping and modeling gaps
Strategies to overcome barriers	The lead agencies, along with input from other state agencies, will develop a comprehensive plan to integrate various models, identify data gaps, and evaluate sea level rise and marsh migration models.
Timeline for action	Develop comprehensive plan by September 2009.

Source: Comprehensive Strategy for Reducing Maryland’s Vulnerability to Climate Change¹⁴

Adaptation action 2	King County will help the region to understand, limit the risks and minimize damage of natural hazards associated with climate change impacts.
Short description	King County will continue to analyze the potential impacts of climate change on natural hazards and will update emergency plans and activities to respond appropriately to projected changes.
Actors	King County Public Health, King County emergency management departments, hospitals,

¹⁴ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

	elected officials, businesses, residents
Needs to implement action	Information on potential climate change impacts
Implementation	Incorporate best available climate change information into discussions of and the next update to the Regional Hazard Mitigation Plan, as part of technical review in the Hazard Identification and Vulnerability Assessment stage and hazard mapping projects.
Necessary resources	Personnel to direct discussion and implementation of climate change information into planning
Steps to secure necessary resources	No listed steps for securing necessary resources <i>Per the climate plan, King County will have an interdepartmental climate change adaptation team. This team could provide personnel to direct discussion and implementation of climate change information into planning for each of the key sectors (King County Public Health, King County emergency management departments, hospitals, elected officials, and businesses).</i>
Known barriers	At present, information about the increased frequency of fall and winter flooding is relatively clear, while we are still learning about climate change impacts to the frequency and intensity of significant storms.
Strategies to overcome barriers	Work with regional experts and universities to develop understanding of climate change impacts on storms.
Timeline for action	TBD

Source: King County Climate Plan 2007¹⁵

Adaptation action 3	Create Blue Ribbon Commission on Adaptation to Climate Change
Short description	Create a state-sanctioned Blue Ribbon Commission on Adaptation to Climate Change to develop a comprehensive state Climate Change Adaptation Plan identifying opportunities to address adaptation issues and risks and recommending tangible, implementable measures to ameliorate these issues and risks to North Carolina citizens.
Actors	All appropriate state and local agencies, organizations, and institutions (e.g., universities)
Needs to implement action	Climate change projections
Implementation	Conduct benefit-cost analyses to compare the potential costs of a “status quo” approach as opposed to implementing the recommendations proposed in the Climate Change Adaptation Plan. Prioritize recommendations in the adaptation plan based on the certainty and severity of adverse impacts to citizens, ecosystems and local economies. Development of the plan should: (a) involve all affected agencies and entities at all levels of government; (b) involve all affected sectors and interests; and (c) provide for periodic review and update concerning adaptation risks, responses, and opportunities in the state.
Necessary	Experts to participate in commission, meeting space, website to coordinate activities and

¹⁵ <http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf>

resources	communicate progress with the public
Steps to secure necessary resources	<p>No listed steps for securing necessary resources</p> <p><i>The commission will likely need to have representatives from different sectors, including coastal management, health, emergency planning, business, government, etc. Experts in these areas can be found in state and local agencies, universities, non-profit organizations, businesses, and other organizations. The North Carolina Department of Environment and Natural Resources would likely provide the lead in developing this commission, and could provide access to a meeting space and a website to coordinate activities.</i></p>
Known barriers	<p>No listed barriers to formation of commission.</p> <p>Some impacts of climate change, such as sea level rise and inundation of low-lying coastal lands are certain, but their specific timing and magnitude remains unclear. Other impacts are less certain and may have significant variability.</p>
Strategies to overcome barriers	Commission will address issues of uncertainty and identify data gaps.
Timeline for action	<p>The Commission should be established as soon as possible.</p> <p>The development of a state Climate Change Adaptation Plan should be completed within one year of establishing the Commission. Benefit-cost analyses of the potential costs of a “status quo” approach as compared to implementing the Plan’s recommendations should be conducted as a component of the plan.</p> <p>Parallel public education and outreach efforts regarding adaptation should commence immediately.</p> <p>“Early-adoption” opportunities should be addressed as rapidly as possible (even before the Commission is established, if possible), and pro-active adaptation initiatives should commence within the next 2-3 years.</p>

Source: North Carolina Climate Action Plan¹⁶

¹⁶ <http://www.ncclimatechange.us/ewebeditpro/items/O120F10923.pdf>

VI. Goals for implementation

Sort-term, mid-term, and long-term goals were identified to correspond with the selected adaptation actions and their timelines.

Short-term goals for implementation to be implemented in the next [1, 2, 3 years] include [creating a climate change adaptation working group, identifying key partners and resources, holding stakeholder workshops, using climate data to project impacts, developing outreach products, procuring local climate change data, identifying resource needs and data gaps, prioritizing implementation actions, identifying no-regrets or low-regrets actions that are low-cost and easily implemented, revising the estuary’s CCMP, etc.].

