

Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation



Draft Report and Recommendations
for Public Comment

March 18, 2016

The full color version of the New Hampshire Coastal Risk
and Hazards Commission Draft Report and Recommendations

**Preparing New Hampshire for Projected Storm Surge,
Sea-Level Rise, and Extreme Precipitation**

and instructions for submitting public comments are
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ⁱ Commission Alternates and former members are listed in [Appendix B](#).

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EXECUTIVE SUMMARY

Coastal hazards associated with storm surge, sea-level rise, and extreme precipitation events can be devastating to human health and safety, public and private structures and facilities, and the economies of coastal communities. Coastal New Hampshire was fortunate to experience minimal damage from Tropical Storm Irene in 2011 and Superstorm Sandy in 2012. Nevertheless, the impacts of these storms on neighboring states and the more extreme local impacts from storms such as the Mother's Day storm of 2006, the Patriots' Day storm of 2007, and Winter Storm Nemo in 2013 have reinforced our knowledge that strong storm systems are capable of causing immense damage in areas on or near the coast. New Hampshire's coastal exposure to future flood risks is significant. As of 2015, the state's seventeen coastal municipalities are home to approximately 12 percent of the state population, host over 100,000 jobs, and account for a 2013 Gross Regional Product of over \$11 billion.¹

Where and how we build and rebuild as the coastal population and economy grow has critical implications for how coastal New Hampshire will prepare for projected coastal hazards. Should we choose to build using the same strategies and techniques as we have in the past, we will exacerbate our exposure to these hazards by placing structures, facilities, and people directly at risk. Alternatively, if we incorporate projected flood risks into our planning, design, construction, and conservation practices today, we will greatly reduce exposure to flood hazards, resulting in saved lives and property and lower response and recovery costs.

Recognizing the need to prepare for existing and projected coastal flood hazards, in July 2013 the State Legislature enacted Senate Bill 163, sponsored by Senator David Watters (District 4), which established the New Hampshire Coastal Risk and Hazards Commission to "recommend legislation, rules, and other actions to prepare for projected sea-level rise and other coastal and coastal watershed hazards such as storms, increased river flooding, and storm water runoff, and the risks such hazards pose to municipalities and the state assets in New Hampshire." In response to this legislative mandate, the Commission puts forward a final report and set of recommendations for state legislators, state agencies, and coastal municipalities to help these audiences better prepare and minimize coastal risks and hazards. The report presents a summary of the best available science and vulnerability information followed by recommendations for action.

Understanding What We Are Facing

To lay the foundation for our understanding of coastal hazards and flood risks, the Commission established a Science and Technical Advisory Panel (STAP) to review existing science and analyze historic trends and projections for the years 2050 and 2100 for storm surge, sea-level rise, and extreme precipitation in coastal New Hampshire.² Some of the key scientific findings summarized in the STAP report include:

- Global and regional sea levels have been rising for decades, though not uniformly.
- Using mean sea level in 1992 as a starting point, New Hampshire sea levels are expected to rise between 0.6 and 2.0 feet by 2050 and between 1.6 and 6.6 feet by 2100.
- Today's extreme storm surge events will have a significantly greater inundation extent and destructive impact due to higher sea levels.
- It is likely that coastal storms will be more severe as a result of warmer oceans and other changes in climate systems, but at the time of the STAP report publication, the research continues to be uncertain about whether storm frequency will change in the future.
- Annual precipitation is expected to increase by as much as 20 percent by the end of the 21st century compared to the late 20th century, and extreme precipitation events are projected to increase in frequency and in the amount of precipitation produced.

Understanding Our Risks and Vulnerabilities

The Commission's report summarizes vulnerabilities to projected coastal flood hazards and how they could impact different sectors of our life in the coastal region. Recent and ongoing assessments of the coastal and Great Bay communities identify valuable assets at risk of different coastal hazards, evaluate the exposure and sensitivity of those assets to coastal hazards, and assess existing capacity for managing and reducing vulnerabilities. While additional assessments are needed to more fully understand New Hampshire's coastal vulnerabilities, especially in the Great Bay communities and at the site-specific scale, significant progress is underway. Some key findings from regional assessments are presented in this report, focusing on vulnerabilities specific to our economy, our built landscape, our natural resources, and our heritage.

Our Economy

A review of key indicators reinforces the growing importance of the coastal region to the economic vitality of the State. The region is growing in population at nearly three times the rate of the state as a whole. The coastal communities account for 12 percent of the state's population and 15 percent of employment and generate a disproportionate share of statewide tourism revenues as measured in Meals and Rooms tax revenue. A vulnerability assessment conducted for the seven Atlantic Coast communities revealed that, coastal storm surge combined with sea-level rise could potentially put over 7,000 tax parcels valued at nearly \$3.3 billion of assessed property value at risk of flooding and identified key tourism destinations like Hampton beach and Strawberry Banke as vulnerable to storm surge and sea-level rise.

Our Built Landscape

State and local roadways throughout the coastal region are vulnerable to flooding and damage due to storm surge, sea-level rise and extreme precipitation. In many municipalities, flooding is magnified by the combination of tidal or storm-related flooding and freshwater flooding. A vulnerability assessment conducted for the seven Atlantic Coast communities reported that, under an intermediate sea-level rise scenario of 4 feet, 90 public infrastructure sites, 33 critical facilities, and nearly 25 miles of state and local roads could be subject to daily tidal flooding by 2100.

Our Natural Resources

As reported in the 2015 Wildlife Action Plan, sea-level rise will alter the function of coastal habitats such as salt marshes and estuaries, habitat availability, and the timing of nesting and migration for seabirds.³ Total habitat and species losses will likely be greater in developed areas where there is no space for natural habitats to retreat or migrate inland. Modeling results suggest that salt marshes will reach a tipping-point under the highest sea-level rise scenario, with more than 90 percent of salt marshes potentially disappearing.⁴ In addition to long-term sea-level rise, extreme storm events can pose significant risks to coastal systems by altering hydrology, sedimentation, and land forming processes. Coastal dune sediments will be driven inland by storm surges, and dune degradation will further exacerbate the impacts of storms. As dune systems migrate landward they will compete with developed landscapes and, as a result, the remaining dunes could eventually be lost completely.

Our Heritage

Cultural, historic, and recreational resources and amenities are vital assets in the coastal region, in part because they support the tourism industry, as well as a sense of place for New Hampshire residents and visitors alike.. Regional-scale vulnerability analyses have identified some vulnerable recreational destinations, however less than 11 percent of the coastal region has been inventoried for architectural resources.⁵ Much less of the coastal region has been evaluated for archaeological resources, though we know that at least 102 archaeological sites, most of which are historic Native American sites, are already situated below mean sea level.

Understanding What We Need To Do

This report is the start of a critical and ongoing effort in the state to embrace a proactive approach that is responsive to changing conditions and societal and ecological needs. Planning for coastal hazards will evolve with research and as creative adaptation strategies are implemented here and around the country. State, municipal, and private sector responses will likely combine *defending* certain key assets and resources from loss, *accommodating* new flood extent and risk, and *retreating* from areas where the frequency or severity of impacts are too great to defend against or accommodate. The appropriateness of responses varied by location and will change over time as flood risk and exposure changes, requiring the State and municipalities to periodically reassess their responses.

Given this uncertainty and need for flexibility, we present six guiding principles that should be applied at both state and municipal levels to plan for coastal risks and hazards, followed by our goals to achieve a resilient New Hampshire and a summary of the recommendations for action.

Our Guiding Principles

Act Early

By starting now, the normal cycles of reconstruction, replacement and redevelopment can gradually replace failing facilities and construction not designed for future conditions, often at minimal added cost and resulting in long-term cost savings.

Respond Incrementally

Given uncertainties about future flood risk, strategies can be implemented in increments, allowing multiple opportunities to refine and correct actions as understanding of future coastal hazards improves.

Revisit and Revise

Actions must keep pace with observed changes, therefore it is important that state and municipal officials periodically revisit projections and assumptions as the science becomes more certain and adjust their course of action accordingly.

Collaborate and Coordinate

The state and municipalities share assets and infrastructure on the coast that are systematically and functionally linked and as such, they need to work together to align policies, assumptions and responses about future coastal flood hazards.

Incorporate ‘Risk Tolerance’ in Design

The acceptable loss or damage to an asset should be considered in determining the most appropriate design standards for protection, with more critical or expensive structures and facilities having low risk tolerance and lower value, easily replaced structures and facilities having higher risk tolerance.

Make “No Regrets” Decisions

By preparing for future impacts from uncertain coastal hazards, often the results will be beneficial even if those future hazards turn out to be less extreme than anticipated.

Our Goals

We present four goals intended to help achieve our vision for a resilient coastal New Hampshire. These goals form the SAIL framework: Science, Assessment, Implementation, and Legislation.

- 1. The Science Goal:** To research, understand, establish, and use best available science about current and future coastal hazards.
- 2. The Assessment Goal:** To identify our assets that are vulnerable to current and future coastal hazards and evaluate existing policies to identify ways to reduce vulnerabilities.
- 3. The Implementation Goal:** To implement strategies to enable the state and coastal communities to protect, adapt, and sustain our assets.
- 4. The Legislation Goal:** To recommend legislation that leads to actions to reduce vulnerability and adapt to current and future coastal hazards.

Recommendation Highlights

We propose extensive and detailed recommendations and associated actions that should be implemented to prepare for projected sea-level rise and other coastal watershed hazards, which are found in Section 6 of the full report. Highlights from the recommendations are summarized below and form a high-level to do list for New Hampshire's state legislature, state agencies, and coastal municipalities.

- Review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation, and other relevant climate projections; and provide planning guidance.
- Identify vulnerable state and municipal economic assets; structures and facilities; natural resources; and recreational and cultural resources at regional, municipal, and site-specific scales.
- Amend statutes, ordinances, rules and regulations, policies, programs, and plans to incorporate and consider the best available science and vulnerability information.
- Secure funding sources and develop funding mechanisms, including incentives and market-based tools, to pay for vulnerability assessments and implement climate adaptation strategies.
- Encourage businesses to create preparedness plans in order to minimize economic disruptions and ensure continuity of services to essential facilities, people, businesses, and employment centers.
- Make existing structures and facilities more resilient to flooding, acquire properties in high risk areas, and avoid exposing new structures and facilities to current and future flood risks.
- Protect and restore vulnerable natural resources, and consider how natural resources reduce the impacts of flooding in state and municipal planning efforts.
- Develop plans and implement strategies to prepare and adapt recreational and cultural resources vulnerable to climate impacts.

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1. Introduction

Coastal hazards such as coastal storms and extreme precipitation events can be devastating to human health and safety, public and private structures and facilities, and the economies of coastal communities, and these hazards will only get worse as they are exacerbated by sea-level rise. Tropical Storm Irene and Superstorm Sandy demonstrated the immense destruction that strong storm systems can cause in both rural and urban settings in the Northeast. As of 2015, the 17 New Hampshire coastal municipalities were home to approximately 12 percent of the state population and supported more than 100,000 jobs. In 2013, the coastal region generated Gross Regional Product of over \$11 billion.⁶ As the coastal population and economy expand, where and how we build have critical implications for how we will prepare for the hazards associated with coastal storms, sea-level rise, and extreme precipitation events. The crowding of our coastlines and waterfront has become a hazard unto itself, as we continue to put people and the built landscape directly in harm's way.

Preparing for coastal hazards will save lives, money, and natural resources that are critical to maintaining the quality of life on the seacoast. According to the U.S. Chamber Foundation's Business Civic Leadership Center preliminary estimates, Superstorm Sandy negatively affected between 60,000 and 100,000 small businesses, and as many as 30 percent of those companies were projected to fail as a direct result of the storm.⁷ A study completed in 2005 by the Multi-Hazard Mitigation Council of the National Institute of Building Sciences concluded that when it comes to infrastructure, every dollar spent on mitigation saves society an average of four dollars.⁸ Climate impacts could drown the majority of New Hampshire's saltmarshes by 2100⁹ but recent studies conducted locally indicate that proactive planning for the eventual landward migration of salt marshes (i.e., protecting undeveloped uplands) will help ensure their persistence in the face of rising sea levels.

In recognition of the need to prepare for existing hazards and the increased risks associated with climate change, the State Legislature established the New Hampshire Coastal Risk and Hazards Commission in 2013 to "recommend legislation, rules and other actions to prepare for projected sea-level rise and other coastal watershed hazards such as storms, increased river flooding and stormwater runoff, and the risks such hazards pose to municipalities and state assets in New Hampshire." For nearly two years, the Commission gathered data and summarized the best available peer-reviewed science to understand current and projected risks posed by coastal hazards to New Hampshire's coastal region and to establish planning assumptions such as the range of likely sea-level rise, and changes in storm surge and intensity. The Commission evaluated potential impacts of these risks and discussed ongoing efforts to understand and plan for impacts. Finally, the Commission discussed existing knowledge and policy gaps and needs and developed recommendations for municipalities, legislators, and state agencies.

This report summarizes the activities carried out by the Commission as well as the key scientific findings and impact analyses that the Commission used to inform the recommendations and actions laid out in Section 6. The report is divided into several key sections: Section 2 describes the background on the Commission's establishment, membership, scope, and process; Section 3 summarizes the best available climate science as presented by the Science and Technical Advisory Panel report (STAP report); Section 4 presents an overview of known coastal vulnerabilities in the areas of Our Economy, Our Built Landscape, Our Natural Resources, and Our Heritage; and Sections 5 and 6 present the Commission's recommendations and suggested actions for state agencies, municipalities, and the New Hampshire legislature.

2. Coastal Risk and Hazards Commission

2.1 Establishment

The New Hampshire Coastal Risk and Hazards Commission was proposed in Senate Bill 163, sponsored by Senator David Watters (District 4), and established by the State Legislature through RSA 483-E in July 2, 2013 (see [Appendix A](#)). The legislation arose from concerns that neither the state nor coastal municipalities are adequately prepared for projected coastal flooding risks associated with a changing climate. The purpose of the Commission, as stated in the law, is to “recommend legislation, rules and other actions to prepare for projected sea-level rise and other coastal watershed hazards such as storms, increased river flooding and storm water runoff, and the risks such hazards pose to municipalities and the state assets in New Hampshire.” Further, in carrying out this charge, the Commission is specifically directed to “review National Oceanic and Atmospheric Administration and other scientific agency projections of coastal storm inundation and flood risk to determine the appropriate information, data, and property risks” to incorporate into its recommendations. By law, the Commission is scheduled to sunset on December 1, 2016.

2.2 Membership

RSA 483-E established a broad-based membership for the Commission representing both state and local government, as well as other stakeholders in the coastal watersheds. The 36 members include representatives from the New Hampshire Senate and House of Representatives; key New Hampshire state agencies, including the Department of Environmental Services (NHDES), Department of Transportation (NHDOT), Department of Resources and Economic Development (DRED), Fish and Game Department (NHFG), Department of Cultural Resources (NHDCR), and Office of Energy and Planning (NHOEP); the University of New Hampshire; all 17 Coastal Zone municipalities; and from the two regional planning commissions covering the tidal communities. Other stakeholder groups represented on the Commission include the NH Public Risk Management Exchange, Seacoast Board of Realtors and the NH Home Builders Association. Membership participation and engagement has been consistently strong throughout the Commission’s activities, which were led by a Steering Committee made up of a subset of the membership.

2.3 Scope

One of the Commission’s first activities was to define its scope and establish a strategy to accomplish its charge within the limits of its voluntary and unfunded status. The Commission determined that its charge was to help the state and its municipalities interpret the best available peer-reviewed science, including empirical data and modeled information. This information would enhance the Commission’s understanding of expected future conditions and form the basis for the recommendations.

Based on the language of RSA 483-E and the focus on coastal geography, the Commission decided to focus its efforts on the risks and hazards that uniquely or particularly affect coastal watersheds, and less on other climate related impacts such as drought, heat stress, agricultural shifts, and snow cover changes. While these impacts are important to plan for, they are not specific to the coast. Thus, increased coastal flooding hazards associated with storm surge, sea-level rise, and extreme precipitation events have been the Commission’s primary focus.

Finally, the Commission agreed that its work would be synthesized in one or more reports directed at three audiences: the State Legislature, key state agencies, and municipalities.

2.4 Activities

The Commission, led by a volunteer Steering Committee, conducted work in four phases: fact finding, assessing vulnerability, obtaining stakeholder input, and developing recommendations. Key steps in fact finding included reviewing relevant documents and reports, presentations from agencies, communities and other stakeholders, and the commissioning of a Science and Technical Advisory Panel (STAP) to review available scientific information about coastal hazards and flood risks in New Hampshire.

With limited resources, the Commission has relied heavily on existing data and reports, as well as studies that are presently underway. Peer-reviewed scientific sources are referenced in the Commission's STAP report.¹⁰ The Commission also reviewed existing guidance and actions to prepare for climate change impacts at federal agencies and in New Hampshire state agencies, summarized in [Appendix C](#). A few of the most relevant sources referenced by the Commission are:

- High resolution coastal LIDAR, a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light, enabling detailed topographic mapping of low lying coastal areas¹¹
- Sea-level rise scenario mapping for 2050 and 2100¹² and FEMA Flood Insurance Rate Maps for coastal New Hampshire
- New Hampshire Wildlife Action Plan¹³
- Tides to Storms vulnerability assessments to coastal flooding, with sea-level rise and storm surge¹⁴
- Economic flood vulnerability assessment for Hampton-Seabrook estuary using the COAST model¹⁵
- Community vulnerability assessments and plans from Portsmouth¹⁶, and Durham¹⁷, Dover¹⁸
- Region-specific research and modeling on changes in precipitation¹⁹
- Sea level affecting marshes models showing how NH salt marshes could retreat with sea-level rise²⁰
- Municipal hazard mitigation plans and assessor databases
- NH Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future²¹

Town of Newmarket Envisions a Future with Fewer Floods

In 2015, after more than ten years, the Town of Newmarket evaluated its community vision and future direction as part of the Town's master planning process (this chapter was last updated in 2001). With support from the Strafford Regional Planning Commission, the Town developed and implemented a process to engage residents in envisioning the Town's future. This process enabled Newmarket to gain a better understanding of residents' near- and long-term views of the community and provided ideas for addressing current and future challenges. Through a combination of interactive forums, small group discussions, live polling, and an online survey, input from over 455 residents was used to develop a robust set of visionary statements and strategies.



Overturned Jeep on Prescott St. in Newmarket during May 2006 flooding event. (Photo credit: Town of Newmarket)

As a result of this effort, Newmarket's overall vision statement guides the Town in becoming more resilient against coastal and riverine flooding through local land use policies and regulations that reduce risk and vulnerability. The Town also supports the integration of climate adaptation measures into municipal programs, policies, and operations, as well as promotes smart development and greater resilience against adverse impacts and infrastructure vulnerability associated with climate changes, such as sea-level rise and increased flooding.

In addition to written sources, the Commission was fortunate to observe various presentations by Commission members and outside experts and stakeholders. Through these presentations, Commission members engaged in discussions about the issues facing various stakeholder groups. Presentations to the Commission included:

Data Resources for Assessing Coastal Risk and Hazards

- *Coastal Change Analysis Using Airborne LIDAR Data and Historic Aerial Photographs* by Neil Olson, NHDES/NH Geological Survey (July 2015)
- *Tides to Storms Community Vulnerability Assessments*, Julie LaBranche (July 2015)
- *The New Hampshire Coastal Viewer* by Kirsten Howard, NHDES Coastal Program (July 2015)
- *NOAA Flood Exposure Risk Mapper* by Jamie Carter, NOAA (February 2015)
- *Climate Trends in New Hampshire and Its Impact on Storm and Riverine Flood Behavior* by David R. Vallee, NOAA/NWS Northeast River Forecast Center (Feb. 2015)
- *FEMA Preliminary Maps for Coastal NH* by Jennifer Gilbert, NH Program Manager for National Flood Insurance Program (April 2014)

Stakeholder Perspectives on Coastal Risk and Hazards

- *Homebuilder Industry Perspective on Future Coastal Risks and Hazards* by Robert Cormier, Homebuilders and Remodelers Association of NH (May 2014)
- *Role of Insurance in Managing Risk from Natural Hazards* by Jonathan Kipp, Primex (April 2014)

Coastal Risk and Hazard Planning in Other States

- *New York Climate Risk and Resilience Act* by Steve Couture, NHDES Coastal Program (Dec. 2014)
- *State of Maryland Climate Change and Infrastructure Siting and Design Guidelines* by Cliff Sinnott, Rockingham Planning Commission (Dec. 19, 2014)
- *Other State Sea-Level Rise Planning Efforts* by Kirsten Howard, NHDES Coastal Program (July 2014)

State Agency Reports on Coastal Risk and Hazards

- *Division of Parks and Recreation, DRED* by Gail Wolek, DRED (January 2014)
- *Division of Forests and Lands, DRED* by Sabrina Stanwood, Natural Heritage Bureau (January 2014)
- *Cultural Resources and Climate Change, NH Department of Cultural Resources* – by Edna Feighner, Division of Historical Resources (January 2014)
- *NH Office of Energy and Planning*, by Jennifer Gilbert, NH Program Manager for the National Flood Insurance Program (January 2014)
- *NH Department of Environmental Services*, by Ted Diers, NHDES Watershed Management Bureau (Nov. 2013)
- *NH Department of Transportation*, by Kevin Nyhan, NHDOT Bureau of the Environment & Ann Scholz, NHDOT Bureau of Materials and Research (Nov. 2013)
- *NH Fish and Game Dept.*, by Cory Riley, Great Bay National Estuarine Research Reserve (Nov. 2013)

Regional Efforts to Address Coastal Hazards

- *New Hampshire Coastal Adaptation Workgroup Initiatives*, by Sherry Godlewski, NHDES (Oct. 2013)
- *Tides to Storms – Coastal Vulnerability Assessment and Response Planning*, by Julie LaBranche, Rockingham Planning Commission (Oct. 2013)

Municipal Efforts to Address Coastal Hazards

- *New England Climate Adaptation Project – Climate Change Risk Assessment for Dover, NH*, by Steve Bird, Dover; Danya Rumore, New England Climate Adaptation Project; and Carri Hulet, Consensus Building Institute (April 2014)
- *Portsmouth Coastal Resilience Initiative*, by Peter Britz, City of Portsmouth (Oct. 2013)

Coastal Risk and Flooding Related Programs

- *National Flood Insurance Program*, by Jennifer Gilbert, NH Program Manager, National Flood Insurance Program (March 2014)
- *Summary of the New Hampshire Flood Management Study Commission (HB648) Report*, by Steve Couture, NHDES Coastal Program

As needs and possible strategies became evident from information sources and stakeholder presentations, the Commission began developing draft recommendations. Commission members divided into three recommendation working groups: Great Bay communities, Coastal communities, and State and Legislative issues. Initial recommendations from the groups were refined and revised to reduce duplication and to incorporate new information as it became available.

The draft recommendations have been reviewed by Commission members in addition to state agencies and municipal officials. In December 2015, the Commission partnered with NHCAW to hold three discussion groups for coastal municipal officials to provide input on initial draft recommendations, which was later considered by the Commission and incorporated as necessary into this report.

2.5 Where We Go From Here

The Commission was established to develop guidance and recommendations for New Hampshire that will set our state on a responsible path towards enhancing coastal community and watershed resilience to the effects of storm surge, sea-level rise, and extreme precipitation. Because the timing and magnitude of these changes are uncertain, so are the assumptions on which we base our recommendations. While it is true that our level of understanding and degree of certainty about the impacts of climate change will improve over time, we know more than enough now to recognize that we cannot afford to wait for ‘certainty’ to act. We should not wait to respond to these threatening impacts. In fact, the key to managing economic and social costs and risks of climate related impacts in the coast is to begin early and adapt incrementally.