Mid-term goals for implementation to be implemented in the next [3 - 5 years] include [revising floodplain maps, changing zoning ordinances, changing wetland bylaws, creating conservation easements, replacing undersized culverts, building oyster reefs, increasing shoreline setbacks, etc.].

Long-term goals for implementation to be implemented in the next [10, 15, 20 years] include [establish rolling easements, implementing a relocation and resource enhancement program, implementing a comprehensive plan that will encourage sustainable development and infrastructure].¹⁷

Example Related to Transportation Infrastructure

Short term goals	In year one, prepare a detailed map of culverts in the study area which are likely to be adversely impacted by sea level rise and increased peak flows within the next 50 years
Mid term goals	In years two and three, determine the highest priority culverts that will need to be replaced, initiate replacements, and prepare a plan that will protect the most important natural and man-made resources from inundation and enhance biological productivity.
Long term goals	In years six through eight, each local government will prepare: <ul style="list-style-type: none"> ▪ a transportation infrastructure protection program that identifies resources required to maintain any infrastructure that will be impacted by climate change. ▪ a relocation and resource enhancement program for areas will be inundated ▪ a sustainability program to encourage and incentivize locationally efficient new development where sustainable transportation infrastructure can be maintained.

¹⁷ Additional adaptation options for various management goals can be found in *Synthesis of Adaptation Options for Coastal Areas* <http://www.epa.gov/cre/adaptationoptions.html>.

VII. Monitoring and evaluation plan

Monitoring

Climate-driven changes in the estuary will be measured by [a program to monitor basic parameters of temperature, precipitation, and storm frequency and intensity; sophisticated sentinel systems to track changes in key indicator species or other measures of ecosystem health]. These activities will ensure that changes are measured and evaluated as they occur.

As a detailed implementation plan is developed for the monitoring efforts identified below, the estuary will seek to build upon and leverage existing monitoring efforts within the estuary and involve key partners (such as local and state agencies, universities, and other organizations), where possible.

Example

Monitoring of climate changes	Utilize Maryland iMap, an Internet-based interactive map currently under development for use by state agencies, local governments, and the public, to house and display existing and future sea level rise data and spatially-based information.
	Complete state-wide sea level rise inundation and storm surge modeling at a scale appropriate for both state and local planning.
	Adopt a production and maintenance schedule for mapping and modeling activities including the data necessary for both activities. This schedule should include anticipated costs, financing options, data sources, and increasing the accuracy of predicted results.
	Review institutional and organizational data management practices and make recommendations to enhance efficiency and cost-effectiveness of data gathering, sharing, maintenance, and processing efforts and to minimize duplication of effort and data and modeling redundancies.
	Create a digital, spatial inventory of infrastructure potentially impacted by sea level rise, including the identification of public and private systems and facilities and threatened historical structures. This database should be maintained relative to sea level rise projections and scenarios.
	Utilize GIS systems to model and monitor specific 'leading indicators' of climate change impacts.

Source: Comprehensive Strategy for Reducing Maryland’s Vulnerability to Climate Change: Sea level rise and coastal storms¹⁸

Evaluation

The effectiveness of actions taken to reduce the impacts of climate changes will be assessed by [annual review of actions, continuous monitoring of specified indicators, individual workgroups]. These activities will help to track whether the adaptation actions are effective in lessening negative impacts of climate change stressors.

Example

Evaluation Plan	To ensure the longevity of the City’s climate protection planning efforts, Keene should consider hiring a Sustainability Coordinator, as recommended in the CCP Action Plan, and
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¹⁸ <http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

reiterated in this document. This staff person would assist the City in tracking and implementing its climate change and sustainability efforts. The Coordinator would also work to prioritize City sustainability goals and targets; help set up subgroups within City government for specific tasks; coordinate with the appropriate City departments; provide updates to the City Manager and City Council; and review projects and initiatives for consistency, monitor effectiveness, and generally ensure that climate protection remains a key component of the land development and capital improvement program decision-making process in Keene.

Source: Keene, New Hampshire: Adapting to Climate Change: Planning a Climate Resilient Community, 2007¹⁹

VIII. Planned updates

The developers of this plan recognize the need to proceed without complete information, but plan to revisit and update the plan every [1, 3, 5] years. These periodic updates will ensure that new information can be incorporated into the plan and goals and strategies adjusted accordingly.

Appendices

The following appendices contain documents from [*working group meetings, workshops, assessments*] that were critical to the development of this adaptation plan.

¹⁹ http://www.ci.keene.nh.us/planning/Keene%20Report_ICLEI_FINAL_v2.pdf