We have approached the recommendations contained in Section 6 with practical and effective actions in mind. The recommendations are a mixture of short- and long- term actions, and range from relatively straightforward and easy to difficult. The recommendations are primarily directed to the State Legislature, State agencies, and municipal governments. Lead responsible parties—the entities most likely to lead and coordinate efforts to achieve the recommendation—are identified for each recommendation. It is important to note, however, that every recommendation will require collaboration and coordination among the three primary audiences and additional public and private stakeholders.

Our central message is this: **begin now**. Even though we expect the impacts from climate change to be gradual on average, instances of severe flooding occurring at specific places and times will occur, as they always have, but are likely to worsen as changes in storm surge and sea level continue to develop. This means we do not have the luxury to wait. Actions taken now, even costly ones, will more than likely pay for themselves in the form of reduced losses and greater resilience. In addition, the normal cycles of reconstruction, replacement and redevelopment can be utilized to introduce more resilient design into structures and facilities.

As first “next steps” the Commission recommends that:

1. State agencies begin an immediate review of their policies, programs, rules and authorizing legislation and determine which should be altered to take the actions recommended in this report. They should begin making those changes and/or seek appropriate authorization where needed.
2. The legislature establish a permanent capacity and responsibility within state government to coordinate the review and update of scientific understanding and assumptions concerning the timing and magnitude of climate change impacts for the coastal region, and to monitor progress on implementing these recommendations.
3. The design and construction of state funded structures and facilities in coastal areas initiated from this point forward be done using flood management standards consistent with the guidelines and recommendations made in this report, or as superseded.
4. Detailed studies be assigned and undertaken to determine site-specific vulnerabilities and appropriate management actions for state structures and facilities and other vital assets.
5. Coastal communities implement enhanced flood hazard overlay districts to reduce vulnerability of development to higher flood risk and prevent further development in areas with highest risk.
6. State agencies and municipalities work cooperatively to develop integrated response, recovery, and continuity plans to reduce impacts from severe coastal flooding.
7. Consider financial resources and mechanisms needed at the state and municipal level to address storm surge, sea-level rise, and extreme precipitation events.

Finally, it is important that the recommendations and actions suggested in this report be reviewed regularly to ensure that timely progress is made where needed and that the recommendations themselves be refined or replaced as new information and better understanding comes to light. Given the dynamic nature of climate change and the threats it poses to New Hampshire’s coastal region, this guidance needs to be treated as a living, evolving document.

3. Understanding What We Are Facing

While New Hampshire has been very fortunate to have avoided the most extreme impacts of recent events like Tropical Storm Irene and Superstorm Sandy, the state has experienced other significant weather events in the coastal region. We have seen intense Nor'easters like Nemo in February 2013, the October snowstorm of 2011, and others that have had large and lasting impacts on our communities. These types of storms will have even greater impacts as sea levels continue to rise, and floods will continue to worsen as extreme rain events intensify. Understanding the best science behind projected risks and hazards is essential to enabling our coastal communities to be as prepared as they can be to avoid costly impacts and the potential loss of life.



Photo credit: UNH Stormwater Center

3.1 The Science and Technical Advisory Panel

The Commission created a Science and Technical Advisory Panel (STAP) to review available scientific information about coastal hazards and flood risks in New Hampshire. Comprised of scientists and experts in the fields of meteorology, engineering, climate, hydrology, and other related sciences, the Panel's charge was to

1. Ensure the Commission is aware of and is using the best available and relevant scientific and technical information to inform its recommendations; and
2. Assist the Commission in interpreting and reconciling conflicting projections, scenarios and probabilities about future conditions.

The Panel analyzed the latest published data on historic trends and projections for the years 2050 and 2100 for sea-level rise, coastal storms, and extreme precipitation. These findings were summarized in a peer-reviewed STAP report entitled *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends*,²² which the Commission unanimously adopted after careful and deliberate discussion in July 2014 and used to develop its recommendations to assist in planning and preparation for the changing climatic conditions in coastal areas of the state. The Panel recommends the STAP report be updated regularly as new research and data become available.

While a changing climate, melting ice sheets, and warmer ocean temperatures are enhancing coastal storms and extreme precipitation hazards, and are contributing to sea-level rise, it is important to note that our current and historical development patterns also contribute to the coastal risks and hazards we are facing. We have historically developed along rivers and shorelands. We continue to encroach on natural buffers with development that is, as a result, at risk from flooding. The increases in pavement and other impervious surfaces associated with development cause an increase in runoff and flooding due to the inability of these surfaces to absorb rain and snow melt. These development patterns exacerbate the climatic impacts and contribute to changing floodplains.

3.2 The Science and Technical Advisory Panel Report

The following section is a summary of the information presented in the STAP report. A condensed two-page summary of the STAP report is provided in [Appendix D](#).ⁱⁱ

Sea-Level Rise

Forecasting rates of global greenhouse gas emissions is challenging, but research shows that current greenhouse gas concentrations and current or accelerated emissions rates will continue to influence sea levels in the future. Planning for a 100-year flood now can also prepare us for mid-century sea-level rise. Figure 1 illustrates the processes contributing to sea-level rise and their proportions over the period from 1990-2012. Figure 2 shows the projected sea-level rise for the years 2050 and 2100 under different greenhouse gas emissions scenarios as reported in the National Climate Assessment published in 2014. These scenarios assume intermediate-low greenhouse gas emissions, intermediate-high emissions, and the highest emissions conceivable. Based on local tide gauge data, sea levels in New Hampshire have been rising by an average of 0.7 inches per decade since 1900. The rate of sea-level rise has increased to approximately 1.3 inches per decade since 1993. Using 1992 sea levels as a baseline, New Hampshire sea levels are expected to rise between 0.6 and 2.0 feet by 2050 and between 1.6 and 6.6 feet by 2100.

FIGURE 1. Processes causing sea levels to rise from 1990-2012.

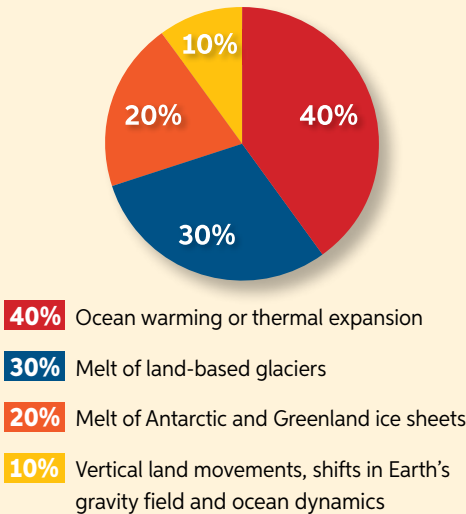


Figure modified from NH Coastal Risks and Hazards Commission, Science and Technical Advisory Panel Report (2014).

FIGURE 2. Sea-level rise scenarios under different emission levels in 2050 and 2100.

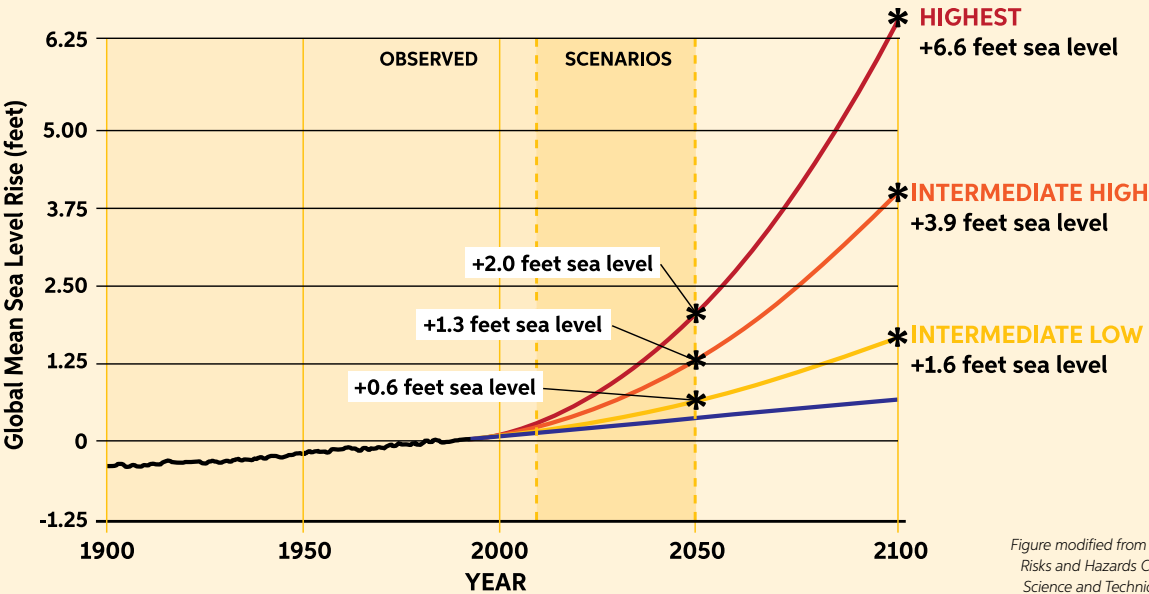


Figure modified from NH Coastal Risks and Hazards Commission, Science and Technical Advisory Panel Report (2014).

ⁱⁱ To view the full STAP report and associated scientific references, please visit the Commission's website at: http://nhcrhc.stormsmart.org/files/2013/11/CRHC_SAP_FinalDraft_09-24-14.pdf.

Storm Surge

Considering changes in water levels due to sea-level rise alone, today's extreme storm surge events (i.e. 1-percent-annual-chance flood /100-year flood) will have a greater inundation extent and occur more frequently over time. Due to increased coastal development, there has been a significant increase in impacts from hurricanes nationwide over the 20th Century. However, there is some uncertainty in the projection of trends in hurricane frequency and intensity in any given region, and no research consistently finds a trend in the frequency and intensity of Nor'easters.



Photo credit: Ron Sher

Annual and Extreme Precipitation

Annual precipitation is expected to increase by as much as 20 percent by the end of the 21st century compared to the late 20th century. Most of the precipitation increases are expected to be in winter and spring in the form of rain or snow. Fall and summer are expected to experience less of an increase.

Extreme precipitationⁱⁱⁱ events are projected to increase in frequency and in the amount of precipitation produced. In particular, the rainfall amount produced by hurricanes is projected to increase. However, current climate models and analyses are not as good at projecting future changes in the frequency or magnitude of extreme precipitation events.

Other Hazards and Risks

The Commission recognizes that New Hampshire's coastal communities face additional coastal risks and hazards that were not explicitly summarized by the Science and Technical Advisory Panel or by the Commission's recommendations. The Commission limited its focus based on the legislative mandate, available information, and resources, however additional coastal hazards pose serious risks and should be studied further and acted upon, where deemed necessary. Some of these hazards include increases in average temperatures; drought; snowfall; seasonal shifts; potential air quality issues; saltwater intrusion and rising groundwater tables from sea-level rise; ocean acidification and the impacts on habitats and fisheries; and other impacts to well-being and quality of life, including the health of New Hampshire coastal residents. [Appendix E](#) highlights some of the additional hazards that should be studied in future iterations of the STAP report and discussed in future Commission efforts. These hazards have significant and increasing health implications as they are exacerbated by climate change, and though efforts have begun in the State to better understand health impacts, this needs to be a continuing focus of study.



Photo credit: Tricia Miller

Based on this summary of the science, the STAP offered planning guidance for adapting to sea-level rise, storm surge, and changes in annual and extreme precipitation. This guidance is summarized in Section 5.2.

ⁱⁱⁱ For the purposes of this report, "extreme precipitation" is defined as the largest one percent of daily events in a year. This definition comes from the 2014 National Climate Assessment, however many other valid definitions of the term "extreme precipitation" exist.

4. Understanding Our Risks and Vulnerabilities

To prepare wisely for and reduce our risks to coastal hazards, the scope of vulnerability needs to be assessed and understood. Vulnerability is the likelihood that an asset will experience harm due to exposure to coastal hazards, as well as historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes. To determine vulnerability, the following questions are asked:

1. What assets are we interested in understanding and protecting?

In this report, we have identified four types of assets that are important to protect: our economy, our built landscape, our natural resources, and our heritage.

2. How exposed are our assets to coastal hazards?

To understand exposure, we look at where the hazard is likely to occur, and what assets will be in the way. For this report, we look at how exposed our assets are to coastal flooding from sea-level rise, storm surge, and extreme precipitation. As an example of how our exposure has shifted in recent decades, the population in coastal floodplains has more than doubled between 1970 and 2010 as the population in coastal municipalities continues to grow.

3. How sensitive are our assets to coastal hazards?

Sensitivity tells us how severe of an impact a hazard will have on an asset. As an example, extreme precipitation may expose many assets in the floodplain; however, certain types of housing are more sensitive to extreme events (mobile homes) and therefore are more vulnerable.

4. Can the assets adapt or be adapted to coastal hazards?

Lastly, vulnerability is influenced by how easily an asset can adapt or be adapted to a change. For example, salt marshes are expected to respond to sea level rise by migrating towards higher elevations; however, the presence of coastal development may limit the amount of space available and obstruct wetland migration inland, resulting in the total loss of wetlands in some areas. Similarly, structures and facilities in the built landscape may be elevated or designed to accommodate increased flooding (e.g., add freeboard to elevate structures above base flood elevation; increase culvert size). Existing building standards (e.g., height restrictions), replacement costs, and secondary impacts to other assets (e.g., increased downstream flooding) may reduce an asset's adaptive capacity and require modification to allow for flexibility in design.

Once the important assets are identified and exposure, sensitivity, and adaptive capacity are ascertained, strategies can be identified to prepare for coastal hazards based on the vulnerability assessment. These adaptation strategies will vary depending on the asset and hazards in question. For example, in the case of a salt marsh, the selected strategy might be to ensure conditions are appropriate to allow for marsh migration as sea levels rise.

While additional research is needed to establish a more complete picture of the vulnerability of specific assets along New Hampshire's coast, particularly as it relates to asset sensitivity and adaptability, significant progress has been made to identify and map important assets and assess their exposure to specific hazards like storm surge and sea-level rise. This section summarizes some of the existing information about our coastal vulnerabilities to some hazards. Section 4.1 presents a summary of the Coastal Region followed by four sections representing the key topic areas identified by the Commission:^{iv} Our Economy (4.2), Our Built Landscape (4.3), Our Natural Resources (4.4), and Our Heritage (4.5). Each section summarizes and provides references about our known vulnerabilities and explains critical gaps in our understanding about the vulnerabilities for each topic area. The vulnerabilities outlined in these sections are not a comprehensive assessment of vulnerable assets in coastal New Hampshire, but rather they illustrate some of the known vulnerabilities that exist in the region.

^{iv} The four topic areas are also used to organize the recommendations presented in Section 6.

4.1 Summary of the Coastal Region

As of 2015, 157,954 people live in New Hampshire's 17 coastal municipalities, comprising almost 12 percent of the state's population. Population in the coastal region has increased 3.1 percent in the last five years, compared to statewide population growth of 0.9 percent.²³ The New Hampshire Department of Employment Security estimates that coastal population will increase an additional 2.9 percent over the next ten years. Figure 3 shows the current distribution of population across coastal municipalities, while Figure 4 illustrates how coastal population is projected to change over the next decade. As population increases in New Hampshire's coastal communities, more people live and work – and own property – in areas prone to coastal risk and hazards. According to NOAA's State of the Coast, the population in New Hampshire coastal floodplains has more than doubled between 1970 and 2010. Additionally, scientists have posited that future climate changes may result in an additional population increase as people migrate away from water-starved western United States as well as other countries.²⁴ These historical population trends and possible future migration, and the development trends that inevitably follow, give added importance to ongoing efforts to identify coastal vulnerabilities and take action to reduce those vulnerabilities.

As we think about vulnerability, it is important to recognize the diversity of New Hampshire's coast. There are two distinct geographic areas that are impacted by coastal hazards and risks: the municipalities that directly border the Atlantic Ocean, and those that surround Great Bay and its tidal tributaries.

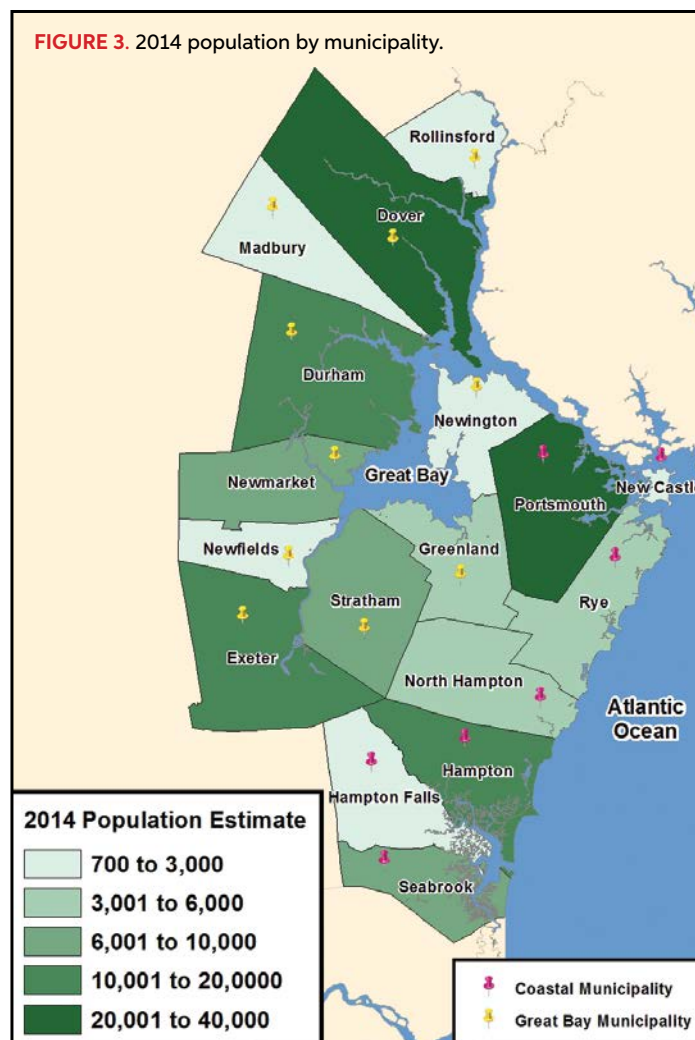
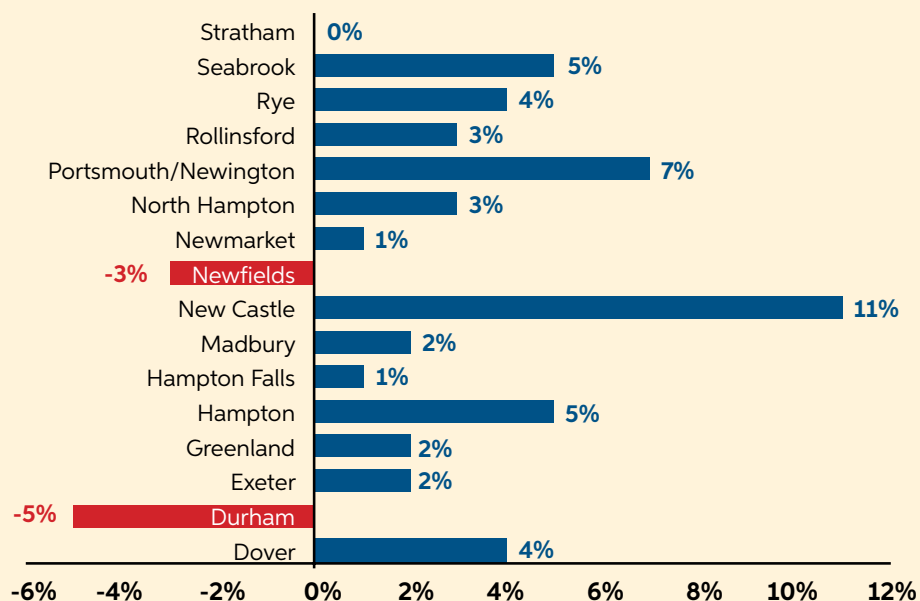


FIGURE 4. Projected Population Changes in Coastal New Hampshire between 2015 and 2024.



4.1.1 Atlantic Coast Municipalities

New Hampshire's seven Atlantic Coast communities include Hampton, Hampton Falls, North Hampton, New Castle, Portsmouth, Rye, and Seabrook. These communities are located in the southeastern corner of the state directly exposed to the Atlantic Ocean. The Atlantic Coast is characterized by tidal and riverine systems and landforms. The southern Atlantic coast consists of a barrier beach system including the extensive salt marshes of the Hampton-Seabrook Estuary, a broad sand beach at Hampton, and dune systems in Hampton and Seabrook. The northern Atlantic coast is marked by prominent bedrock headlands, small cove beaches and tidal waterways that extend far inland. The primary inland riverine systems include the Taylor River and Winnicut River.

The Atlantic Coast municipalities have a distinct and pressing need to address existing and future impacts relating to climate change, particularly relating to coastal flooding from storm surge and sea-level rise. Without proactive solutions to address the expected impacts of climate change, these communities face a multitude of challenges to ensure the security, health and welfare of their citizens and provide for a stable and viable economic future. In September 2015 the Rockingham Planning Commission (RPC) completed the Tides to Storms project²⁵ to assess the vulnerability of roadways and supporting transportation assets, critical facilities, and natural resources to flooding from expected increases in storm surge and rates of sea-level rise in the seven Atlantic Coast communities. This study is the first statistical and spatial analysis of its kind conducted for New Hampshire communities. It used a uniform methodology to identify specific state and municipal assets that are vulnerable to flooding under different storm surge and sea-level rise scenarios. The study did not include an assessment of the specific degree of damage nor estimate monetary losses to specific sites or properties. Further depth-damage analyses of affected assets using the flood depth maps may yield some of this information in follow-up work.

Flooding scenario maps were based on the 2014 National Climate Assessment, 2014 (Preliminary) Flood Insurance Rates Maps released by the Federal Emergency Management Agency (FEMA),²⁶ and high resolution digital elevation data. Data sources and assumptions that underlie the flood scenarios used in this assessment are explained more fully in the Tides to Storms final report.²⁷

Key findings of this assessment are based on evaluation of the extent of inundation that would result under three scenarios of sea-level rise: 1.7 feet, 4.0 feet, and 6.3^v feet for the year 2100 and three additional scenarios that pair the sea-level rise combined with the 100-year storm surge. For example, Figure 5 shows the extent of projected tidal flooding from 1.7 feet, 4.0 feet, and 6.3 feet of sea level rise scenarios for the Hampton-Seabrook Estuary and surrounding areas. The green color scheme is arranged from lightest to darkest with increasing flood extent.

^v These sea-level rise maps were developed prior to the STAP report summary and therefore used slightly different estimates for sea-level rise. The maps do not show a significant difference in inundated area due to the resolution of the elevation data.

Portsmouth Coastal Resilience Initiative

In 2012, Portsmouth was one of five communities selected for a pilot program with \$30,000 in funding from the Gulf of Maine Council, through a grant from the National Oceanic and Atmospheric Administration (NOAA). This grant funded a research study the "Coastal Resilience Initiative (CRI)" prepared for the City by a team of researchers from the University of New Hampshire and the Rockingham Planning Commission. This detailed, 50-page report provides the starting point for understanding the impacts of climate change and offers a number of possible adaptation measures that the City can take over time to protect private property and public facilities. The report evaluated potential impacts from sea-level rise and storm related flooding on critical facilities, buildings and salt marshes. The City is actively implementing measures to adapt its stormwater drainage facilities to increases in extreme precipitation and rising sea levels.



The City's current climate initiative "Prepare. Protect. Portsmouth." showcases the CRI report and

information about what residents and businesses can do to prepare for climate change. Find more information on the Prepare. Protect. Portsmouth. website at <http://www.planportsmouth.com/cri/>.

FIGURE 5. Illustration of the extent of flooding from three sea-level rise scenarios in the Hampton-Seabrook estuary.

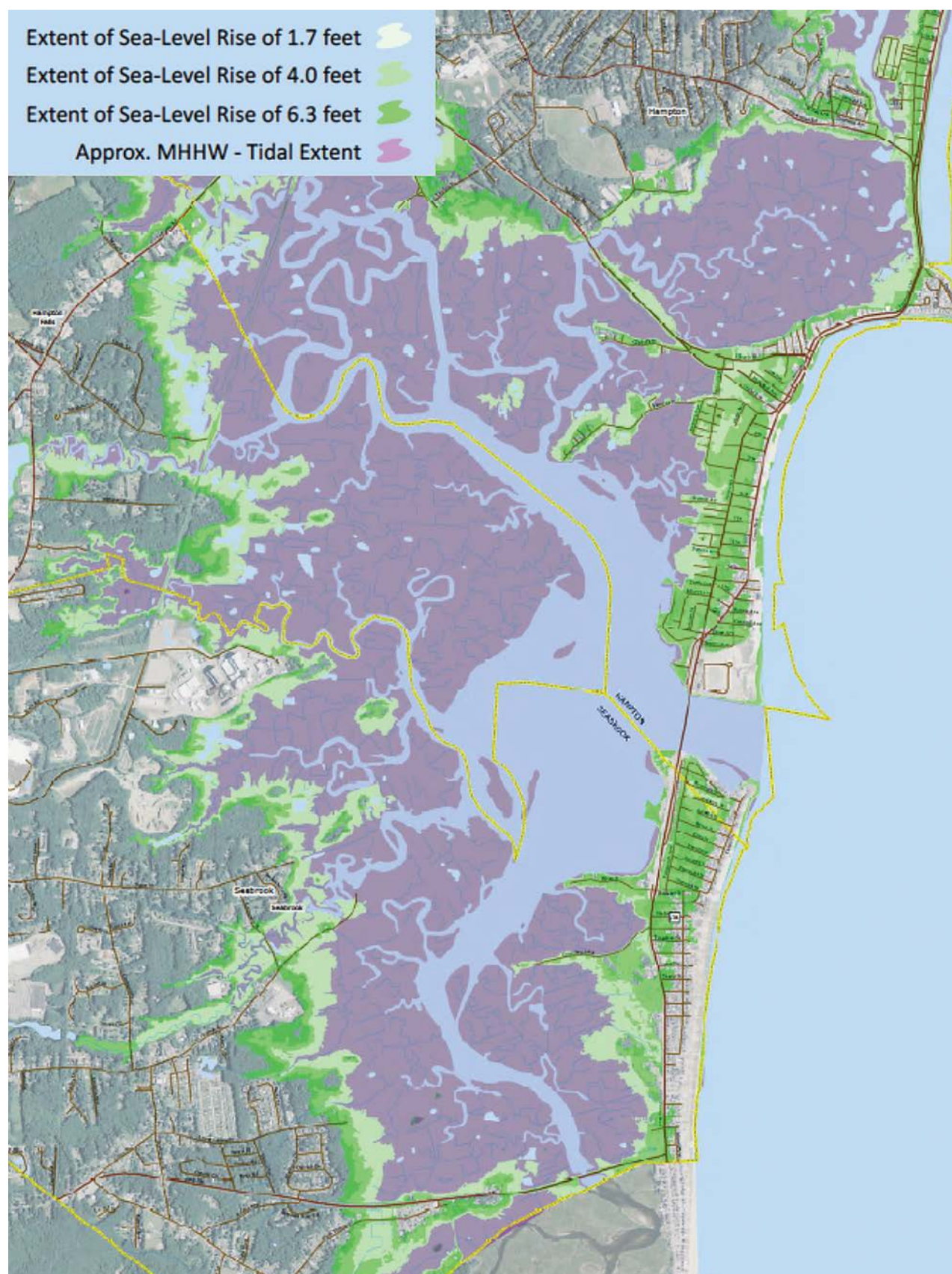


FIGURE 6. illustration of the extent of flooding from three sea-level rise scenarios with a 100-year/one-percent-annual-chance storm surge in the Hampton-Seabrook estuary.

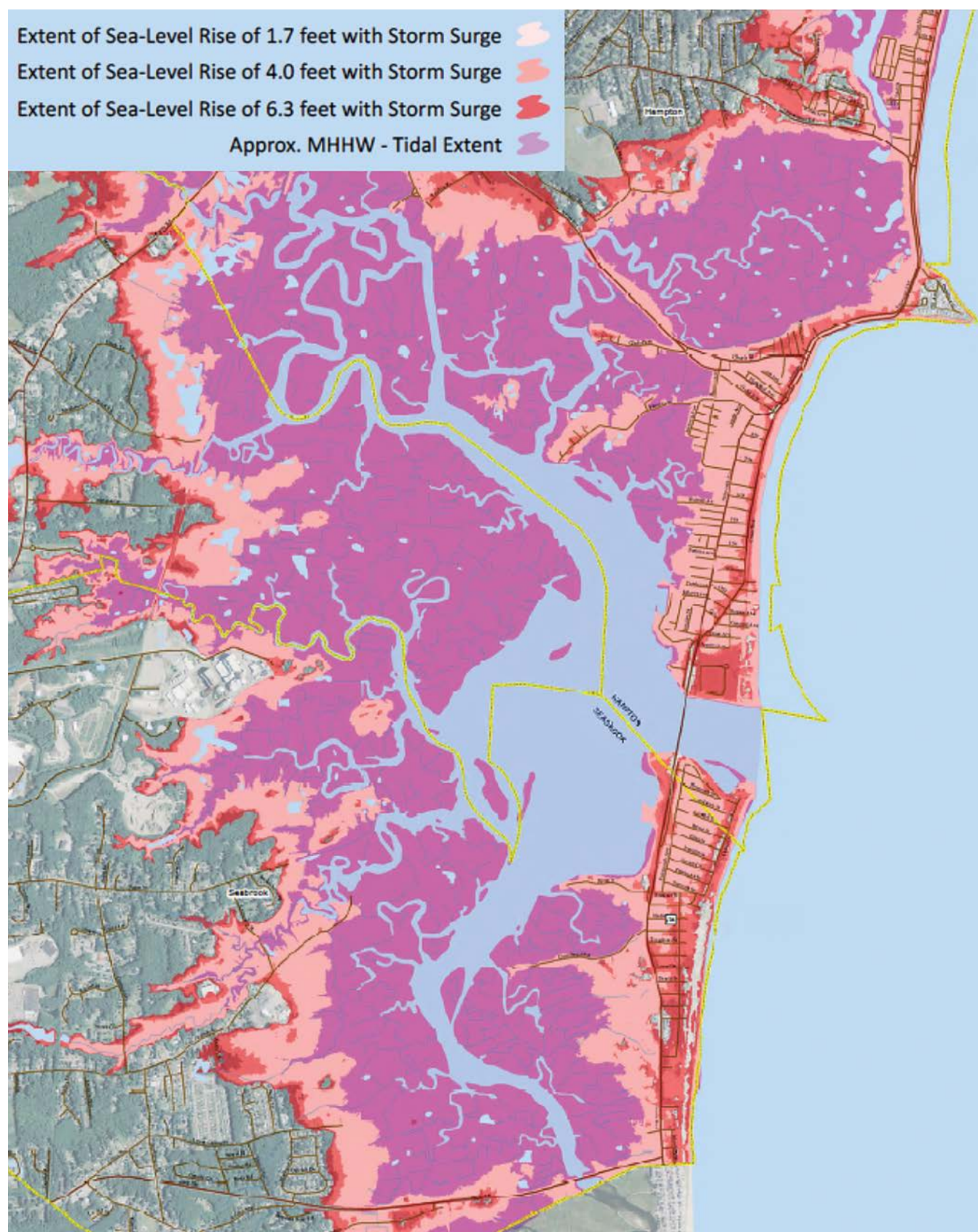


Figure 6 shows the extent of projected tidal flooding from 1.7 feet, 4.0 feet, and 6.3 feet of sea level rise plus storm surge scenarios for the Hampton-Seabrook Estuary and surrounding areas. The pink color scheme is arranged from lightest to darkest with increasing flood extent.

Figure 7 provides a statistical overview of the flood impacts to specific assets and resources from the sea-level rise and storm surge scenarios evaluated for the seven Atlantic Coast municipalities. The seven Atlantic Coast municipalities combined have 49,266 acres of upland (land currently above mean higher-high water). At the 1.7-foot sea-level rise scenario, about 3 percent (1,484 acres) of this upland will be inundated by tides on a regular basis; at the 4.0-foot scenario, 5.3 percent (2,602 acres) of upland would be regularly flooded by tides; and at the 6.3-foot sea-level rise scenario, 7.3 percent or 3,613 acres would be affected. Upland impacts are greater in Rye than in other communities because of the extensive low-lying areas around the marshes west of Odiorne Point. Additional findings are summarized throughout Section 4 and referenced in Figure 7.

4.1.2 Great Bay Municipalities

New Hampshire's Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, Stratham, and Portsmouth (which is often included in both groups). These communities are located in the southeastern corner of the state surrounding Great Bay, which is a nationally recognized Estuarine Research Reserve. This area is set apart by its beautiful natural resources, diverse urban and rural communities, and rich cultural heritage. Established during the Industrial Revolution as a hub of textile production within the northeast, these communities continue to be defined by traditional mill-town development,

FIGURE 7. Summary of flood impacts from sea-level rise and storm surge for the seven municipalities* along the Atlantic Coast.

Sea-Level Rise + Storm Surge*** Scenarios	Sea-Level Rise 1.7 feet	Sea-Level Rise 4.0 feet	Sea-Level Rise 6.3 feet	Sea-Level Rise 1.7 feet + Storm Surge	Sea-Level Rise 4.0 feet + Storm Surge	Sea-Level Rise 6.3 feet + Storm Surge
Upland** (acres)	1,485	2,602	3,615	3,475	4,439	5,298
BUILT LANDSCAPE						
Infrastructure (# of sites)	37	90	135	137	162	190
Critical Facilities (# of sites)	13	33	48	44	64	98
Roadways – Local (miles)	4	17	29	33	39	51
Roadways – State (miles)	2	7	14	19	22	26
Transportation Assets (sites)	35	50	68	65	78	90
100-year floodplain (acres)	8,180	9,361	9,593	9,639	9,766	9,818
NATURAL RESOURCES						
Freshwater Wetlands (acres)	184	396	519	489	593	661
Tidal Wetlands (acres)	235	257	264	267	268	269
Conserved Lands (acres)	493	717	873	883	1,007	1,131
Land Protection Priorities (acres)	4,022	4,851	5,469	5,385	5,948	6,458
Critical Wildlife Habitat (acres)	1,081	1,600	1,915	1,865	2,112	2,310

* Seven Atlantic Coast communities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.

** Upland refers to land above mean higher high water (highest tidal extent). The seven coastal region municipalities have approximately 52,751.8 acres of upland.

*** Storm surge = 100-year / one-percent-annual-chance flood event.

built upon the veins of the many coastal rivers leading south to the port of Portsmouth. However, with the increased frequency of severe storm events combined with an increase in impervious surfaces resulting from extensive development over the past four decades, communities have experienced substantial economic losses and damages to critical facilities from major flooding events. The Mother's Day (2006) and Patriots' Day (2007) floods are two examples of catastrophic flooding that wreaked havoc on municipalities in the coastal watershed.

Most of the Great Bay communities lie within the Piscataqua River Basin through which flow a number of coastal rivers, including the Cocheco, Lamprey, Oyster, Exeter, Winnicut, and Salmon Falls. The Salmon Falls flows south into the Piscataqua River and acts as the boundary between New Hampshire and Maine before draining into the Gulf of Maine through Portsmouth Harbor. Influenced by historic development patterns and significant changes in land use, as well as extreme precipitation and coastal surge, these complex freshwater river systems have experienced much more flooding during storm events in recent years. These contributing factors translate into the Great Bay communities being vulnerable to future sea-level rise potential.

A UNH-led research project investigated how flooding in the Lamprey River may change in the future based on scenarios of land cover change and climate change. The research relied upon rainfall-runoff models used by FEMA to define one-percent-annual-chance floods (100-year floods).²⁸ Results clearly show that the one-percent-annual-chance floodplain, peak flood water discharge, and flood water surface elevations have increased significantly over the past four decades and will continue to increase in the future under the build-out and climate scenarios developed for the research project (Figure 8). Low impact development zoning was shown to have its greatest mitigation value in terms of resiliency in high impervious cover areas.²⁹ This increase in the one-percent-annual-chance floodplain and one-percent-annual-chance flood discharge has important ramifications for natural resources, the built landscape, public health and safety, emergency management, and planning. In addition, the risk of municipal legal liability associated with using the new one-percent-annual-chance floodplain maps is low, so long as municipalities follow sound planning principles.³⁰

A detailed statistical and spatial analysis similar to the Tides to Storms project is currently being conducted for the 10 Great Bay municipalities as part of the Climate Risk in the Seacoast: Assessing Vulnerability of Municipal Resources to Climate Change (C-RiSe) project. Results are expected in spring of 2016. The Commission expects to update Section 4 of the report when more detailed statistical information is made available for the Great Bay municipalities.

A Master Plan for Climate Change in Durham

In 2013, the Town of Durham, in partnership with the Strafford Regional Planning Commission, underwent a process in which the community evaluated their risks to climate change and its associated impacts. Durham specifically focused on future changes in extreme temperature and precipitation, sea-level rise, and coastal flooding. This process resulted in the development of the town's [climate adaptation chapter](#) and provides a list of recommendations as to the kinds of steps Durham should be taking over the next several decades.



Durham Town Administrator Todd Selig holds up the town's climate adaptation chapter. (photo credit: Fosters.com)

In 2014, Durham was awarded the NOAA Walter B. Jones Memorial Award for Excellence in Local Government, which is awarded to five towns across the country every two years. The award is given to local governments that have created positive change in coastal management.

FIGURE 8. Potential change in the area of one-percent-annual-chance* floodplains on the main stem of the Lamprey Rivers based on climate and land use change scenarios

Town	Total acreage in watershed	One-Percent-Annual-Chance Floodplains (acres)		Percent increase in one-percent-annual-chance floodplain area 2100 vs. 2005
		2005 FIRM	2100 'Conventional' Buildout**	
Durham	4,984	499	625	20%
Epping	16,752	899	1,026	12%
Lee	7,927	551	916	40%
Newmarket	6,559	450	741	39%
Raymond	12,277	874	1,113	21%
Total	48,499	3,273	4,421	26%

*The one-percent-annual-chance floodplain or storm is the more accurate term preferred by FEMA for what is more commonly known of as the 100-year floodplain or storm.

**Projected residential and nonresidential development scenario for 2100 based on historical 1962-2005 residential and nonresidential developed land data.

4.2 Our Economy



OUR ECONOMY is the systematic and productive exchange and flow of goods, services, and transactions that must be intact, functioning, and resilient to coastal risks and hazards in order to create and sustain a high quality of life in coastal New Hampshire.

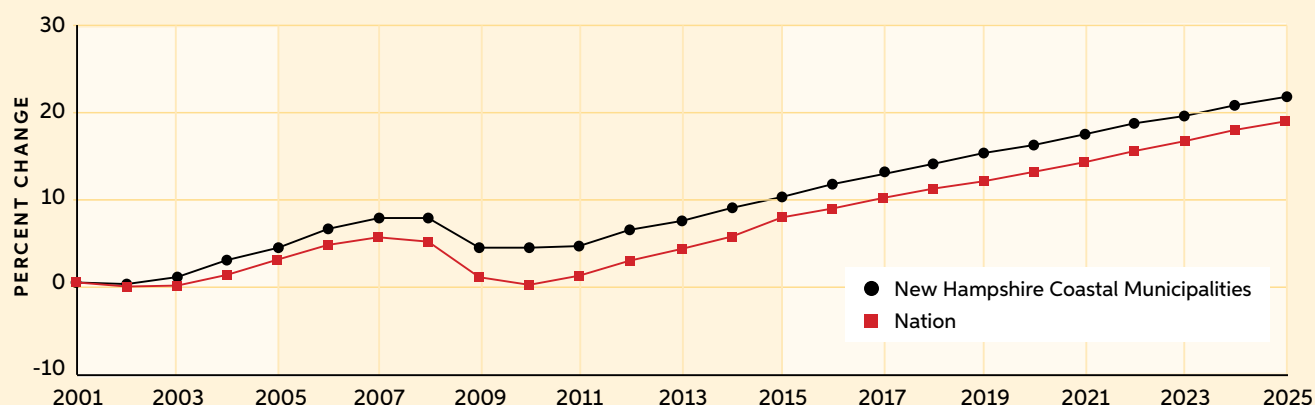
4.2.1 How We Assess Vulnerability

When it comes to assessing the vulnerability of the coastal region to coastal risks and hazards, the regional economy must be considered in two ways. First, research shows that communities with diversified economies and established institutions have a greater capacity to protect and prepare their assets, including the built environment, natural resources, and heritage against coastal risks and hazards. As a result, vulnerability is likely higher in municipalities with fewer financial resources, less stable economic activity, and/or lower average incomes.³¹

The second consideration is that key components of the economy may be vulnerable to climate change impacts like storms and sea-level rise. A significant portion of the economy in New Hampshire's coastal region is related to coastal industries that may inherently be vulnerable to storms and sea-level rise. For example, the New Hampshire Port Authority in the City of Portsmouth ranks 86th out of 150 ports in the U.S. handling nearly 3 million tons of materials annually consisting mostly of petroleum products and sand, and lesser amounts of coal and iron.³² According to New Hampshire Sea Grant, in 2010 New Hampshire's commercial fisheries industry had a catch value of approximately \$17 million.³³ Additionally, businesses that may not deal directly with coastal goods and services may have supply chains, customers, and other resources that are vulnerable to hazards like coastal storms.³⁴

New Hampshire's coastal region is an important economic driver for the state and consistently ranks above the national average for job growth. According to the NH Center for Public Policy Studies, the Seacoast has a diverse economy that includes more than a quarter of New Hampshire's labor force – the highest of any region in the State.³⁵ The Gross Regional Product of the 17 coastal municipalities totaled more than \$11 billion in 2013, with 14 percent derived from the finance and insurance industry and 13 percent coming from the manufacturing industry. Between 2001 and 2015 job growth for the coastal region was 10 percent, outpacing the national average of 7.5 percent. In 2015, the 17 municipalities supported 107,506 jobs. Figure 9 shows the percent change in jobs from 2001 to 2015 and projected to 2025 for New Hampshire's coastal municipalities vs. the nation.¹

FIGURE 9. Percent change in jobs from 2001-2015 and projected to 2025 for New Hampshire's 17 coastal municipalities vs. the nation.



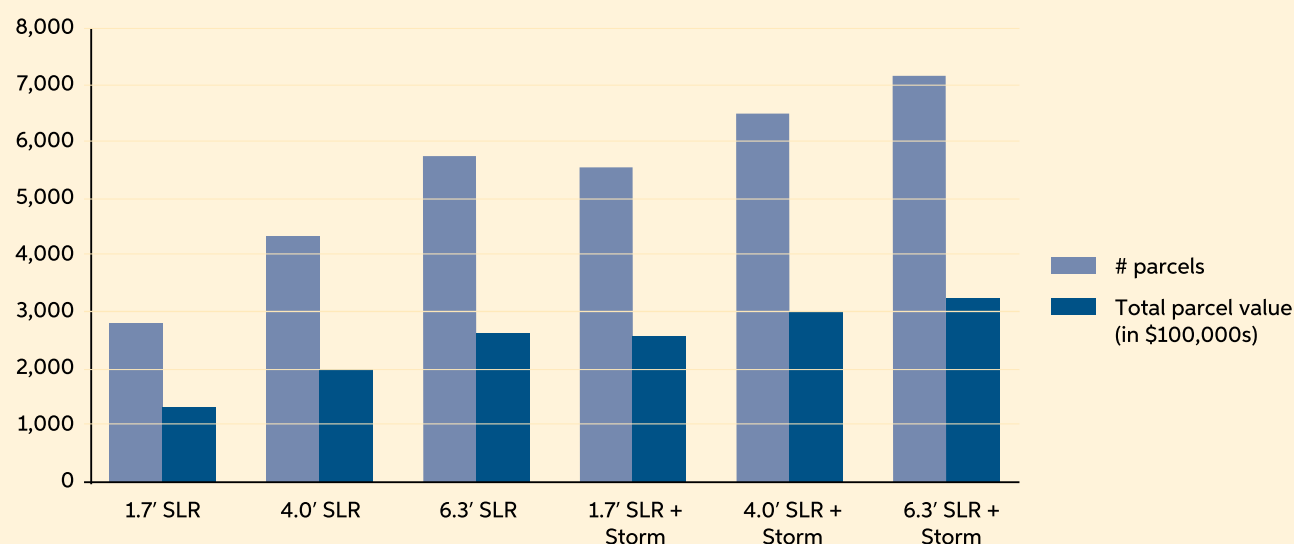
4.2.2 Highlights of Vulnerabilities

Assessed Property Tax Base

The economic vulnerability of municipalities can be evaluated by determining the exposure of the property tax base to coastal hazards. As shown in Figure 10, the Tides to Storms project analyzed the number of tax parcels in the seven Atlantic Coast municipalities affected by each of the six sea-level rise and storm surge scenarios evaluated and shows the aggregated assessed value of these parcels. Affected parcels were identified if they were found to be partially or fully located within the extent of the scenarios evaluated; however, the extent to which a parcel and any structure or development on the parcel will be impacted by flooding was not analyzed.

Between 2,800 and 5,700 parcels will be partially or wholly affected by daily tidal flooding, depending on the sea-level rise scenario. Up to 7,200 parcels will be affected when storm surge is added, putting nearly \$3.3 billion of assessed property value at risk of flooding. The data shows a 55 percent increase in the number of parcels affected and a \$651 million increase in the assessed value of affected parcels when comparing the 1.7 feet to the

FIGURE 10. Number and aggregated assessed value of parcels affected by sea-level rise and storm surge scenarios for the Atlantic Coast municipalities.*

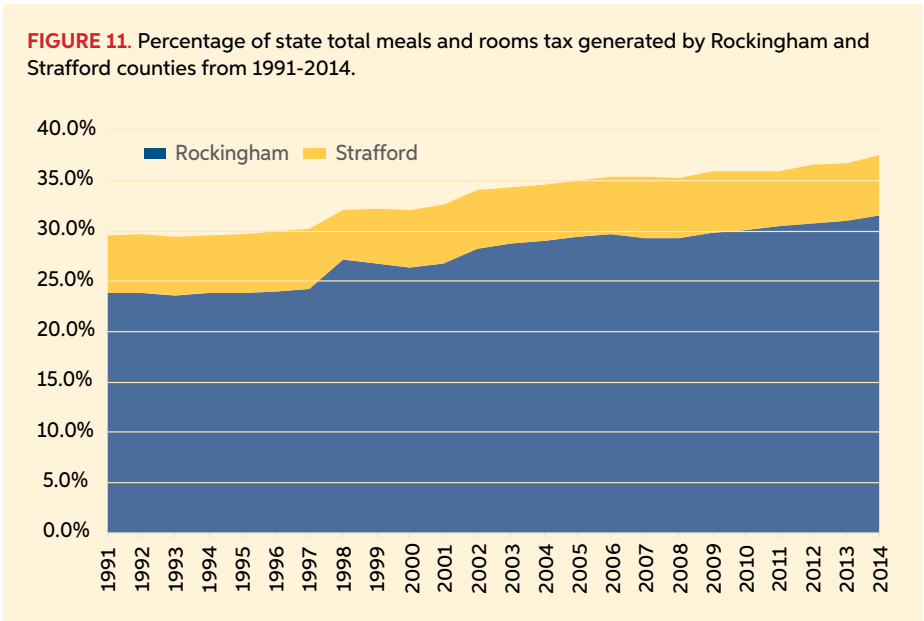


*Seven Atlantic Coast communities include Portsmouth, New Castle, Rye, North Hampton, Hampton Falls, Hampton, and Seabrook.

4.0 feet sea-level rise scenario. The 6.3 feet sea-level rise scenario shows a 32 percent increase in the number of parcels affected and a \$659 million increase in the assessed value of affected parcels compared to the 4.0 feet sea-level rise scenario. These data includes a number of high value parcels under state and municipal ownership.

Coastal Tourism

County meals and rooms tax revenue data are considered one of the most important indicators for the tourism sector, as they provide the basis for estimating other tourism indicators such as traveler counts and spending. Counties that are visited by large numbers of tourists generate much of the revenue under New Hampshire’s meals and room tax, which is collected from the patrons of hotels, restaurants, and car rental agencies. In particular, Rockingham and Strafford Counties, which include



14 and 3 coastal municipalities respectively, continue to generate significant revenue for the state under the meals and rooms tax. As shown in Figure 11, Rockingham and Strafford counties contributed 37.5 percent of the total state meals and room tax revenue in fiscal year 2014, accounting for \$104.7 million.³⁶ These data suggest that the coastal tourism economy in Rockingham County continues to be a valuable state asset.

The tourism and recreation sectors would likely be severely impacted by a major coastal storm and may be impacted more gradually over the long-term by sea-level rise. Key tourism destinations like Hampton Beach and Strawberry Banke Museum are known to be vulnerable to storm surge and sea-level rise.³⁷ Additional research is needed, however, to determine specific vulnerabilities within the tourism sector and to identify specific strategies to deal with those vulnerabilities.

4.2.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Economy	
E1.	Identify vulnerability of sector-based economic assets, including but not limited to tax base, workforce and jobs, property values, insurance costs, trade facilities, and public recreational facilities based on best available climate science. <i>[Lead: State Agencies; Municipalities].</i>
E2.	Incorporate best available climate science and vulnerability assessment information in state, regional, and municipal economic development plans. <i>[Lead: State Agencies; Municipalities].</i>
E3.	Use appropriate and available mechanisms, including but not limited to incentives and market-based tools to fund climate adaptation strategies. <i>[Lead: State Agencies; Municipalities].</i>
E4.	Improve information available to property owners and prospective buyers about coastal hazards and vulnerabilities. <i>[Lead: State Agencies; Municipalities].</i>

4.3 Our Built Landscape



OUR BUILT LANDSCAPE is the network of structures and facilities owned by state and local governments and private entities in coastal New Hampshire. Our built environment must be prepared, adaptive, and responsive to coastal risks and hazards.

4.3.1 How We Assess Vulnerability

A number of methodologies can be used to assess the vulnerabilities in the built landscape, and these methods vary based on the type of built asset and the level of detail desired. In coastal New Hampshire, we benefit from high quality spatial data for roads, critical facilities, and other important built assets. To date, preliminary assessments have overlaid sea-level rise and storm surge inundation maps with mapped roadways and buildings to determine which areas are likely to flood under different scenarios. Many of these mapping resources are publicly available on the New Hampshire Coastal Viewer. These preliminary vulnerability assessments are useful for highlighting patterns, summary statistics, and planning implications for municipalities, however, in most cases more detailed assessments are needed to identify site-specific vulnerabilities and possible adaptation strategies or solutions.

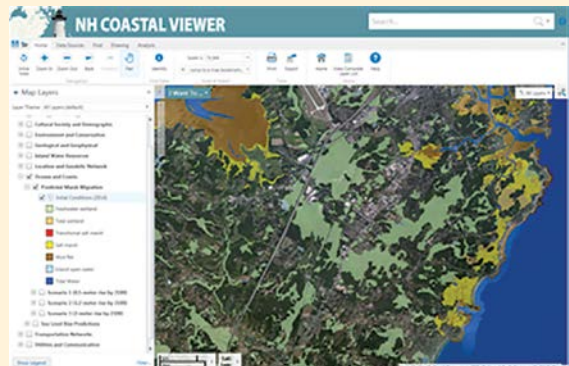
4.3.2 Highlights of Vulnerabilities

Roadways and Transportation Assets

State and local roadways throughout the seacoast region are vulnerable to flooding and damage from storm surge, sea-level rise, and extreme precipitation. In many municipalities, flooding is magnified by the combination of tidal or storm related flooding and freshwater flooding.

Throughout the Atlantic Coast municipalities, Route 1-A provides the vital transportation link on the immediate coast and is essential to coastal communities for access, safety, livability, recreation and for the continued viability of the coastal tourist economy. With its immediate shoreline exposure, it comes as no surprise that Route 1-A is the transportation asset most vulnerable to coastal flooding and disruption from sea-level rise. Route 1-A and any connecting streets and roads are significantly affected by sea-level rise in the 4.0 feet and 6.3 feet sea-level rise scenarios. In addition to Route 1-A, local roads are highly vulnerable to sea-level rise and storms. In all of the seven Atlantic Coast municipalities, the miles of local roadways impacted by flooding are at least double the miles of state roadways affected under all six flood

The New Hampshire Coastal Viewer: You Can Map Vulnerabilities Too!



The NH Coastal Viewer is an online mapping tool that brings coastal resources spatial data, hazards-related spatial data, and other spatial data sets within NH's 42 coastal watershed communities together in one place. Users can search for available data sets; display the data sets in multiple ways; and create, print, and share customized maps. The Coastal Viewer endeavors to serve as a one-stop shop for all coastal resources and hazards-related spatial data in NH's coastal watershed; to improve access to new and existing spatial data sets; and to provide information about coastal resources, hazards, and opportunities to reduce risk from these hazards and increase coastal resiliency. The Coastal Viewer was developed by NH GRANIT and the NHDES Coastal Program and funded by the National Oceanic and Atmospheric Administration's Office for Coastal Management. You can access the Coastal Viewer to explore data and make maps focused on understanding local vulnerability to coastal hazards at <http://granit.unh.edu/nhcoastalviewer/>.

scenarios. To a great extent, local responses on municipal roads will depend on State plans for improving the resilience of Route 1-A and Route 1, and will require extensive regional coordination.

The Great Bay communities are closely tied together by a dense network of state highway and local road systems. The primary state highways serving these communities are Interstate 95 and Routes 1, 1A, 4, 16, 33, 101, 108, and 125, all of which have sections that traverse tidal waters and freshwater bodies.

Figure 12 reports the miles of state and local roadways affected by each of the sea-level rise and storm surge scenarios for the coastal region and by municipality as identified in the Tides to Storms (Atlantic Coast; 2015) Vulnerability Assessment. Statistical information for Great Bay municipalities will be added to Figure 12 upon completion of the C-RiSe (Great Bay; 2016) vulnerability assessment. A preliminary analysis of vulnerable Great Bay roadways under 6.3 feet sea-level scenario is included in [Appendix F](#).

In addition to road surfaces, road crossing facilities such as culverts and bridges are vulnerable to flooding from coastal storms, sea-level rise, and extreme precipitation and damage to crossings can cause significant impacts downstream of roadways. Efforts are ongoing to identify and assess the tidally-influenced culverts at risk of sea-level rise and additional flooding from extreme precipitation. Some red-listed bridges in the Coastal Region may also be at risk of sea-level rise and storm surge, including bridges in Hampton, New Castle, Dover, and the Portsmouth US1 Bypass over the Piscataqua River, however more analysis is needed to understand the scope of that vulnerability.³⁸

FIGURE 12. Miles of state and local roadways affected by sea-level rise and storm surge scenarios for the seven Atlantic Coast municipalities.

Sea-Level Rise (SLR) Scenarios	SLR + 1.7 feet	SLR + 4.0 feet	SLR + 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
ROAD TYPE						
Local	3.5	17.0	29.4	32.8	38.8	50.5
State	1.6	6.6	14.1	18.7	21.8	25.6
Interstate	0.1	0.1	0.1	0.1	0.1	0.1
State	1.0	5.6	12.5	17.3	19.6	23.0
US Route	0.5	0.9	1.5	1.3	2.1	2.5
TOTAL MILES	5.1	23.6	43.6	51.5	60.6	76.1
Portsmouth	1.1	2.2	4.9	4.2	7.5	11.0
New Castle	0.1	0.5	1.4	1.5	1.8	2.8
Rye	0.2	4.5	9.5	10.6	14.1	17.1
North Hampton	0.0	0.7	1.3	1.4	2.6	3.0
Hampton	3.4	13.2	20.6	25.8	26.7	31.3
Hampton Falls	0.0	0.1	0.3	0.2	0.4	0.7
Seabrook	0.4	2.4	5.7	7.8	7.5	10.3

NOTE: Information for Great Bay municipalities will be added to this table upon completion of the C-RiSe vulnerability assessment in 2016.

Critical Structures and Facilities

Communities recognize the importance of ensuring that emergency facilities and shelters be located in places that are secure and accessible. A preliminary assessment of some critical facilities shows a few examples at risk of sea-level rise and storm surge. If a one-percent-annual-chance-storm occurred on top of 6.3 feet of sea-level rise, facilities that may be vulnerable include the Hampton Police Station and Fire Station; the Hampton and Seabrook wastewater treatment facilities; the Durham primary sewer lift station; and the Riverwalk/Schanda Park and the Creighton Street Pump Station, both in Newmarket.

Energy facilities fuel our economy and are uniquely important as they power all other critical structures and facilities, including those emergency facilities and shelters that we rely upon during coastal storms and floods. The electrical grid is especially vulnerable to extreme weather events.³⁹ On average, over 300,000 people were affected by electricity outages between 2008 and 2013 across New Hampshire; the leading causes of electricity outages were weather and falling trees.⁴⁰ Following the massive power outages that occurred in 2011 after a large snowfall event in October, utility companies across the region have worked to improve the resilience of the electrical grid. However, additional assessment is needed to better understand the vulnerability of the electrical grid in New Hampshire, and in particular, the vulnerability of large power transformers and substations.

Similar to energy systems, communication systems are an integral component of our economy and provide critical services required to support daily operations in business, government, education, and public safety organizations.⁴¹ Over the last 25 years, the communications sector has evolved into a highly interconnected sector that relies upon terrestrial, satellite and wireless transmission systems; we now rely heavily on cellular networks and the internet. Private sector entities are the primary owners and operators of the majority of our communications infrastructure, and are responsible for protecting communication assets and maintaining overall function of the system. Additional information is required to determine system vulnerabilities to projected flood risks in coastal New Hampshire. As with the electrical grid and energy systems, this vulnerability assessment will require collaboration with the private sector.

Private Property and the National Flood Insurance Program

Floodplain management is one of the most useful existing regulatory frameworks intended to identify existing flood vulnerabilities in the built environment and reduce negative impacts from flooding. The National Flood Insurance Program (NFIP) is a voluntary program administered by the Federal Emergency Management Agency (FEMA) in which communities agree to adopt and enforce at least the minimum requirements established under the NFIP for all development in mapped special flood hazard areas which encompass the one-percent-annual-chance flood area (or 100-year flood). All residents in NFIP communities are then eligible to purchase flood insurance whether the structure is located in or outside a special flood hazard area as shown on FEMA's Flood Insurance Rate Maps (FIRMs).

All 17 coastal municipalities participate in the NFIP. All but two communities have adopted the NFIP minimum standards, which offer structures some protection from flood damage; however, communities are encouraged by FEMA and the NHOEP to adopt additional standards, such as freeboard, which is the most common higher

Madbury and Dover: Leaders in Floodplain Management

Two coastal municipalities currently enforce regulations that exceed the National Flood Insurance Program minimum standards. In 2009, Madbury adopted freeboard regulations, which require the lowest floor of new residential structures and manufactured homes to be elevated one foot above the base flood elevation. Madbury also adopted regulations that prohibit new buildings and certain other development in special flood hazard areas.



In 2015, Dover adopted freeboard regulations, which require the lowest floor of residential and non-residential structures that are new construction or substantial improvements to be elevated two feet above base flood elevation.

(Left: Floodplain management brochure distributed by the City of Dover to residents).

standard adopted by communities across the country. The NFIP minimum standard requires that the lowest floor of a structure be elevated at the base flood elevation (to the elevation to which floodwater is expected to rise to during a one-percent-annual-chance-flood). Freeboard is an additional height requirement above base flood elevation that provides a margin of safety against extraordinary or unknown risks.

As of September 2015, there were a total of 3,116 flood insurance policies in effect in New Hampshire's coastal zone with a total insured value of over \$650 million, both of which are approximately 34 percent of the state's totals. Figure 13 shows that Hampton holds 57 percent of those policies followed by Rye with 11 percent and Seabrook Beach Village District with six percent.⁴² Since 1978, there has been a total of over \$10 million in NFIP paid losses in the 17 coastal communities—approximately 20 percent of the state's total. As shown in Figure 14, Hampton has 43 percent of those losses followed by Rye with 16 percent and Exeter with 11 percent.⁴³

While FEMA-mapped FIRMs only consider historical flood extent, future sea-level rise scenario maps are mostly contained within the current 100-year floodplain, with minor incursions within the 500-year floodplain in the lowest lying areas. This also means that if sea-level rise reaches higher projections, today's one-percent-annual-chance floods could occur twice every day and the new one-percent-annual-chance flood would reach further upland. Figure 7 shows that in the seven Atlantic Coast municipalities, the one-percent-annual-chance floodplain could increase by several hundred acres in the future.

FIGURE 13. Percent of total NFIP policies in Coastal New Hampshire in September 2015.

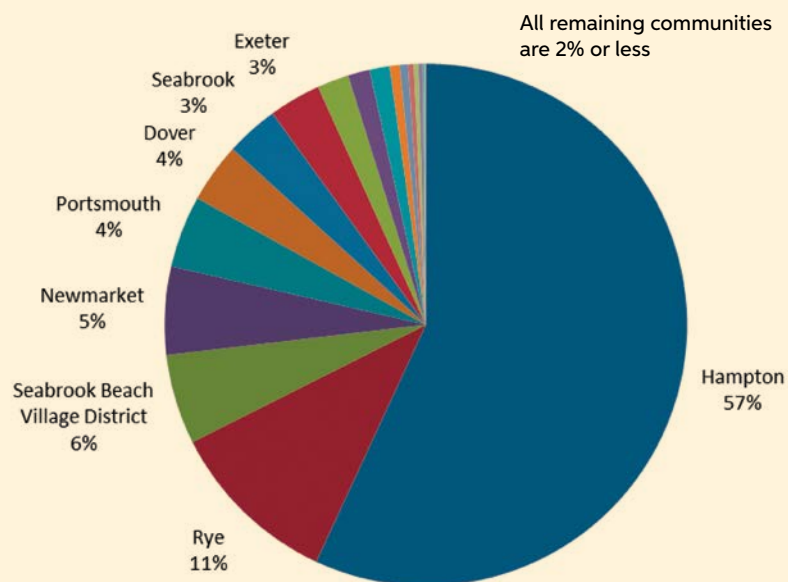
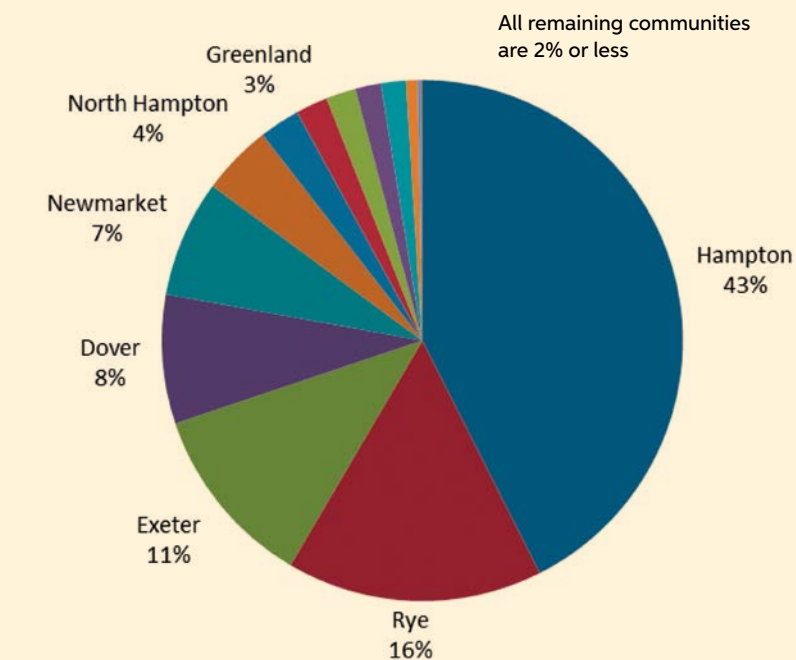


FIGURE 14. Percent of total NFIP paid loss amounts in Coastal New Hampshire since 1978.



4.3.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Built Landscape

- BL1.** Encourage state agencies and municipalities to complete vulnerability assessments for state, municipal, and regulated private structures and facilities. *[Lead: State Legislature; State Agencies; Municipalities].*

 - BL2.** Implement regulatory standards and/or enact enabling legislation to ensure that the best available climate science and flood risk information are used for the siting and design of new, reconstructed, and rehabilitated state-funded structures and facilities, municipal structures and facilities, and private structures. *[Lead: State Legislature; State Agencies; Municipalities].*

 - BL3.** Map the plausible future changes in freshwater and coastal floodplain extent and depth based on best available information about future precipitation and land use for all municipalities. *[Lead: State Agencies].*

 - BL4.** Integrate comprehensive land use and environmental planning with floodplain management approaches that prevent and minimize impacts from coastal hazards. *[Lead: State Agencies; Municipalities].*

 - BL5.** Document coastal and riverine shoreline conditions and assess vulnerability of natural features and engineered structures that protect people, structures, and facilities under current and future conditions. *[Lead: State Agencies].*

 - BL6.** Develop a comprehensive, integrated New Hampshire Coastal Shoreline Management Plan (CSMP) that presents general priorities for coastal shoreline management, as well as site-specific and place-based strategies including, where appropriate, protection, adaptation, and abandonment. *[Lead: State Agencies].*
-

4.4 Our Natural Resources



OUR NATURAL RESOURCES are the natural systems that that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, raw materials, and recreation opportunities.

4.4.1 How We Assess Vulnerability

The natural resources that draw residents, visitors, and businesses to southeastern New Hampshire are a cornerstone of our quality of life. Residents, visitors, and businesses depend on clean water for drinking, swimming, and boating; floodplains and wetlands provide water storage in extreme weather events and as water levels rise; oyster reefs and dune systems provide physical barriers to coastal storms; salt marshes and eelgrass beds are critical habitat for our commercial and recreational fisheries; our beaches draw hundreds of thousands of visitors that boost our state economy and tax income; and our forests and lands provide materials for heating, building and construction, and farm and food products like maple syrup. Together, our coastal natural resources provide important benefits to the people who live here.

Maintaining these benefits is critical to our economy, health, and safety. Yet, as our rivers, estuaries and ocean waters are impacted by extreme storm surge, sea-level rise, extreme precipitation, and other climate impacts, the physical and biological character of our coast is expected to change. Persistent coastal flooding and large

storms events already pose risks to the built landscape. Coastal natural resources like salt marshes and near shore ecosystems may be particularly affected due to their close proximity to various components of the built landscape such as roads, drainage facilities, buildings and utilities. Future decisions about how best to manage the built landscape may require trade-offs between public benefits and natural resource protection as both compete for space to adapt to changing conditions.

Sea-Level Rise Impacts on Species and Habitats

Higher water levels will drown salt marshes, deepen estuarine waters, and convert salt marsh to mudflats and mudflats to subtidal zones. Salt marshes are among the most productive ecosystems in the world, and in addition to wildlife habitat, they provide multiple benefits to humans including flood mitigation, healthy fisheries, storm protection, and long term carbon storage. Salt marshes may be able to migrate where the shore has a gentle undeveloped slope, but otherwise will not be able to keep up with sea-level rise and will disappear.⁴⁴ Modeling can indicate where ecosystems like salt marshes and eelgrass are most likely to be successful under future sea-level rise scenarios. To invest in restoration wisely, we will want to make sure the habitats we restore will survive future conditions.

Deeper estuarine waters will deplete eelgrass beds because the light necessary for eelgrass growth and survival will no longer penetrate to the estuarine floor. Rocky intertidal zones will migrate landward where conditions are favorable and disappear where conditions are unfavorable. Changing water levels may impact where fish and waterfowl feed and breed, and saltwater intrusion may change freshwater wetlands to brackish wetlands- altering the types of flora and fauna those systems can support. Rising groundwater levels due to changes in sea level and saltwater intrusion may also impact water resources including local aquifers and drinking water sources (municipal, private and commercial supplies), agricultural lands, and later the hydrology of forest ecosystems, and riparian ecosystems.

Storm Surge Impacts to Dunes, Salt Marshes and Estuaries

Storm surges disrupt dunes, salt marshes, and estuaries. These habitat types are critical to rare species like the saltmarsh sparrow and the piping plover. The sudden changes in salinity, water level, and sedimentation that storm surge causes can be devastating to coastal plants and animals and the habitat types that they depend on. Dunes protect structures and facilities as well as the habitat that lies behind them, and major storm surges would naturally push dunes “back.” When dunes do not have a natural path to retreat, they disappear and/or erode. High tides and storm surges will move dunes and may lead to barrier beaches being breached by large storm events. A major breach would change the salt marsh habitat behind the dunes, as well as the beach itself, and sedimentation from large storm events could also smother eelgrass and shellfish beds.

Running Out of Room: Saltmarsh Sparrows and Sea-level Rise



New Hampshire has three species of sparrows that depend on salt marsh habitat to survive: the saltmarsh sparrow, the seaside sparrow, and Nelson’s sparrow. All three species build their nests in the salt marsh, right on the high tide line. When there are unusually

high tides, the birds’ nests flood and their breeding success is compromised. As sea level rises, the critical breeding habitat for these birds is threatened if salt marshes cannot migrate inward. And if more extreme events cause higher water levels from precipitation or storm surge, the nests’ position at the high tide line makes them extremely vulnerable.

[\(Creative Commons License\)](#) | Photo credit Magnus Manske)

Extreme Precipitation Impacts on Natural Systems

Extreme precipitation will change the temporal distribution of fresh water to river and estuarine systems. In the marine environment, freshwater pulses may impact the timing and abundance of algal blooms and influence which species can enter the estuary to breed or feed. This could lead to changes in freshwater wetland systems, an important habitat for many of southern NH birds and amphibians. Increases in episodic water flow in floodplains may change the types of plants and animals that can live in and along our rivers. For example, many fish are sensitive to water temperature which is related both to storm events and to the types of shrubs and trees that live along the bank. With increased flooding both the shoreline species and the in water species will need to be able to adapt to a wider range of salinity and temperature conditions. Increased precipitation will also lead to an increase in untreated stormwater and, potentially, wastewater when combined sewer outflows are overwhelmed. Rising groundwater levels and increased precipitation could compromise the function of individual septic systems and both private and municipal stormwater management facilities. These system failures may result in increased transfer of pollutants to groundwater, surface waters, wetlands and estuarine systems. Pollutants adversely affect all natural systems and can lead to fish kills, oyster die offs, smothered eelgrass beds, and noxious algal blooms. Freshwater pulses and decaying algal blooms also contribute to ocean acidification. As the ocean becomes more acidic, shellfish and other marine organisms face mortality and reduced fertility.

Human Response to At-Risk Coastal Habitats

Natural systems are inherently adaptive. Most species and habitats can move, accommodate change and adapt to new surroundings if they have intact natural systems around them. Therefore the way that people react to rising seas, coastal storms, and riverine flooding can lead to the most serious threats to coastal ecology. Hardening shorelines to defend structures and facilities against flood and storm surge hazards alters the natural system, and prevents habitats and species from migrating landward as sea levels rise and coastal flooding occurs. Hardened structures also alter the hydrology of natural systems, diverting water and increasing runoff. Polluted runoff will increase as precipitation events increase, compounding the damage to natural systems. Human response to extreme coastal flooding or storm surge also compromises living resources, often deploying heavy equipment and structures intended to protect human lives and property.

The cumulative impact of these threats, in combination with climate-driven threats, will result in different conditions along the coast. In some cases, the species that have thrived in southeastern New Hampshire will have a difficult time adapting to changes in water level, salinity, sedimentation, and temperature. At the same time, opportunistic invasive species are likely to gain advantage over native species. This loss of biodiversity has a cascading effect on the natural systems ability to recover from disruption and maintain the functions (flood attenuation, recreational benefits, fisheries habitat) that people value.

4.4.2 Highlights of Vulnerabilities

Much work is being done to determine which natural coastal resources are vulnerable to climate change impacts in New Hampshire and to identify strategies to minimize risk to those natural resources. The 2015 NHFG Wildlife Action Plan presents substantial information about the vulnerabilities faced by New Hampshire species and ecosystems.⁴⁵

In one specific example, NHFG ran a model in 2014 to determine how coastal habitats, and specifically salt marshes, might respond to different sea-level rise scenarios. The model demonstrates where marshes have the ability to migrate landward, and if they will have the chance to do so before being drowned by rising water levels. Model results indicate that if sea level rises at a rate of 6.6 feet by 2100, we are likely to lose 240 of the 6040 acres of salt marsh we see today in just the next decade, and we are likely to reach a statewide “tipping point” where less than 300 acres of currently existing salt marsh remains by 2100.⁴⁶ Figure 15 demonstrates current

habitat distribution in the Hampton Seabrook Estuary: the yellow color represents salt marsh and the brown color represents mudflat.⁴⁷ Modeling indicates that under a scenario of 6.6 feet of sea-level rise by 2100, the habitat distribution changes dramatically, as seen in Figure 16 where there is almost no salt marsh present and the majority of the estuary is either open water or mudflat.⁴⁸

Impacts to the following natural resources were also evaluated as part of the Tides to Storm Vulnerability assessment for the Atlantic Coast municipalities: surface water; aquifers; freshwater and tidal wetlands; critical wildlife habitat; land protection priorities; conserved land; and agricultural soils. Figure 17 reports the number of acres of each natural resource affected by each sea-level rise and coastal storm surge scenario for Atlantic Coast municipalities. Similar statistical information will be developed for the Great Bay municipalities as part of the C-RiSE vulnerability assessment and will be incorporated into this section of the report upon completion.

Major freshwater river systems impacted by sea-level rise and coastal storm surge flooding include Cains Brook in Seabrook, Taylor River in Hampton, Little River in North Hampton, and Eel Pond in Rye. In the assessment of flood impacts to tidal wetland systems (identified from the National Wetland Inventory), only estuarine and marine wetland types above mean higher high water were evaluated. The data indicates greater acres of freshwater wetlands are flooded from sea-level rise and coastal storm surge than these estuarine and marine wetland types above mean higher high water. Portsmouth, Rye, Hampton and Seabrook have the greatest amount of conserved and public land within the coastal floodplain. Although impacted by sea-level rise and coastal storm surge flooding, these undeveloped lands serve as important flood storage areas and allow space for future habitat conversation and salt marsh migration.

FIGURE 15. Current Hampton-Seabrook tidal wetlands.

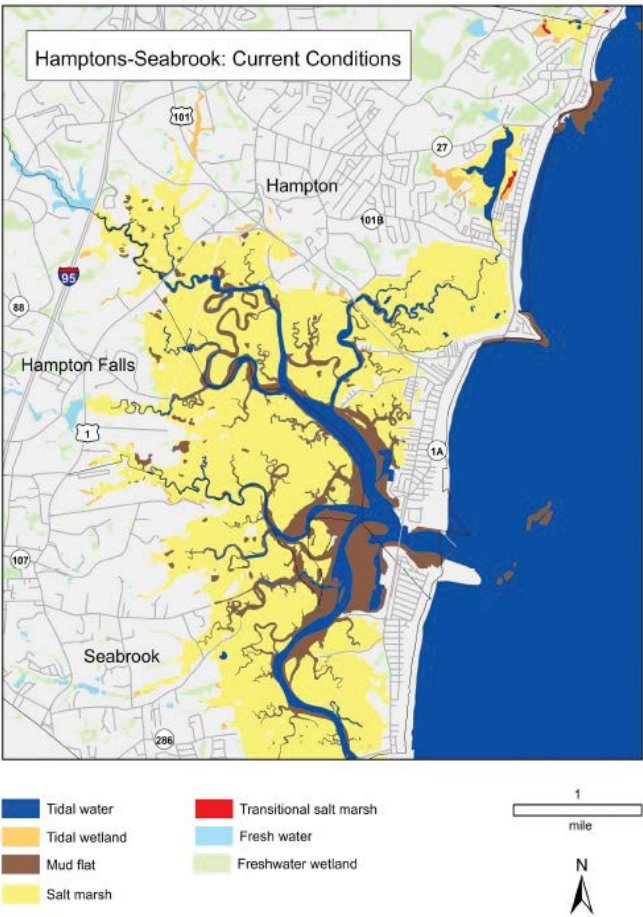


FIGURE 16. Modeled Hampton-Seabrook estuary wetlands in 2100 with 6.6 feet of sea-level rise.

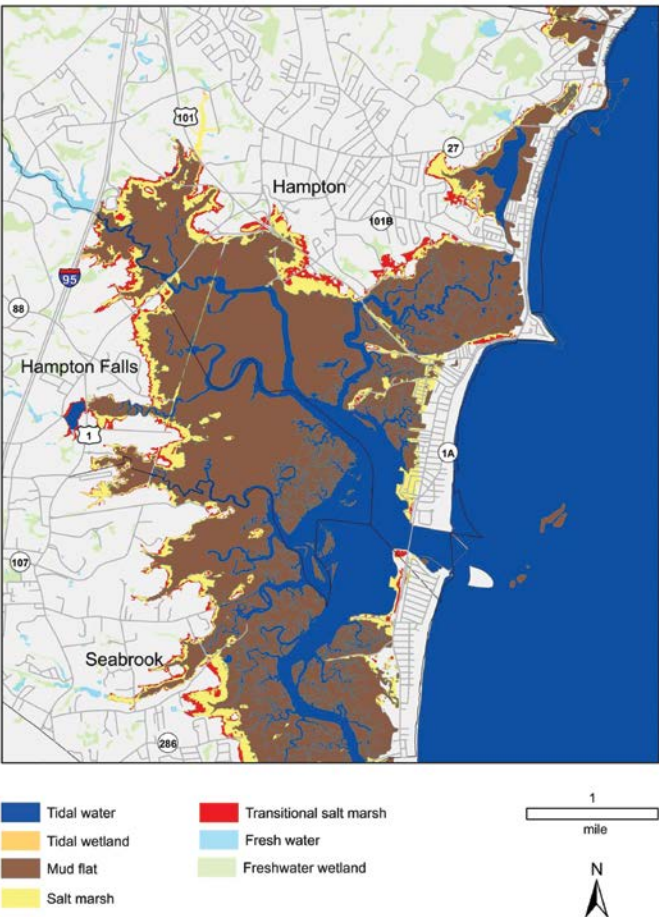


FIGURE 17. Natural resources (acres) affected by sea-level rise and coastal storm surge scenarios in Atlantic Coast municipalities.

Sea-Level Rise (SLR) Scenarios	SLR + 1.7 feet	SLR + 4.0 feet	SLR + 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Surface Water	49	134	144	144	152	156
Aquifers	8	24	56	48	87	122
Freshwater Wetlands	184	396	519	489	593	661
Tidal Water Wetlands	235	257	264	266	268	269
Critical Wildlife Habitat	4,022	4,851	5,469	5,385	5,948	6,458
Land Protection Priorities	1,081	1,600	1,915	1,865	2,112	2,310
Conserved Land	493	717	873	883	1,007	1,131
Agricultural Soils	123	378	678	620	937	1,238

To protect the plants, animals, and natural systems that New Hampshire values we need to understand how coastal hazards and risks might impact natural resources and prioritize management actions. Some actions, like land protection, suggested in this report can protect multiple species from both known and unknown impacts of climate change. It is important to recognize that some of the most significant threats to our natural resources may be associated with climate related threats that are not investigated by this commission; such as changes in air and water temperatures and water chemistry.

4.4.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Natural Resources

-
- NR1.** Identify and map natural resources that are vulnerable to current and future coastal risk and hazards. *[Lead: State Agencies].*
-
- NR2.** Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide. *[Lead: State Agencies; Municipalities].*
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- NR3.** Protect land that allows coastal habitats and populations to adapt to changing conditions and also provides ecosystem services that protect people, structures, and facilities. *[Lead: State Legislature; State Agencies; Municipalities].*
-
- NR4.** Encourage State agencies and municipalities to consider ecosystem services provided by natural resources in land use planning, master plans, and asset decisions. *[Lead: State Agencies; Municipalities].*
-
- NR5.** Assess the impact of freshwater and tidal crossings on adjacent tidal wetlands, aquatic organism passage, and public safety under existing and future climate conditions. *[Lead: State Agencies].*
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- NR6.** Assess current conditions of groundwater resources and impacts from best available climate science. *[Lead: State Agencies].*
-
- NR7.** Restore or maintain natural flow regimes (groundwater, surface water and wetlands) to increase ecosystem resilience to extreme weather events and other coastal hazards, including floods, drought, and sea-level rise. *[Lead: State Agencies].*
-

4.5 Our Heritage



OUR HERITAGE encompasses the abundance of recreational, cultural, and historic resources, including economic assets and elements of the built landscape, in coastal New Hampshire that our state and communities wish to protect in the face of coastal risk and hazards.

4.5.1 How We Assess Vulnerability

Recreational Resources

Recreational destinations can be directly vulnerable to coastal storm surges, sea-level rise, and extreme precipitation. Because the resources vary significantly, vulnerabilities can and should be assessed in a variety of ways. Depending on their geology, public coastal beaches may be at risk of long-term erosion from sea-level rise and extreme short-term erosion in coastal storms. Our public parks located near tidal waters may be vulnerable to sea-level rise and storm surge, however they may also be less sensitive to these impacts, serving as intentional flood storage areas during extreme events.

Indirect impacts to recreational resources will also affect their use by residents and tourists. If coastal habitats disappear with sea-level rise or more intense storms, then recreational fishing and birding may become less popular.

In order to fully understand how recreational resources are vulnerable to coastal risks and hazards, an assessment should evaluate both the physical exposure of recreational destinations to impacts, their sensitivity or capacity to bounce back after a shock, and finally, whether those resources can adapt to changes. For example, in the event that a beach destination is eroding, we must understand whether that beach should be renourished and if so, for how long. We could also evaluate whether alternative beach locations exist that could accommodate the recreational demand if that particular beach were to disappear.

Cultural and Historic Resources

Cultural resources are not a stand-alone or separate resource type. Cultural resources include historic buildings and districts, archaeological sites, and institutions such as museums and libraries. These represent the tangible histories of places, but also the histories and cultures of the people who have lived in these places. Cultural resources often survive because of the value in their ongoing uses; think of the Main Street areas of towns and cities and how they have adapted over time. Many of these resources have economic value as well as historic value (e.g. Main Street stores), recreational value (e.g. museums, parks), or functional value (e.g. bridges, dams, culverts). This multi-layered resource type makes historic resources even more valuable when looking at disaster

The Wentworth-Coolidge Mansion: A Vulnerable Historic Landmark



Photo credit: Andy Willey

The 18th-century Wentworth-Coolidge Mansion was home to New Hampshire's first Royal Governor Benning Wentworth, from 1753 to 1767. It is the only surviving residence of a Royal Governor in the United States. The mansion, listed in the National Register of Historic Places, sits on the banks of Little Harbor. Sea-level rise and storm mapping show that the grounds and part of the mansion are exposed to sea-level rise and storm surge. The site is managed by the New Hampshire Division of Resources and Economic Development (DRED) as a State Park. It is a popular tourist destination within the City of Portsmouth. DRED has identified the site as a priority for a detailed vulnerability analysis and preparedness planning.

recovery. Research shows that communities that retain a strong sense of place have a leg up on recovery efforts, as people will return to and invest in places where they have strong emotional and interpersonal ties.⁴⁹ A strong sense of place comes, in part, from a connection to the history of this place, demonstrated by the use of community landmarks. Therefore, protecting these resources protects the sense of place within communities and can accelerate recovery after a disaster.

Historic buildings and neighborhoods and archaeological sites are irreplaceable history, creating a sense of place in New Hampshire communities. Replacing them with modern buildings will not recreate the heritage; when they are lost, they are lost forever.

The built landscape in general is vulnerable to anything which may cause moisture damage, particularly extreme storms and flood. The high winds that come with extreme storms are also potentially damaging to structures and facilities. The increase in temperature, leading to more days around the freezing temperature, leads to more frequent freeze-thaw cycles; this causes damage to building materials, particularly wood and brick, which expand and contract with each cycle. Historic buildings may be more vulnerable than newer buildings in several respects. While they have stood the test of time, many older buildings may have deferred maintenance issues which can be worsened by storm-driven moisture. Additionally, historic neighborhoods in New Hampshire, especially the oldest developments along the coast, are along water ways as these were primary transportation corridors. These areas pre-date zoning, flood mapping, and other safety-minded planning concerns, which may mean they have mostly been built in areas that did not flood frequently, but also may mean that they are more vulnerable having been “grandfathered” into current rules. Additional survey and risk assessments are needed to determine the level of risk. With expected sea-level rise due to climate change, the historic flood plains are changing, and more buildings may be at risk of flood damage.

Archaeological sites also are vulnerable to coastal hazards. For most sites, gradual change in sea-level rise is of less concern than some of the other consequences of climate change. Underwater sites may survive intact. Most negative effects will come from higher storm surges, changes in storm tide levels, changing wave dynamics, extreme precipitation events, and flooding. These all have the potential to cause erosion, which exposes and damages, or even destroys, archaeological sites.

Another consequence of climate change that will affect cultural resources will be the effects on plant and animal (insect) communities and distributions; as temperatures change, whole ecosystems are likely to change. Changes in vegetation will result in changes to the degree of root damage and other biological activities resulting in impacts to subsurface archaeological deposits. Invasive plants and pests may affect buildings and structures, as well as historic landscapes. More controllably, the human response to climate change through adaptation and defense may also affect cultural resources if communities are unaware of their resources and where they are. Including cultural resources in planning will be the best way to mitigate unintended damage during clean up or adaptation projects.

4.5.2 Highlights of Vulnerabilities

Recreational Resources

While no comprehensive analysis has been done to understand the vulnerability of coastal recreational resources to climate change impacts, it is clear that some important recreation destinations are at risk of sea-level rise and coastal storms, such as the State and Town-owned beaches, as well as outdoor destinations like Strawberry Banke Museum in Portsmouth and exposed downtown areas such as Hampton’s Ocean Boulevard strip. Between 493 and 873 acres of existing conserved and public lands in the seven Atlantic Coast municipalities could be impacted under the 1.7 feet and 6.3 feet sea-level rise scenarios by the year 2100.⁵⁰ In a future one-percent-annual-chance storm event the number of acres impacted could reach up to 1,131 acres. These estimates have serious implications for publicly accessible recreation amenities. Additionally, adverse storm and sea-level rise impacts to natural resources like

fisheries and bird habitat could have detrimental effects on recreational activities in coastal New Hampshire. A more detailed assessment is needed to highlight specific vulnerabilities and prioritize areas for preparedness actions.

Cultural and Historic Resources

In order to determine the vulnerability of cultural resources to coastal area risks, data on surveyed resources and risk assessments will need to be compared. These assessments would yield hazards to known resources, as well as potentially at-risk areas about which little or nothing is known. Above-ground (architectural) and below-ground (archaeological) resources are different data sets and are therefore addressed separately.

New Hampshire towns center on a few key public or semi-public buildings. The Meetinghouse represents the need for communal gathering places for both decision making and socialization. The Toleration Act of 1819 separated state needs and religious needs, resulting in many independent church buildings and town halls or town houses, depending on who kept the original building. These physically represent this change in official state policy. Granges and libraries represent movements for education and social and political outlets. Domestic buildings, including factory worker housing, elaborate estates, and every variation in between are represented in the housing stock of each town. Factory and mill buildings remain from the industries that drove the economies of many towns, and Main Street commercial districts continue to offer business opportunities. The transportation and communication networks that tied these communities together have evolved over time, leaving physical remnants of their evolution. All of these features and more represent the tangible, irreplaceable heritage of our state and serve to make each community a unique representation of its own history and that history's reuse today.

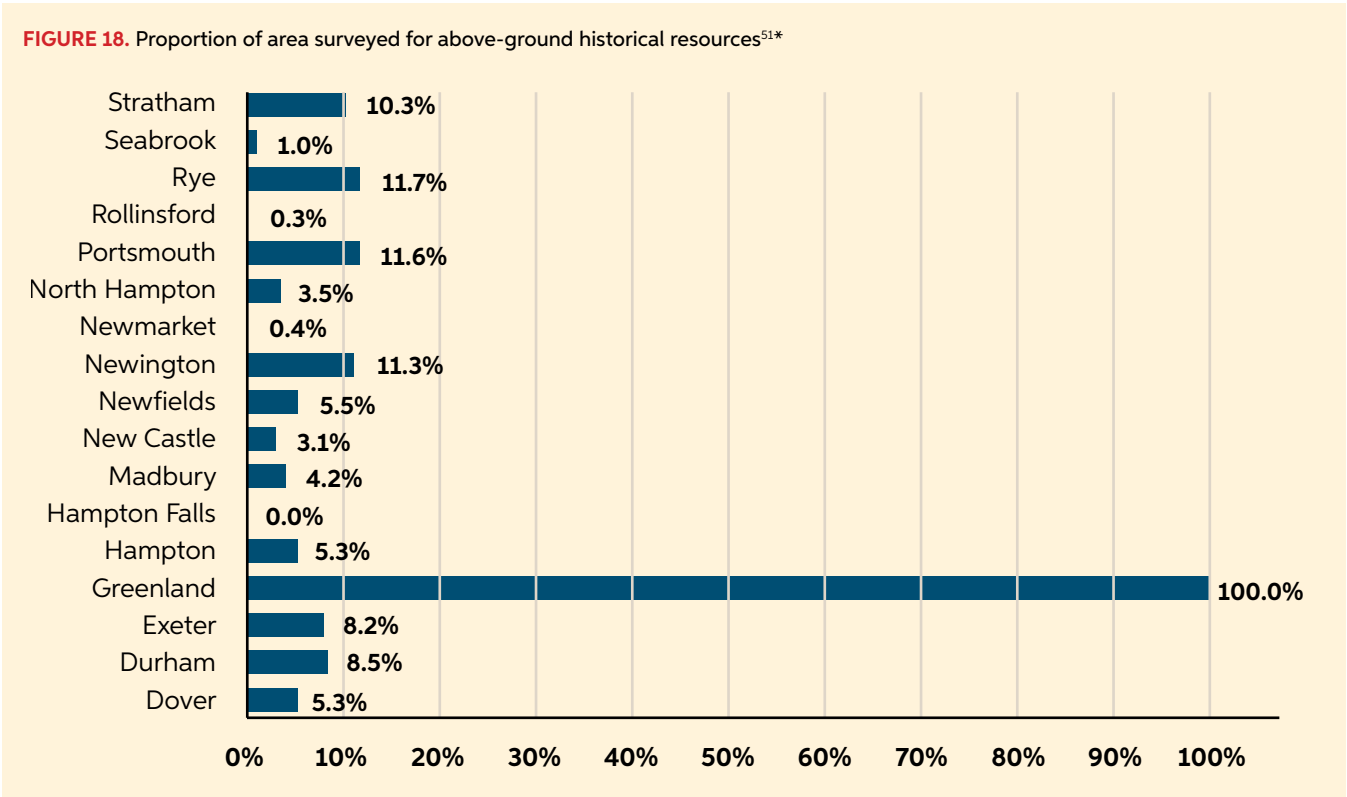
Coastal New Hampshire contains some of the oldest settlements in the state dating back 12,500-13,000 years before present (B.P.). During the earliest years of settlement the environment consisted of open tundra and lower sea levels than present day. It is suspected that many of the earliest sites dating to 10,000 B.P. along the Seaboard Lowland lie just offshore and are inundated. The remaining periods of Native American occupation and settlement from 8,000 years to European contact are well-represented in the archaeological record within the New Hampshire seacoast region. With exploration by the English beginning around 1603 in the region, and settlement beginning in the 1620s and 1630s, the cultural and historical resources of the seacoast and Great Bay regions of New Hampshire are a rich tradition that is key to the identity of the State of New Hampshire.

While the value of archaeological sites is partly scientific, revealing new information about the past, it is also social, providing opportunities for education, recreation, and reflection. Archaeological properties range from larger native village sites, historic forts, and tidal mills to smaller sites such as temporary encampments of native populations. Archaeological research carried out to date has identified 102 sites along New Hampshire's coastal margins and surrounding the Great Bay. The majority of sites relate to Native American occupation, but sites relating to European settlement are also represented. The identification of sites and systematic archaeological excavations and research has occurred only sporadically in this region through the years. Reliable reconstruction of the past depends on the recovery and examination of a range of archaeological sites from different periods across varying landscapes along coastal margins. Archaeological sites have revealed evidence of fishing practices and storage methods. Natural resources were also attractive and plentiful, including: fish, shellfish, crustaceans, birds, fish eggs and marine mammals. Europeans rapidly adapted Native American knowledge of fishing and seafood collection for subsistence. All of this information can be verified and expanded through the archaeological record.

Above-ground Resources (Architectural)

While datasets exist for the National Register of Historic Places and the New Hampshire State Register of Historic Places, the designation of these properties does not come from systematic review of the resources at hand and would not provide a good assessment of overall risk to historic properties.

Research in town file databases (above-ground survey of buildings, structures, and districts) show that, for above-ground resources (buildings, districts, structures), 15,034 acres of land have been surveyed in the 17 coastal municipalities, representing only 10.8 percent of the total area that could be surveyed. Figure 18 shows the proportion of area surveyed for above-ground historical resources. This does not mean that all of the unsurveyed areas contain historical resources. It means that at this time, we lack information to determine the presence of historic resources, and that basic baseline data is needed to fully assess the vulnerability of above-ground historical resources in the coastal region.



*Data does not include all National Register-listed properties, and includes only information in the databases as of this date. Dataset should not be considered complete and is included for informational purposes only.

Below-ground Resources (Archaeological)

There are 581 archaeological properties recorded in Rockingham and Strafford Counties, of these properties 102 sites are located below the 20 foot mean sea level and are threatened by climate change and its effects. The coast has always been an attractive settlement location and these resources represent the only record of the rich Native American cultures that once lived there.

The big vulnerability for cultural resources is that we do not know what we have or where it is. Many towns rely on the memories of local long-time citizens, volunteers in their historical societies and on heritage commissions. These are valuable sources of information, but not easily accessible to emergency planners, creators of hazard mitigation plans, or emergency responders, and the data aren’t available in digital or mapped formats. The NHDHR has been collecting information on historic resources for over 40 years, but as budgets have not kept up with the pace of technology, the majority of our information is not available in digital or mapped format. The NHDHR is currently working on GIS maps and digitization of records for six of the ten New Hampshire counties with funding from a National Park Service grant from Superstorm Sandy. The counties not covered by this project are Hillsborough, Merrimack, Cheshire, and Strafford, which means four of the communities covered by the Commission are not included in this project.

Additionally, more survey is needed to see where areas that have high potential for archaeological sites and/or historic buildings and structures may also be at high risk from natural disasters. The work done on community hazard mitigation plans and master plans that include chapters on cultural resources may be helpful in allowing communities to target high risk/high potential areas for future survey. Funding is needed to allow communities to both gather and analyze this material so that mitigation and adaptation plans can be discussed for at-risk resources.

4.5.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Heritage

- H1.** Identify and survey recreational resources and assess their vulnerability to coastal risk and hazards based on best available climate science. *[Lead: State Agencies; Municipalities].*

 - H2.** Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. *[Lead: State Agencies; Municipalities].*

 - H3.** Identify and survey cultural and historic resources and assess their vulnerability to coastal risk and hazards based on best available climate science. *[Lead: State Agencies; Municipalities].*

 - H4.** Require State agencies and encourage municipalities to develop long-term plans for protecting, adapting, or reducing risk to cultural resources affected by climate change. *[Lead: State Agencies; Municipalities].*

 - H5.** Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans. *[Lead: State Legislature].*
-

5. Understanding What We Need To Do

5.1 General Guidance for Responding to Coastal Flood Risk

In formulating its recommendations, the Commission considered existing approaches to establishing general design and construction standards for structures and facilities that have been considered and enacted in New Hampshire, other states, and at the Federal level. These guidance resources have been summarized in [Appendix C](#). Based on that research, the Commission lays out general guidance and planning principles for responding to coastal flood risk in New Hampshire.

Options for Responses

The increased risk of exposure to coastal flooding from storm surge, sea-level rise, and extreme precipitation raises a number of important issues that should be considered at the state, regional, and local levels. There are considerations that apply to our collective approach and response to this challenge as a state and as communities, as well as responses that apply to the specific asset classes affected (e.g. our economy, our built landscape, our natural resources, and our heritage). The options for responses can be divided into three categories.

1. Defend

This response employs primarily engineered solutions whereby specific sections or features of coastline are protected to prevent coastal erosion and the loss of structures and facilities from flooding—to “keep the water out.” Defense techniques can include natural and built systems. Examples of natural systems include creating or protecting or refurbishing existing sand dunes, vegetated and appropriately sized buffers along rivers and streams and intact wetland systems that can serve to absorb flood waters and wave energy. Built structures include seawalls, and dikes, revetments, and ablative defenses such as beach nourishment. There are also hybrids of built and natural defense strategies. Other states have utilized sea walls in certain areas with vegetated sections included. This approach enhances the look of the structure and offers additional benefits from natural defenses and other ecosystem services that vegetation can provide (habitat, food, shading etc.) Defensive strategies may be appropriate where total cost is not excessive relative to the value of the assets being protected or where safety of populations are at stake. In the case of continuing sea-level rise, the cost effectiveness of this strategy can be expected to decline over time as the cost to defend fixed assets and populations becomes progressively greater. At some point, safety may no longer be reasonably assured regardless of the built and natural defenses.

Adapting Our Coastal Communities Together

The New Hampshire Coastal Adaptation Workgroup (NHCAW) is a collaboration of 22 partners and organizations working to help communities in southeastern New Hampshire prepare for the effects of extreme weather events and other effects of long term climate change.



Photo by Cathy Coletti.

Since inception in 2010, NHCAW has led numerous projects and events that have elevated discussions about climate preparedness at municipal, state, and regional levels. NHCAW partners incorporate peer-reviewed science and research in the development of tools and technical guidance, and outreach in the coastal watershed to help communities better prepare for the effects of a changing climate in order to protect their social, economic, human and environmental health. For more information, refer to NHCAW’s website at www.nhcaw.org.

2. Accommodate

Accommodation combines engineered, natural, behavioral, and land use solutions to minimize flooding and, where possible, “live with water.” Common accommodate examples include elevating structures on pilings in flood prone areas and designing buildings to allow flood waters to enter the lowest floor while relocating vulnerable systems (heating/cooling units, electricity, and plumbing) to upper floors to avoid damage. Another accommodate strategy is the use of cleared natural drainage corridors for storm driven waves between the ocean and back channel sides of barrier islands. Accommodation usually happens incrementally in response to changing conditions; however, this incremental approach presents significant challenges in the case of linear facilities such as roads, sewer lines and other utilities. They must be modified in logical segments requiring a coordinated approach. The mix of accommodate strategies can be expected to change incrementally as some strategies lose effectiveness as the severity of the flooding impact progresses.

3. Retreat

This response involves abandoning or converting areas where the frequency and severity of flooding impacts are such that permanent settlement is no longer viable or desirable. This response could be undertaken quickly as the consequence of a government buyout or resettlement program (e.g., immediately after a severe flood), or it could occur slowly – the result of a growing inability to provide essential services, and of many independent decisions made over time by individual property owners to leave a vulnerable area because of rising costs, repeated loss, or unacceptable risk. Innovative regulatory methods such as rolling easements can facilitate incremental retreat by allowing the existing use of properties for as long as that remains viable, but prohibiting any shoreline armoring or other engineered protections.

In New Hampshire, and likely in other coastal states, the approach taken will be a combination of all three categories. Appropriate strategies will likely change over time as the degree of flood risk and exposure rises, requiring the State and municipalities to periodically reassess their responses.

Guiding Principles

Based on the science reviewed and documented in the STAP report, flood risk in the coast is rising, but the rate of that rise is uncertain. A response to defend a segment of coast that is sensible and cost effective in 2050, may become untenable in 2100. Making sensible long-term recommendations with this uncertainty is challenging, and requires flexible approaches. Nevertheless, there are some general guidelines and principles that are useful in making the best possible decisions along the way.

Act Early

Responding now to the future threat of coastal flooding will maximize long-term cost savings that result from building more resilient communities. Resilience is achieved in part by ensuring all current and future investments in facilities and structures can accommodate increases in flood levels expected over their design life without sustaining large losses. If all future new construction and major renovations in vulnerable areas incorporate resilient designs appropriate to the risk expected within the facility’s design life, communities can become incrementally more resilient over time. By starting now, the normal cycles of construction, replacement, and redevelopment can be harnessed to gradually replace substandard designs, often at minimal additional costs.

Communities that implement climate adaptation actions early may see many benefits, including but not limited to:

- Enhanced preparedness and community awareness of future flood risks
- Early identification of cost-effective measures to protect and adapt to changing conditions
- Improved resiliency of facilities, structures, and other community investments
- Protected life, property, and local economies

- Protected coastal natural resources and the critical services they provide
- Preserved historical assets and unique community character
- Additional credit points awarded through the NFIP Community Rating System (CRS), which provides flood insurance premium discounts for residents in participating communities

Respond Incrementally

The most difficult circumstance under which to take action in response to a future threat is when there is uncertainty about the degree of risk from that threat. This is especially true when the threat is distant in time and the cost of responding is high – such as with the coastal flooding threat from climate change. In coastal flooding there is risk both in over and under estimating the threat. If overestimated, actions may be taken that are unnecessarily expensive and disruptive. If underestimated significant losses in property, resources and even lives could result.

In these circumstances, an incremental and iterative approach is best, allowing multiple opportunities to refine and correct actions as understanding improves. An incremental approach can adjust to either gradual or catastrophic sea-level rise. At this juncture wholesale investment in hardened shoreline protection structures and major efforts to retreat are not necessary, though these strategies may be appropriate in select, isolated locations. Instead, improving resiliency and the ability to adapt to a wide range of scenarios is the best course of collective action.

Revisit and Revise

Over time, we expect projections of sea-level rise and other contributors to coastal flooding to become more certain and as they do, we will be better able to predict both the rate at which and by how much sea level is expected to rise. This refinement will allow estimates of vulnerability to become more precise as well. Likewise, our responses must keep pace with changes in understanding. It is vitally important that state and municipal officials periodically revisit these projections and assumptions and adjust the report’s recommendations accordingly.

Collaborate and Coordinate

The State and municipalities share built and natural assets on the coast and as a result, they need to align policies, assumptions, and responses about future coastal flood hazards to the greatest extent possible. Failure to coordinate such policies and actions will increase the cost and decrease the effectiveness of planning and preparation. Long-term planning and actions to prepare for future flood risk should be developed collaboratively between state, regional, and local governments.

Incorporate “Risk Tolerance” in Design

With respect to future coastal flood risk, structures, facilities, and other resources should be designed with high safety margins, however, in preparing for future hazards, not all situations warrant the same precautions. Risk tolerance is an important concept in creating sensible and flexible building and design standards. Buildings and facilities that are critical to public functions or safety, that are intended to last a very long time, or that are very expensive to replace should be considered to have “low risk tolerance.” Facilities and assets with low risk tolerance include (but are not limited to) hospitals, water treatment facilities, bridges, and utilities, as well as irreplaceable or unique historic sites, essential ecosystems, and high value economic assets. In other words these are assets we can’t afford to lose. Design standards should be high for facilities that have low risk tolerance, even if cost is higher to build or maintain them – because as a society we can’t afford to do otherwise. Conversely, facilities and structures that are low value, short-lived, easily replaced, or that don’t serve a critical function have a “high risk tolerance.” They do not necessarily require as much concern and can be designed to lower standards.

Make “No Regrets” Decisions

Generally a “no regrets” policy or approach refers to actions that yield benefits even under the lowest sea-level rise scenario.^{vi} More often than not, acting in ways that improve a community’s resilience to present-day risk and hazards will enhance its adaptive capacity to address longer term climate change impacts. Additionally, no regrets decisions should incur relatively low costs, or save money over the medium to long term. For example, elevating a pump station three feet above current base flood elevation will increase its ability to function during current coastal storm and flood events, regardless of how much sea level rises in the future. Not only will a functioning pump reduce flooding impacts, it may also remove the need and associated risk and costs for repairs or replacement during, or immediately following, an emergency or disaster.

5.2 STAP Guidance

As described in Section 3, The Science and Technical Advisory Panel (STAP) report synthesized the best available science regarding future estimates of storm surge, sea-level rise, and extreme precipitation. The STAP report includes several suggested planning guidelines for the three hazards identified in the STAP report: storm surge, sea-level rise, and extreme precipitation.

Storm Surge

The STAP recommends using probabilities of storm frequency and magnitude embodied in updated FEMA Federal Insurance Rate Maps for coastal New Hampshire.

Sea-level Rise

The STAP recommends that for coastal locations where there is **little tolerance for risk** to a built or natural asset; the range of sea-level rise (SLR) to consider in planning and design includes the ‘Intermediate High’ and ‘Highest’ scenarios (see Figure 2). The STAP suggests the following planning guidance to determine the appropriate range based on design life:

-
1. Determine the time period over which the system, structure, or facility is designed or desired to serve (either in the range 2014 to 2050, or 2051 to 2100).
-
2. If the design time period is 2014-2050, commit to manage to 1.3 feet of sea-level rise, but be prepared to manage and adapt to 2 feet if necessary.
-
3. If the design or desired time period is 2050-2100, commit to manage to 3.9 feet of sea-level rise, but be prepared to manage and adapt to 6.6 feet if necessary.
-
4. Be aware that the projected sea-level rise ranges may change and prepare to adjust design considerations if necessary. The choice of management strategies can include strategies to protect, accommodate or retreat from the flood risk.
-

For example, in the case of a new tide gate intended to last until 2075, the gate could be constructed for the Highest scenario (6.6 feet) now, which would be the most robust approach, or constructed for 2 feet of future sea-level rise now but in a manner that would facilitate expanding and raising the gate to protect against 3.9 or 6.6 feet of sea-level rise, if future assessments indicate that is necessary. This could be accomplished by designing

^{vi} The National Climate Assessment (2014) *lowest scenario* (0.7 feet by 2100), summarized by the STAP, assumes the historical rate of sea-level rise over the past century continues into the future and does not account for projected rapid changes in atmospheric and ocean temperatures over the 21st century, nor the projected rapid loss of ice from the Greenland and West Antarctic ice sheets.

and constructing the gate foundation for the 6.6 feet sea-level rise scenario while only constructing the gate for a 2-foot sea-level rise scenario. The choice of management strategies can include strategies to protect, accommodate, or retreat from the threat.

Extreme precipitation

For extreme precipitation the STAP recommends:

- If the design time period is 2014-2050, buildings and infrastructure should be designed to withstand extreme precipitation intensities based on the most current precipitation data^{vii}, with the assumption that a gradual increase in frequency of extreme precipitation events will occur over time.
- If the design period is 2050-2100, buildings and infrastructure should be designed to manage a 15 percent increase in the frequency of extreme precipitation events after 2050.

Over time, improved data collection, analysis, and modelling will provide better scientific understanding and higher confidence in projected future changes in storm surge, sea level, and extreme precipitation. Given the current limitations in providing narrow estimates of future conditions with high confidence, applying the concept of risk tolerance becomes important in determining how best to plan and design for the future. The STAP guidance strongly suggests that adaptive and flexible design that anticipates future flood scenarios become standard procedure for construction within vulnerable areas.

^{vii} Current precipitation data can be taken from the NOAA Atlas 14 (<http://hdsc.nws.noaa.gov/hdsc/pfds/>), the Northeast Regional Climate Center (<http://www.nrcc.cornell.edu/>), or more up to date or better resolution sources.

6. Our Goals, Recommendations, and Actions



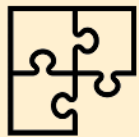
Four Goals for a Resilient Coastal New Hampshire – SAIL

The Commission has defined four goals for coastal New Hampshire that are paramount to managing our coastal risk and hazards so that municipalities along the Atlantic Ocean and surrounding the Great Bay estuary can be resilient in the face of climate changes, including changes in storm surge, sea level, and extreme precipitation. The four goals focus on **s**cience, **a**ssessment, **i**mplementation, and **l**egislation – “SAIL,” in honor of the New Hampshire state seal which features the frigate Raleigh, a warship built in Portsmouth in 1776, and a granite boulder in the foreground that, according to seal law, is “symbolic of the Granite State’s rugged terrain and the character of its citizenry.”^v



Goal 1: SCIENCE

Research, understand, establish, and use the best available science about current and future coastal hazards in New Hampshire relating to storm surge, sea-level rise, and extreme precipitation



Goal 2: ASSESSMENT

Identify assets and resources within our economy, our built landscape, our natural resources, and our heritage that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Goal 3: IMPLEMENTATION

Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future economy, built landscape, natural resources, and heritage.



Goal 4: LEGISLATION

Recommend timely considerations for legislation that leads to actions, both immediate and long-term, that reduce and/or eliminate vulnerability and result in adaptation to existing and future coastal hazards.

Who are these recommendations for and how will we achieve them?

Under each SAIL goal, the Commission identified key recommendations and actions that will help coastal New Hampshire prepare for and respond to coastal risk and hazards. In order to carry out the recommendations, and ultimately, achieve the SAIL goals, many different groups will need to work together. The recommendations are primarily directed to the State Legislature, State agencies, and municipal governments. Lead responsible parties—the entity most likely to lead and coordinate efforts to achieve the recommendation—are identified under each recommendation in parentheses; however it is important to note that every recommendation will require collaboration and coordination between the three primary audiences and additional public and private stakeholders.

^v <https://www.nh.gov/nhinfo/seal.html>.

The Commission recognizes that many of the recommendations will take time to achieve and require new funding and expertise. Additionally, the Commission recognizes that state agencies, municipalities, and other stakeholders have started to carry out some of the recommendations listed. The recommendations and the associated actions should be prioritized by the lead responsible parties based on the risk associated with the hazard addressed, the cost, and the ease of implementation. Additional details concerning the target timeframe and estimated budget to complete each recommendation and the associated actions should also be developed by responsible parties as they prioritize recommendations for implementation.

How are these recommendations organized?

The Commission makes **5 Science** recommendations and **30 Assessment and Implementation** recommendations. Of these 35 recommendations, **13** have **Legislative** implications. Assessment and Implementation recommendations are paired by subject and organized into four topic areas: **Our Economy**, **Our Built Landscape**, **Our Natural Resources**, and **Our Heritage**. **Cross-cutting** recommendations include recommendations that apply to all four of the topic areas. It is important to note that the topic areas overlap—some of the structures and facilities that comprise our built landscape may also be part of our heritage—so many recommendations could fit into multiple topic areas. These four topic areas help to organize the recommendations, but should not be seen as mutually exclusive categories.



OUR ECONOMY is the systematic and productive exchange and flow of goods, services and transactions that must be intact, functioning, and resilient to coastal risk and hazards in order to create and sustain jobs and a high quality of life in coastal New Hampshire.



OUR BUILT LANDSCAPE is the network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire. Our built landscape must be prepared to adapt and respond to coastal risk and hazards.



OUR NATURAL RESOURCES are the natural systems that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, raw materials, and recreation opportunities.



OUR HERITAGE encompasses the abundance of recreational, cultural, and historic resources, including economic assets and elements of the built landscape, in coastal New Hampshire that our state and municipalities wish to protect from coastal risk and hazards.

6.1 Science Recommendations



GOAL 1 is to research, understand, establish, and use the best available science about current and future coastal hazards in New Hampshire relating to storm surge, sea-level rise, and extreme precipitation.



S1. Legislatively authorize a state agency to convene a Science and Technical Advisory Panel to review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation and other relevant climate projections and provide planning guidance at least once every five years. [Lead: State Legislature].

ACTIONS:

- a. Establish a collaborative Science and Technical Advisory Panel and a lead state agency to coordinate updated information and recommendations.
- b. The Panel, lead agency, and other participating agencies develop a mechanism that ensures communication of the updated climate science and planning guidance to a wide range of stakeholders.

S2. Identify gaps in scientific information, work to fill existing scientific information gaps, and conduct quantitative analyses detailing coastal risk and hazards. [Lead: State Agencies].

ACTIONS:

- a. Improve coastal storm surge analysis by including wave effects and upland flooding impacts.
- b. Gather baseline data to improve analysis of coastal and riverine flood risks resulting from a combination of storm surge, sea-level rise, and extreme precipitation events in coastal areas directly exposed to the Atlantic Ocean and inland areas with tidal rivers, bays and marshes.
- c. Conduct additional applied research to better understand the following:
 - i. Flooding extent resulting from combined impacts of future climate and land use changes for upland and riverine communities and ecosystems.
 - ii. Capacity of natural resources like salt marshes and eelgrass beds to respond to projected changes in storm surge, sea level, and extreme precipitation.
 - iii. Changes in physical parameters, species composition, and ecological communities resulting from projected changes in storm surge, sea level, and extreme precipitation.
 - iv. Changes in the species food web that may endanger New Hampshire ecosystems resulting from projected changes in storm surge, sea level, and extreme precipitation.
 - v. Ecosystem services related to flood attenuation, physical protection from storms, and pollutant attenuation.
 - vi. Changes in frequency and severity of winter storm events resulting in large amounts of snow and ice pack and related impacts.
 - vii. Saltwater intrusion into groundwater and drinking water sources.
 - viii. Impacts of future drought conditions on groundwater and drinking water sources, natural resources, and other assets.
- d. Collaborate with science, planning and management professionals to determine current and future research gaps. The Panel established under Science Recommendation S.1 (a) could help coordinate this collaboration.

S3. Establish a central repository for spatial coastal hazards-related information, and assign and fund an entity to maintain and adapt this tool over time. [Lead: State Agencies].

ACTIONS:

- a. Identify the appropriate data repository for critical coastal information and a strategy for its funding and maintenance. Consider existing spatial databases, including the NH Coastal Viewer managed by NH GRANIT.
- b. Identify funding for on-going support of the coastal hazards data repository or database.
- c. Establish a mechanism to ensure adequate data sharing exists among state agencies and GRANIT for spatial coastal hazards-related information.

S4. Provide clear, concise, science-based information to inform and raise awareness of relevant audiences about the risks and vulnerabilities associated with coastal risk and hazards. [Lead: State Agencies].

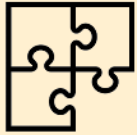
ACTIONS:

- a. Create and compile informational materials about coastal hazards, risks and vulnerability.
- b. Strengthen state, regional, and municipal capacities to better understand the best available science related to potential future impacts of climate change in order to improve decisions.
- c. Improve understanding of the concepts of uncertainty and risk and how they can be applied to decision-making and action planning.
- d. Partner with federal and state agencies as well as regional and local organizations to expand resources for education, outreach, and coordination.
- e. Identify and provide education and outreach to new audiences by partnering with new groups and by holding events at their established venues and meetings.
- f. Encourage the incorporation of climate science and information about the risks and hazards associated with changing climatic conditions in public school curriculum.
- g. Dedicate funding and technical support to implement science-based education and outreach efforts related to coastal risk and hazards.



S5. Augment state funding in support of applied research that improves understanding, modeling, and projections of current and future coastal risk and hazards in New Hampshire's coastal zone. [Lead: State Legislature].

6.2 Assessment & Implementation Recommendations: Cross-Cutting



GOAL 2 is to identify assets and resources within our economy, our built landscape, our natural resources, and our heritage that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



GOAL 3 is to Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future economy, built landscape, natural resources, and heritage.



The Crosscutting recommendations below include assessment and implementation recommendations that apply to all four of the topic areas: **Our Economy, Our Built Landscape, Our Natural Resources, and Our Heritage.**



CC1. Secure new and allocate existing funding sources for state agencies and municipalities to conduct vulnerability assessments of assets at appropriate scales and to implement adaptation strategies. [Lead: State Legislature; State Agencies; Municipalities].

Note: This recommendation summarizes the funding-related actions found throughout the assessment and implementation recommendations.

ACTIONS:

- a. Fund coastal vulnerability assessments and dissemination of results (see CC2 and BL1 (b)).
- b. Fund state agency audits of existing statutes and administrative rules (see CC3).
- c. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans (see CC5 (b)).
- d. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery (see CC 5(e)).
- e. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts (see CC6 (a)).
- f. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed (see CC6 (d)).
- g. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund (see CC6 (e)).
- h. Establish stormwater utilities to fund retrofits to existing development and future improvements (see E3 (b)).
- i. Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund) (see NR2 (d)).
- j. Establish dedicated funds and sources to support land preservation, restoration, acquisition of easements, and development rights to transfer vulnerable property to conservation lands (see NR3 (b)).
- k. Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans (see H5).



CC2. Identify vulnerable state and municipal assets at regional, municipal, and site-specific scales as appropriate. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Assess existing regional emergency services and evacuation routes and identify additional service needs, points, and routes where necessary.
- b. Collaborate with private sector representatives to evaluate and identify necessary improvements to emergency communications systems preparedness to ensure 911 and other critical communications services remain operational during emergencies and disasters.
- c. Develop site-specific vulnerability assessments for public assets at risk from increased coastal flooding based on the flooding scenarios presented in the Science and Technical Advisory Panel report, as amended.
- d. Provide local technical assistance to perform vulnerability assessments through collaborative partnerships and local and regional networks, such as the NH Coastal Adaptation Workgroup.
- e. Disseminate and share results from coastal vulnerability assessments with relevant audiences.
- f. Dedicate existing funding for coastal vulnerability assessments and dissemination of results.



CC3. Review whether existing state statutes and rules adequately permit state agencies and municipalities to prepare and adapt to best available climate science and impacts, and make recommendations for amendments or new regulations where necessary. [Lead: State Agencies].

ACTIONS:

- a. Require and provide funding for state agencies to evaluate and recommend necessary amendments to relevant statutes and administrative rules with respect to best available climate science, involving relevant stakeholders as appropriate. Relevant statutes and administrative rules include, but are not limited to, the following: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use.
- b. Review current practices to determine the most appropriate buffer and setback distances, freeboard, shoreline treatment, and other design standards and approaches needed to provide adequate levels of risk reduction and protection for at risk structures and facilities.
- c. Develop an approach to consolidate RSA 483-B Shoreland Water Quality Protection Act and RSA 482-A Fill and Dredge in Wetlands to create permitting efficiencies and allow for comprehensive management of tidal resources.
- d. Assess the status of existing state agency, municipal, and other disaster response and recovery plans, and determine whether new procedures or regulations are necessary to enable response and recovery planning at state and municipal levels.
- e. Identify and recommend modifications to state and local building codes necessary to protect against likely changes in flooding and other coastal hazards.



CC4. Amend state laws and rules to incorporate consideration of best available climate science and weather-related data. [Lead: State Legislature].

ACTIONS:

- a. Adopt amendments to state statutes and administrative rules identified under Cross-cutting Recommendation CC3, including, but not limited to: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use Taxation.



CC5. By 2019^{vi}, state agencies will consider and use best available climate science in their activities and plans. [Lead: State Legislature].

ACTIONS:

- a. Establish the Science and Technical Advisory Panel report (see Science Recommendation S1), as amended, as state agency and municipal guidance about anticipated future climate and coastal flooding conditions.
- b. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans.
- c. Establish a mechanism to monitor state agency and municipal use of Science and Technical Advisory Panel findings and recommended approaches to risk management.
- d. Require state agencies to address current and future coastal risk and hazards in preparation, response, and recovery plans.
- e. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery.



CC6. Make existing structures and facilities more resilient and acquire properties in high risk areas in order to reduce or eliminate flooding impacts. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts.
- b. Elevate existing at-risk structures and implement higher freeboard standards above the Base Flood Elevation on new and substantially reconstructed structures and facilities to protect from future flood risks (see BL2 for more detail).
- c. Acquire at-risk and repetitive loss properties to create buffers and open space that facilitate restoration of floodplain functions.
- d. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed.
- e. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund.

^{vi} This timeframe was determined to be acceptable by the state agencies on the NH Coastal Risk and Hazards Commission.



CC7. Encourage municipalities to incorporate coastal hazards, risks and vulnerability in policies, plans and investments. [Lead: Municipalities].

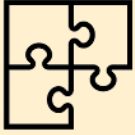
ACTIONS:

- a. Evaluate deficiencies and barriers in municipal regulations, plans and policies, and their implications for regional vulnerability.
- b. Incorporate coastal hazards and risks assessments in municipal emergency management and hazard mitigation plans, natural hazards and climate change adaptation chapters for Master Plans, and emergency management plans.
- c. Encourage municipalities to develop detailed preparation, response and recovery plans that build on existing plans and initiatives.
- d. Encourage municipalities to adopt buffers and setbacks that better account for risk and vulnerability of structures, facilities, and natural resources and maintain ecosystem services (e.g. flood storage, storm surge attenuation, reduced impacts to public structures and facilities, and private property).
- e. Incorporate vulnerability assessment information and adaptation strategies for structures and facilities planning and investment for long term capital projects in municipal Capital Improvement Programs (CIPs).
- f. Improve connections between municipal hazard mitigation plans, master plans and capital improvement plans.
- g. Identify and reduce existing inconsistencies between municipal plans and state plans, such as hazard mitigation plans, building codes, design standards, and evacuation plans.
- h. Consider the concepts of uncertainty and risk in decision-making and action planning.



CC8. Establish an adaptation coordinator to monitor and coordinate implementation of the NH Coastal Risk and Hazards Commission recommendations. [Lead: State Legislature].

6.3 Assessment & Implementation Recommendations: Our Economy



Identify economic assets that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement adaptation strategies that will enable the State and coastal municipalities to protect, adapt, and sustain our current and future economy.



Our Economy is the systematic and productive exchange and flow of goods, services and transactions that must be intact, functioning, and resilient to coastal risk and hazards in order to create and sustain jobs and a high quality of life in coastal New Hampshire.



- E1. Identify vulnerability of sector-based economic assets, including but not limited to tax base, workforce and jobs, property values, insurance costs, trade facilities, and public recreational facilities based on best available climate science. [Lead: State Agencies; Municipalities].**



- E2. Incorporate best available climate science and vulnerability assessment information in state, regional, and municipal economic development plans. [Lead: State Agencies; Municipalities].**

ACTIONS:

- Encourage private property owners and businesses to incorporate best available climate science and vulnerability assessments in their decision making and preparedness plans.
- Consider vulnerabilities of local tax base, state economic development plan, retention or replacement of economic resources, at risk populations and population migration.
- Improve management, coordination and delivery mechanisms to ensure continuity of services to essential facilities, people, businesses and employment centers.



- E3. Use appropriate and available mechanisms, including but not limited to incentives and market-based tools to fund climate adaptation strategies. [Lead: State Agencies; Municipalities].**

ACTIONS:

- Align land acquisition and easement programs to transfer vulnerable properties into conservation.
- Establish stormwater utilities to fund retrofits to existing development and future improvements.
- Develop and utilize tools to identify cost effective strategies and public investments for adapting to increased flood risk in vulnerable areas.
- Develop special overlay districts, tax credits and revolving loan funds as mechanisms to discourage development in vulnerable areas.

- e. Implement voluntary transfer of development rights programs and other economic incentives to acquire or conserve property in high risk areas.
 - f. Create statewide and municipal funding programs for climate adaptation strategies.
 - g. Adapt economic development planning approaches to respond to changing environmental conditions and leverage shifting opportunities.
 - h. Promote resilience and sustainability planning as economic development strategies.
-

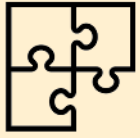


E4. Improve information available to property owners and prospective buyers about coastal hazards and vulnerabilities. *[Lead: State Agencies; Municipalities].*

ACTIONS:

- a. Improve consumer protection disclosure of properties vulnerable to coastal flooding.
 - b. Distribute flood protection safety information to property owners in high-risk areas.
 - c. Encourage homeowners in moderate- to low-risk areas to purchase Preferred Risk Policy.
-

6.4 Assessment & Implementation Recommendations: Our Built Landscape



Identify assets (i.e., structures and facilities) in our built landscape that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future built landscape.



Our Built Landscape is the network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire. Our built landscape must be prepared to adapt and respond to coastal risk and hazards.



BL1. Encourage state agencies and municipalities to complete vulnerability assessments for state, municipal, and regulated private structures and facilities. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- Use initial assessments to identify need for more detailed assessments.
- Require and secure funding for state agencies to conduct vulnerability assessments of state-owned structures and facilities located in the coastal zone at regional, municipal, and/or site-specific scales as appropriate.



BL2. Implement regulatory standards and/or enact enabling legislation to ensure that the best available climate science and flood risk information are used for the siting and design of new, reconstructed, and rehabilitated state-funded structures and facilities, municipal structures and facilities, and private structures. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- Adopt amendments to state and local building codes recommended under Cross-cutting Recommendation CC3.
- Require state agencies, through legislation or amendment to NH Executive Order 96-4^{vii}, to use one of the following approaches^{viii,ix,x} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for state-funded new construction, substantial improvement, or repairs to substantially-damaged structures and facilities:
 - Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xi}

^{vii} NH Executive Order 96-4 directs State agencies to comply with the floodplain management requirements of all local communities participating in the NFIP in which State-owned properties are located.

^{viii} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{ix} See Guidelines for Implementing Executive Order 13690.

^x See [Appendix G](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xi} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

- ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xii} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- c. Encourage municipalities to use one of the following three approaches^{xiii,xiv,xv} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for new construction, substantial improvement, or repairs to substantially-damaged municipal and private structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xvi}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xvii} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- d. Amend the New Hampshire Stream Crossing Guidelines to incorporate anticipated future stormwater flows based on best available climate science.
- e. Incorporate the Science and Technical Advisory Panel report information, as amended, into benefit-cost analyses for applications submitted under FEMA Hazard Mitigation Assistance and Public Assistance grant programs. In relevant cases, consider timeframes for potential future relocation or retreat by acquiring at-risk properties.
- f. Require, through legislation or other means, that the New Hampshire Site Evaluation Committee and Public Utilities Commission take future sea-level rise and coastal flooding into account in project siting decisions and other planning.



BL3. Map the plausible future changes in freshwater and coastal floodplain extent and depth based on best available information about future precipitation and land use for all municipalities. [Lead: State Agencies].

ACTIONS:

- a. Use the Lamprey River Watershed study or other similar methods for projecting future riverine floodplain extents and vulnerabilities for rivers within the coastal watershed and apply results as appropriate in municipal policy and planning (see BL4(b) for more detail).
-

^{xii} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

^{xiii} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xiv} See Guidelines for Implementing Executive Order 13690.

^{xv} See [Appendix G](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xvi} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xvii} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.



BL4. Integrate comprehensive land use and environmental planning with floodplain management approaches that prevent and minimize impacts from coastal hazards. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Establish minimum regulations at state and municipal levels that consider vulnerability assessment information to support appropriate amendments to building codes, floodplain management, fluvial erosion hazard zones, and stormwater management.
- b. Create and encourage adoption of local flood hazard overlay districts that include higher development standards that minimize impacts from natural hazards and climate change.
- c. Promote land development regulations that reduce vulnerability and protect ecosystem services (e.g. open space/cluster development).
- d. Prepare watershed-based plans that address comprehensive water resource management principles focused on changes in hydrologic systems resulting from climate change.
- e. Consider prohibiting development in areas destroyed by storms, experiencing repetitive loss of structures, and subject to chronic flooding and erosion. Consider adaptive reuse and/or acquisition of at-risk private properties.



BL5. Document coastal and riverine shoreline conditions and assess vulnerability of natural features and engineered structures that protect people, structures, and facilities under current and future conditions. [Lead: State Agencies].

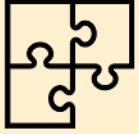
ACTIONS:

- a. Establish a beach monitoring program to collect long-term data regarding beach erosion, sea-level rise, landform changes, and sediment characteristics and processes.
- b. Identify areas where erosion and shoreline instability exist.
- c. Identify potential sites for nature-based approaches to shoreline stabilization.
- d. Prioritize areas for beach nourishment and other shoreline stabilization techniques.



BL6. Develop a comprehensive, integrated New Hampshire Coastal Shoreline Management Plan (CSMP) that presents general priorities for coastal shoreline management, as well as site-specific and place-based strategies including, where appropriate, protection, adaptation, and abandonment. [Lead: State Agencies].

6.5 Assessment & Implementation Recommendations: Our Natural Resources



Identify our natural resources that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future natural resources.



Our Natural Resources

are the natural systems that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, and recreation opportunities.



NR1. Identify and map natural resources that are vulnerable to current and future coastal risk and hazards. [Lead: State Agencies].

ACTIONS:

- Identify where habitats and biological populations would naturally shift in response to best available climate science to prioritize areas and species for protection or restoration.
- Map natural resources that also protect critical built landscapes.
- Utilize marsh migration modeling to identify and prioritize marsh migration areas for conservation and restoration.
- Identify potential changes, and in particular losses, to ecosystem services as a result of sea-level rise and storm surges and compare to current conditions.



NR2. Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide. [Lead: State Agencies; Municipalities].

ACTIONS:

- Include protection of natural systems and services, human well-being and protection of built environments in natural resource restoration plans (i.e. water quality, habitat, flood storage).
- Provide recommendations and incentives for removal of structures and facilities, such as freshwater and tidal crossings, that create barriers to tidal flow and habitat migration, particularly those that will be impaired or severely impacted by sea-level rise, storm surge, or extreme precipitation.
- Engage in best practices for invasive species planning and removal and incorporate climate considerations in invasive species removal plans.
- Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund).
- Invest in coastal dune restoration projects.
- Evaluate and apply sediment application techniques, where feasible, to maintain tidal marsh systems.



NR3. Protect land that allows coastal habitats and populations to adapt to changing conditions and also provides ecosystem services that protect people, structures, and facilities. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Use emerging habitat science to prioritize land and resource conservation projects.
- b. Establish dedicated funds and sources to support land preservation, acquisition of easements, and development rights to transfer vulnerable property to conservation lands.
- c. Prioritize land conservation efforts to adequately account for future sea-level rise and coastal flooding.
- d. Establish buffer requirements for setbacks to rivers, shorelines, and wetlands that include consideration of climate change and create a dedicated fund to support local enforcement.
- e. Encourage landowners to preserve the beneficial functions of natural features like wetlands and to restore and protect coastal dune habitat.
- f. Align land acquisition and conservation easement programs to protect important natural resources and ecosystem services.
- g. Protect future marsh migration areas identified by marsh migration modeling.



NR4. Encourage state agencies and municipalities to consider ecosystem services provided by natural resources in land use planning, master plans, and asset decisions. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Modify NHDES permit requirements and municipal standards to require implementation of stormwater best management practices (BMPs) and low impact development (LID) management systems to minimize impacts and maintain aquatic habitats.
- b. Implement strategies and tools (such as land regulations, incentives, building regulations) designed to maintain or restore pervious surfaces, provide nutrient barriers, protect vegetated buffers and maintain wildlife passage.
- c. Recommend standards for state-issued permits and municipal zoning regulations that protect natural floodplain functions.
- d. Develop watershed-based comprehensive water resource management plans that consider impacts of climate change.
- e. Develop best management practices for shoreline buffers, including information on appropriate use of shoreline hardening, bank stabilization, vegetation restoration and agricultural practices.
- f. Explore options to minimize shoreline hardening and promote natural or hybrid shoreline protection strategies.
- g. Create shoreline management standards that help stabilize banks for more frequent storm events, wave impacts, or higher volume flows (e.g. by using natural vegetation and proper building setbacks).
- h. Develop guidelines and provide incentives for communities to incorporate climate adaptation actions for wildlife protection in master plans, hazard mitigation plans, and zoning ordinances.



NR5. Assess the impact of freshwater and tidal crossings on adjacent tidal wetlands, aquatic organism passage, and public safety under existing and future climate conditions. [Lead: State Agencies].

ACTIONS:

- a. Continue the NHDES freshwater culvert inventory program (SADES).
- b. Develop methodology for assessing tidal crossings and implement assessment protocol throughout coastal NH.
- c. Prioritize tidal crossing replacement projects and restoration opportunities based on environmental and resiliency criteria.
- d. Conduct feasibility analysis and due diligence inquiries on prioritized tidal crossing projects.
- e. Assess the impacts of future increased precipitation and stormwater on surface water resources.



NR6. Assess current conditions of groundwater resources and impacts from best available climate science. [Lead: State Agencies].

ACTIONS:

- a. Assess location, quality and quantity of groundwater under current and future climate conditions.

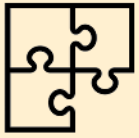


NR7. Restore or maintain natural flow regimes (groundwater, surface water and wetlands) to increase ecosystem resilience to extreme weather events and other coastal hazards, including floods, drought, and sea-level rise. [Lead: State Agencies].

ACTIONS:

- a. Improve designs for dams, culverts and bridges to maintain existing function and reconnect fragmented surface waters (wetlands, lakes, ponds, rivers and streams) to provide higher quality habitat for aquatic organisms and the ability to improve resilience of these systems.
- b. Work with Federal Energy Regulatory Commission, NHDES Wetlands, Dam and Watershed Management Bureaus to ensure habitat connectivity and resilience to help sustain intact coastal ecosystems.
- c. Adopt ecosystem-friendly approaches in the placement and design of freshwater and tidal stream crossing facilities. For example, appropriate sizing for new culverts, identify undersized culverts, and identify dams that need improvements to protect aquatic habitats.
- d. Comprehensively manage groundwater resources to consider infiltration and recharge, water quality, and changes to groundwater levels and salinity from sea-level rise.

6.6 Assessment & Implementation Recommendations: Our Heritage



Identify our recreational, cultural, and historic resources, including economic resources and elements of the built landscape, that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement adaptation strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain current and future recreational and cultural resources.



Our Heritage

encompasses the abundance of recreational, cultural, and historic resources, including economic assets and elements of the built landscape, in coastal New Hampshire that our state and municipalities wish to protect from coastal risk and hazards.



H1. Identify and survey recreational resources and assess their vulnerability to coastal risk and hazards based on best available climate science. [Lead: State Agencies; Municipalities].



H2. Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Conduct public information hearings to understand the impacts of proposed climate adaptation strategies.
- b. Assess existing and future recreational areas for their potential to provide storage for flood waters and stormwater runoff.
- c. Preserve open space and recreational areas that serve to minimize climate change impacts.
- d. Integrate recreational and open space planning into climate adaptation planning and the Comprehensive Shoreline Management Plan.
- e. Integrate protection of recreational resources into land use and management, engineering, regulatory components of state and municipal plans including the Coastal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design standards.



H3. Identify and survey cultural and historic resources and assess their vulnerability to coastal risk and hazards based on best available climate science. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Map all currently surveyed cultural and historical resources.
- b. Identify asset types that may also be cultural and historic resources.
- c. Use reconnaissance level survey and vulnerability assessments to identify high priority areas for intensive survey.



H4. Require state agencies and encourage municipalities to develop long-term plans for protecting, adapting, or reducing risk to cultural resources affected by climate change. [Lead: State Agencies; Municipalities].



ACTIONS:

- a. Create or modify adaptation strategies for cultural and historic buildings affected by climate change, including plans for protecting or relocating resources.
- b. Integrate protection of cultural and historical resources into land use and management, engineering, regulatory components of state and municipal plans including the Coastal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design guidelines.
- c. Establish expert group to create a decision-making process for property owners and municipalities to determine when and how to mitigate sites that will be lost.
- d. Establish guidelines for adaptation or risk reduction of cultural resources in state ownership.
- e. Create programmatic strategies to compensate for the loss of historic asset types that will be replaced in order to adapt to climate change impacts.
- f. Modify the Land and Cultural Heritage Investment Program (LCHIP) to include selection criteria that incentivize funding for climate adaptation actions.



H5. Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans. [Lead: State Legislature].



6.7 Legislation Recommendations



Goal 4 is to recommend timely considerations for legislation that leads to actions, both immediate and long-term, that reduce and/or eliminate vulnerability and result in adaptation to existing and future coastal hazards.



- S1. Legislatively authorize a state agency to convene a Science and Technical Advisory Panel to review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation and other relevant climate projections and provide planning guidance at least once every five years. [Lead: State Legislature].**

ACTIONS:

- Establish a collaborative Science and Technical Advisory Panel and a lead state agency to coordinate updated information and recommendations.
- The Panel, lead agency, and other participating agencies develop a mechanism that ensures communication of the updated climate science and planning guidance to a wide range of stakeholders.



- S5. Augment state funding in support of applied research that improves understanding, modeling, and projections of current and future coastal risk and hazards in New Hampshire's coastal zone. [Lead: State Legislature].**



- CC1. Secure new and allocate existing funding sources for state agencies and municipalities to conduct vulnerability assessments of assets at appropriate scales and to implement adaptation strategies. [Lead: State Legislature; State Agencies; Municipalities].**

Note: This recommendation summarizes the funding-related actions found throughout the assessment and implementation recommendations.

ACTIONS:

- Fund coastal vulnerability assessments and dissemination of results (see CC2 and BL1 (b)).
- Fund state agency audits of existing statutes and administrative rules (see CC3).
- Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans (see CC5 (b)).
- Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery (see CC 5(e)).
- Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts (see CC6 (a)).
- Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed (see CC6 (d)).
- Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund (see CC6 (e)).

- h. Establish stormwater utilities to fund retrofits to existing development and future improvements (see E3 (b)).
- i. Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund) (see NR2 (d)).
- j. Establish dedicated funds and sources to support land preservation, restoration, acquisition of easements, and development rights to transfer vulnerable property to conservation lands (see NR3 (b)).
- k. Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans (see H5).



CC3. Review whether existing state statutes and rules adequately permit state agencies and municipalities to prepare and adapt to best available climate science and impacts, and make recommendations for amendments or new regulations where necessary. [Lead: State agencies].

ACTIONS:

- a. Require and provide funding for state agencies to evaluate and recommend necessary amendments to relevant statutes and administrative rules with respect to best available climate science, involving relevant stakeholders as appropriate. Relevant statutes and administrative rules include, but are not limited to, the following: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use.
- b. Review current practices to determine the most appropriate buffer and setback distances, freeboard, shoreline treatment, and other design standards and approaches needed to provide adequate levels of risk reduction and protection for at risk structures and facilities.
- c. Develop an approach to consolidate RSA 483-B Shoreland Water Quality Protection Act and RSA 482-A Fill and Dredge in Wetlands to create permitting efficiencies and allow for comprehensive management of tidal resources.
- d. Assess the status of existing state agency, municipal, and other disaster response and recovery plans, and determine whether new procedures or regulations are necessary to enable response and recovery planning at state and municipal levels.
- e. Identify and recommend modifications to state and local building codes necessary to protect against likely changes in flooding and other coastal hazards.



CC4. Amend state laws and rules to incorporate consideration of best available climate science and weather-related data. [Lead: State Legislature].

ACTIONS:

- a. Adopt amendments to state statutes and administrative rules identified under Cross-cutting Recommendation CC3, including, but not limited to: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use Taxation.



CC5. By 2019^{xviii}, state agencies will consider and use best available climate science in their activities and plans. [Lead: State Legislature].

ACTIONS:

- a. Establish the Science and Technical Advisory Panel report (see Science Recommendation S1), as amended, as state agency and municipal guidance about anticipated future climate and coastal flooding conditions.
- b. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans.
- c. Establish a mechanism to monitor state agency and municipal use of Science and Technical Advisory Panel findings and recommended approaches to risk management.
- d. Require state agencies to address current and future coastal risk and hazards in preparation, response, and recovery plans.
- e. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery.



CC6. Make existing structures and facilities more resilient and acquire properties in high risk areas in order to reduce or eliminate flooding impacts. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts.
- b. Elevate existing at-risk structures and implement higher freeboard standards above the Base Flood Elevation on new and substantially reconstructed structures and facilities to protect from future flood risks (see BL2 for more detail).
- c. Acquire at-risk and repetitive loss properties to create buffers and open space that facilitate restoration of floodplain functions.
- d. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed.
- e. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund.



CC8. Establish an adaptation coordinator to monitor and coordinate implementation of the NH Coastal Risk and Hazards Commission recommendations. [Lead: State Legislature].



BL1. Encourage state agencies and municipalities to complete vulnerability assessments for state, municipal, and regulated private structures and facilities. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Use initial assessments to identify need for more detailed assessments.
- b. Require and secure funding for state agencies to conduct vulnerability assessments of state-owned structures and facilities located in the coastal zone at regional, municipal, and/or site-specific scales as appropriate.

^{xviii} This timeframe was determined to be acceptable by the state agencies on the NH Coastal Risk and Hazards Commission.



BL2. Implement regulatory standards and/or enact enabling legislation to ensure that the best available climate science and flood risk information are used for the siting and design of new, reconstructed, and rehabilitated state-funded structures and facilities, municipal structures and facilities, and private structures. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Adopt amendments to state and local building codes recommended under Cross-cutting Recommendation CC3.
- b. Require state agencies, through legislation or amendment to NH Executive Order 96-4,^{xxix} to use one of the following approaches^{xx,xxi,xxii} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for state-funded new construction, substantial improvement, or repairs to substantially damaged structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xxiii}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xxiv} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- c. Encourage municipalities to use one of the following three approaches^{xxv,xxvi,xxvii} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for new construction, substantial improvement, or repairs to both municipal and private structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xxviii}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xxix} structures and facilities.

^{xxix} NH Executive Order 96-4 directs State agencies to comply with the floodplain management requirements of all local communities participating in the NFIP in which State-owned properties are located.

^{xx} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xxi} See Guidelines for Implementing Executive Order 13690.

^{xxii} See [Appendix G](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xxiii} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xxiv} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

^{xxv} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xxvi} See Guidelines for Implementing Executive Order 13690.

^{xxvii} See [Appendix G](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xxviii} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xxix} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

- iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- d. Amend the New Hampshire Stream Crossing Guidelines to incorporate anticipated future stormwater flows based on best available climate science.
- e. Incorporate the Science and Technical Advisory Panel report information, as amended, into benefit-cost analyses for applications submitted under FEMA Hazard Mitigation Assistance and Public Assistance grant programs. In relevant cases, consider timeframes for potential future relocation or retreat by acquiring at-risk properties.
- f. Require, through legislation or other means, that the New Hampshire Site Evaluation Committee and Public Utilities Commission take future sea-level rise and coastal flooding impacts into account in project siting decisions and other planning.



NR3. Protect land that allows coastal habitats and populations to adapt to changing conditions and also provides ecosystem services that protect people, structures, and facilities. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Use emerging habitat science to prioritize land and resource conservation projects.
- b. Establish dedicated funds and sources to support land preservation, acquisition of easements, and development rights to transfer vulnerable property to conservation lands.
- c. Prioritize land conservation efforts to adequately account for future sea-level rise and coastal flooding.
- d. Establish buffer requirements for setbacks to rivers, shorelines, and wetlands that include consideration of climate change and create a dedicated fund to support local enforcement.
- e. Encourage landowners to preserve the beneficial functions of natural features like wetlands and to restore and protect coastal dune habitat.
- f. Align land acquisition and conservation easement programs to protect important natural resources and ecosystem services.
- g. Protect future marsh migration areas identified by marsh migration modeling.



H2. Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Conduct public information hearings to understand the impacts of proposed climate adaptation strategies.
- b. Assess existing and future recreational areas for their potential to provide storage for flood waters and stormwater runoff.
- c. Preserve open space and recreational areas that serve to minimize climate change impacts.
- d. Integrate recreational and open space planning into climate adaptation planning and the Comprehensive Shoreline Management Plan.
- e. Integrate protection of recreational resources into land use and management, engineering, regulatory components of state and municipal plans including the Coastal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design standards.



- H4. Require state agencies and encourage municipalities to develop long-term plans for protecting, adapting, or reducing risk to cultural resources affected by climate change. [Lead: State Agencies; Municipalities].**

ACTIONS:

- a. Create or modify adaptation strategies for cultural and historic buildings affected by climate change, including plans for protecting or relocating resources.
- b. Integrate protection of cultural and historical resources into land use and management, engineering, regulatory components of state and municipal plans including the Coastal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design guidelines.
- c. Establish expert group to create a decision-making process for property owners and municipalities to determine when and how to mitigate sites that will be lost.
- d. Establish guidelines for adaptation or risk reduction of cultural resources in state ownership.
- e. Create programmatic strategies to compensate for the loss of historic asset types that will be replaced in order to adapt to climate change impacts.
- f. Modify the Land and Cultural Heritage Investment Program (LCHIP) to include selection criteria that incentivize funding for climate adaptation actions.



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- H5. Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans. [Lead: State Legislature].**
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7. Definitions and Acronyms

Definitions

Atlantic Coast Municipalities	The seven New Hampshire municipalities in the coastal zone that are directly exposed to the Atlantic Ocean. Includes Hampton, Hampton Falls, North Hampton, New Castle, Portsmouth, Rye, and Seabrook.
Adaptation	Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.
Adaptive Capacity ⁵²	The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.
Built Landscape	The network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire.
Climate Effect	A direct result of climate change (e.g., an effect of climate change is that the average annual temperature is rising).
Climate Impact	A consequence of one or more climate change effects (e.g., rising average annual temperature (climate effect) may lengthen the agricultural growing season (climate impact) in some regions).
Climate-Ready	The state of being able to prepare for, adapt to, and respond after expected impacts of climate change. This can refer to a variety of entities, including a program, regulation, or entity like a municipality or State agency.
Coastal Hazard	Natural or human-induced physical events (e.g., hurricanes, nor easters, storm surge, sea-level rise, extreme precipitation) that may cause loss of life, injury or other health impacts, as well as damage and loss to property, facilities, livelihoods, and natural resources.
Coastal Risk ⁵³	The probability that coastal hazards will adversely affect a coastal area as determined by the combination of physical hazards and vulnerabilities of exposed elements.
Coastal Zone	New Hampshire's coastal zone includes the seventeen coastal municipalities bordering tidal waters in New Hampshire. Represents the geographical scope of the Coastal Risk and Hazards Commission.
Critical Action ⁵⁴	<p>Any action for which even a slight chance of flooding is too great. Critical actions include, but are not limited to, those which create or extend the useful life of structures or facilities:</p> <ol style="list-style-type: none">Such as those which produce, use or store highly volatile, flammable, explosive, toxic or water reactive materials;Such as hospitals and nursing homes, and housing for the elderly, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury during flood and storm events;Such as emergency operation centers, or data storage centers which contain records or services that may become lost or inoperative during flood and storm events; and such as generating plants, and other principal points of utility lines.

Cultural and Historic Resources	A district, site, building, structure or object that is significant in the history, architecture, engineering, archaeology or culture of this state, its communities, or the nation.
Ecosystem Services	The benefits humans derive from nature such as food and water, erosion and flood control, nutrient cycling, and recreation.
Exposure⁵⁵	The presence of people, livelihoods, environmental services and resources, structures, facilities, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage.
Extreme Precipitation	Precipitation falling as extreme events, defined by the 2014 National Climate Assessment and in this report as the largest one percent of daily events in a year. There are many other definitions of “extreme precipitation.”
Facility	Any man-made or man-placed item other than a structure. ⁵⁶ Examples include, but are not limited to, bridges and roads. The term “structure” is defined later in the glossary.
Great Bay Municipalities	The ten New Hampshire municipalities in the coastal zone that are not directly exposed to the Atlantic Ocean, but whose boundaries are exposed to tidal waters along Great Bay and its tributaries. Includes Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.
Infrastructure	A subset of the term “facilities,” as defined in this glossary. Often refers to roads and other transportation assets, wastewater and stormwater management facilities, and other facilities. Can also refer to natural resources that provide services similar to manmade infrastructure. For example, a salt marsh that cleans and provides flood storage for stormwater is a type of natural infrastructure.
Mean Higher-High Water	The average of all the higher of the two daily high water heights recorded at a particular point or station over a considerable period of time, usually 19 years.
Mean High Water	The average of all the high water heights recorded at a particular point or station over a considerable period of time, usually 19 years.
Mitigation	Any action taken to reduce or eliminate long term risk to people and property from natural hazards. For the purposes of this report, the term mitigation should not to be confused with climate change mitigation, which refers to efforts to reduce or prevent greenhouse gas emissions.
Natural Resources	The natural systems that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, raw materials, and recreation opportunities.
Nature-based Approaches	Features (sometimes referred to as green infrastructure or natural infrastructure) designed to mimic natural processes and provide specific services such as reducing flood risks and/or improving water quality. Nature-based approaches are created by human design (in concert with and to accommodate natural processes) and generally, but not always, must be maintained in order to reliably provide the intended level of service.

New Construction	The construction of a new structure (including the placement of a mobile home) or facility, or the replacement of a structure or facility which has been totally destroyed or is being upgraded. This definition does not override existing or future municipal definitions of this term.
Piscataqua Region (Coastal) Watershed	The land area from which water drains through the Hampton-Seabrook and Great Bay estuaries out to the Atlantic Ocean. Includes 42 municipalities in New Hampshire and portions of Maine and Massachusetts.
Resilience	The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.
Sea-level Rise	The increase in sea level primarily caused by two factors related to climate change: the added water from melting land ice and the expansion of sea water as it warms. The acronym SLR stands for sea-level rise.
Science	The NH Coastal Risk and Hazards Commission defines science as the knowledge about or study of the natural world based on facts learned through experiments and observation and published in peer-reviewed academic journals. Peer review is the evaluation of research methods and results by one or more people of similar competence (peers) to the producers of the research. Reviews are often completed anonymously. Peer review constitutes a form of self-regulation by qualified members of a profession within the relevant field. Peer review is used to maintain standards of quality, improve performance, provide credibility, and reduce the dissemination of unsubstantiated results and unacceptable interpretations. Publications that have not undergone peer review are regarded with a higher degree of skepticism by academics and scientists. Sources and additional resources can be found at: Merriam-Webster Dictionary, Science Magazine, Proceedings of the National Academy of Sciences
Storm Surge⁵⁷	The sea height during storms such as hurricanes that is above the normal expected at that time and place based on the tides alone.
Structures	Walled or roofed buildings, including mobile homes and gas or liquid storage tanks. ⁵⁸ The related term “facility” is defined earlier in the glossary.
Upland	Land currently above mean high-high water line (i.e., shoreline).
Vulnerability	The propensity or predisposition to be adversely affected, which results from diverse historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes.

Acronyms

CRHC	New Hampshire Coastal Risk and Hazards Commission
DHR	New Hampshire Division of Historic Resources (within NHDCCR)
DRED	New Hampshire Department of Resources and Economic Development
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
GBNERR	Great Bay National Estuarine Research Reserve (within NHFG)
HSEM	New Hampshire Department of Homeland Security and Emergency Management
LIDAR	Light Detection and Ranging
NHCAW	New Hampshire Coastal Adaptation Workgroup
NHDCCR	New Hampshire Department of Cultural Resources
NHDES	New Hampshire Department of Environmental Services
NHDOT	New Hampshire Department of Transportation
NHFG	New Hampshire Fish and Game Department
NFIP	National Flood Insurance Program
NHOEP	New Hampshire Office of Energy and Planning
NOAA	National Oceanic and Atmospheric Administration
PREP	Piscataqua Region Estuaries Partnership
RPC	Rockingham Planning Commission
SLR	Sea-level rise
SRPC	Strafford Regional Planning Commission
STAP	Science and Technical Advisory Panel
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey

8. Appendices

APPENDIX A: RSA 483-E

TITLE L

WATER MANAGEMENT AND PROTECTION

CHAPTER 483-E

COASTAL RISK AND HAZARDS COMMISSION

Section 483-E:1

[RSA 483-E:1 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:1 Commission Established. –

There is established a coastal risk and hazards commission.

Source. 2013, 188:1, eff. July 2, 2013.

Section 483-E:2

[RSA 483-E:2 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:2 Membership and Compensation. –

I. The members of the commission shall be as follows:

- (a) Two members of the house of representatives, appointed by the speaker of the house of representatives.
 - (b) Two members of the senate, appointed by the president of the senate.
 - (c) The commissioner of the department of environmental services, or designee.
 - (d) The executive director of the fish and game department, or designee.
 - (e) The administrator of the division of public works design and construction in the department of administrative services, or designee.
 - (f) The commissioner of the department of transportation, or designee.
 - (g) The director of the division of parks and recreation, or designee.
 - (h) The director of the division of historical resources, or designee.
 - (i) The president of the Seacoast Board of Realtors, or designee.
 - (j) The director of the New Hampshire Sea Grant, or designee.
 - (k) A representative of the New Hampshire Public Risk Management Exchange, appointed by the exchange.
 - (l) The director of the office of energy and planning, or designee.
 - (m) The president of the Homebuilders and Remodelers Association of New Hampshire, or designee.
 - (n) The commissioner of the department of resources and economic development, or designee.
 - (o) The president of the university of New Hampshire, or designee.
 - (p) A representative of the New Hampshire Municipal Association, appointed by that organization.
 - (q) A representative of the Strafford regional planning board, appointed by that body.
 - (r) A representative of the Rockingham regional planning board, appointed by that body.
 - (s) One representative of each of the following towns, appointed by his or her town's governing body: Rollinsford, Greenland, Stratham, Exeter, Newfields, Newmarket, Portsmouth, Rye, North Hampton, Hampton, Dover, Hampton Falls, Seabrook, Newington, New Castle, Madbury, and Durham.
- II. Legislative members of the commission shall receive mileage at the legislative rate when attending

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to the duties of the commission.

III. The members of the commission shall elect a chairperson from among the members. The first meeting of the commission shall be called by the first-named house member. The first meeting of the commission shall be held within 45 days of the effective date of this section. Eighteen members of the commission shall constitute a quorum.

Source. 2013, 188:1, eff. July 2, 2013. 2014, 327:68, eff. Aug. 2, 2014.

Section 483-E:3

[RSA 483-E:3 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:3 Duties. –

I. The commission shall recommend legislation, rules, and other actions to prepare for projected sea level rise and other coastal and coastal watershed hazards such as storms, increased river flooding, and storm water runoff, and the risks such hazards pose to municipalities and state assets in New Hampshire.

II. The commission shall review National Oceanic and Atmospheric Administration and other scientific agency projections of coastal storm inundation, and flood risk to determine the appropriate information, data, and property risks.

III. The commission shall meet 4 times per year.

IV. The commission shall annually report its findings and any recommendations for proposed legislation to the speaker of the house of representatives, the president of the senate, the house clerk, the senate clerk, the governor, and the state library on or before November 1.

Source. 2013, 188:1, eff. July 2, 2013.

To access the online version of this document, go to <http://www.gencourt.state.nh.us/rsa/html/I/483-E/483-E-mrg.htm>

APPENDIX B: Commission Alternates and Former Members

Alternates

Peter Bowman	New Hampshire Department of Resources and Economic Development— Division of Forests & Lands
Steve Couture	New Hampshire Department of Environmental Services
Liz Durfee	Strafford Regional Planning Commission
Brian Fitzgerald	Town of Rye
Mary Kate Ryan	Department of Cultural Resources
Ann Scholz	New Hampshire Department of Transportation

Former Members

Dr. Mimi Becker	Town of Exeter
Robert Cormier	New Hampshire Home Builders Association
Dr. Paul Kirshen	University of New Hampshire
Christopher Muns	Former Representative from Hampton, District 21
Vicki Quiram	New Hampshire Department of Environmental Services
Raymond Smith	Town of Seabrook
David Wood	Town of Hampton

APPENDIX C: Federal, New Hampshire, and Other State Guidance on Climate Change

As scientific findings have continued to emerge and modeling has improved, federal, New Hampshire, and other state government agencies have developed guidance and taken action to both reduce greenhouse gas emissions and prepare for the inevitable impacts expected as a result of climate change. This section summarizes some of the guidance and initiatives underway in federal agencies and in our state.

National Guidance and Actions on Climate Change

U.S. Global Change Research Program (USGCRP) and the National Climate Assessment

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” The GCRA requires that the USGCRP produce a National Climate Assessment every four years. The 2014 National Climate Assessment⁵⁹ synthesizes the current science and understanding about what climate changes are occurring, what future conditions are expected and how they may affect the United States. The 2014 Assessment is a coordinated, interagency resource that can be used to compare and estimate impacts and assess vulnerability.

Federal Flood Risk Management Standard (FFRMS)

The FFRMS was established by Executive Order 13690 in 2015 establishing new management guidelines for federal investments and programs that involve exposure to future flood risk. It serves as a set of general design standards for federally-funded projects (“Federal actions”) subject to coastal flooding and sea-level rise. The FFRMS establishes new criteria for determining future flood risk and requires federally funded projects and other actions to be designed to anticipate future expected flood conditions in addition to existing flood hazards; it anticipates these hazards to increase over time due to the effects of climate change and other threats. The key provision of the new policy is a change in the way federal agencies will determine whether or not a proposed federal “action” (e.g. federally funded and/or permitted projects) would be located within a flood hazard area. This determination is to be made using one of three methods:

1. climate informed science (state or regional-specific estimate of future flood exposure);
2. the minimum freeboard value, adding from 2 to 3 feet of additional elevation from existing base flood levels (depending on risk tolerance of the facility)
3. use the 0.2-percent-annual-chance (500-year) flood elevation as an interim planning value for future flood levels

The FFRMS, also incorporates a process by which an exception to these standards can be made under certain circumstances, relating to emergency, national security and in circumstances where their implementation would be counterproductive.

FEMA Climate Change Adaptation Policy

In January 2012, the Federal Emergency Management Agency (FEMA) issued a policy statement that established an agency-wide directive to integrate climate change considerations, adaptation planning and actions into FEMA’s programs and policies. The policy explicitly recognizes that the potential impacts from climate change may affect FEMA’s ability to effectively manage emergencies. The policy statement contains several key elements that the agency will employ to improve its capacity to manage in the face of climate change.

The key policy elements are to:

1. Enhance climate research, monitoring and adaptation capabilities.
2. Study the specific impacts of climate change on the National Flood Insurance Program (NFIP) and incorporate climate change considerations in future NFIP reform.
3. Evaluate how climate change considerations can be incorporated into grant programs and strategies, and especially on infrastructure.
4. Engage local communities in addressing and supporting climate change efforts.
5. Promote updated building standards and practices that consider the future impacts of climate change.

In March 2015, FEMA issued new guidance for the minimum required content of State Hazard Mitigation Plans. State plans must now consider the projected effects of climate change on natural hazards such as more intense storms, frequent heavy precipitation, heat waves, drought, extreme flooding, and higher sea levels because of their potential to significantly alter the types and magnitudes of hazards impacting states in the future. Specifically, the new guidance requires state plans to include climate projections and data, and to consider climate change effects in evaluating the probability of future hazard events.

Federal Highway Administration (FHWA) Guidance

As of the publication of this report, the Federal Highway Administration (FHWA) had not established design standards or guidelines that require projected acceleration of sea-level rise to be taken into account in highway and bridge design. FHWA has developed planning tools to facilitate consideration of climate change impacts in transportation systems design, including consideration of heat, precipitation, sea-level rise and storm surge.

In 2012 FHWA developed the **Climate Change and Extreme Weather Vulnerability Assessment Framework**, a voluntary process to help transportation agencies assess transportation asset vulnerability to climate change and extreme weather events. It recommends key steps to be followed in conducting vulnerability assessments and incorporating results into decision-making and provides modules and tools to aid in the assessment process. The framework encourages incorporating the results of the vulnerability assessment into the agency's decision-making process to ensure that the information is used in practice.

In 2008, FHWA published the **Highways in the Coastal Environment, Second Edition**⁶⁰ which reviews special factors to consider when designing transportation facilities in coastal areas, including areas prone to flooding and extreme events. The historical eustatic sea-level rise rate is reviewed as well as the possibility that these rates will accelerate as a consequence of ocean warming, however no recommended eustatic sea-level rise levels or scenarios for design purposes are provided.

FHWA's Climate Change Adaptation website provides resources, tools, and guidance to help local and regional transportation agencies implement the FHWA [**Climate Change and Extreme Weather Vulnerability Assessment Framework**](#), a guide to assessing the vulnerability of transportation assets to climate change and extreme weather events. The FHWA also provides a Virtual Framework for Vulnerability Assessment – [**Modules**](#).

U.S Department of Transportation (USDOT)

In 2013 the U.S Department of Transportation Volpe National Transportation Systems Center and the Office of Research, Development and Technology published a report entitled, "Climate Change Adaptation Support for Transportation Practitioners." The report lays the groundwork to support state and local practitioners as they proactively (or reactively) adapt to climate change impacts by:

- Developing a comprehensive database of relevant resources
- Categorizing and tagging those resources to make them more searchable
- Developing an “Expert System” concept to help practitioners quickly identify the resources most relevant to them, through a step-by-step guided approach
- Gathering feedback from USDOT agencies and practitioners to help refine the concept
- Presenting the concept to USDOT agencies and assisting with implementation

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers was one of the first Federal agencies to develop guidance requiring project planning and design to anticipate sea-level rise. The 2011 Circular (revised slightly in 2013) was developed with the aid of other agency experts from the National Oceanic and Atmospheric Administration and U.S. Geological Survey and incorporates sea-level change scenarios into its design requirements.⁶¹ The policy explicitly anticipates the continued acceleration of global mean sea-level rise. Key requirements are:

- Relative sea level change must be considered in all USACE coastal activities within the extent of tidal influence.
- Base level sea-level rise is to be considered from the history of recorded changes for a specific site.
- Project planning and design must consider how sensitive and adaptable natural and managed ecosystem, and human engineered systems are to predicted sea level change and what design or operations and maintenance measures should be implemented to adapt.
- Project development must include consideration of a multiple scenario approach to deal with future condition uncertainty.
- Project alternatives are to be formulated and evaluated for the entire range of future rates of sea level change scenarios using low, medium and high scenario ranges, based on National Research Council’s sea-level rise scenarios (SLR values for the NH coast in 2100 are 0.4, 1.5 and 4.8 feet).

New Hampshire Guidance and Activities on Climate Change

New Hampshire Climate Action Plan

In 2009, the Governor’s Climate Change Policy Task Force released the New Hampshire Climate Action Plan⁶² containing 10 overarching strategies necessary to meet the State’s greenhouse gas reduction and climate change related goals. The Plan describes in detail the benefits of planning for and adapting to climate change and how this may be achieved to minimize impacts to the economy, human health, natural systems, and infrastructure. The New Hampshire Climate Action Plan has helped guide many research and planning initiatives, policy decisions, and audits of the existing regulatory standards and procedures by State agencies to address climate change. The plan envisions that all stakeholders throughout the state would contribute to implementation of its recommendations.

New Hampshire Department of Environmental Services

In September 2015, NHDES published a report summarizing the Department Climate Initiative.⁶³ NHDES recognizes that climate change is real, serious, and substantially man-made and that New Hampshire’s residents, environment and economy are already experiencing its effects. NHDES has a responsibility to respond by taking steps to reduce the causes of climate change locally and regionally, as well as to prepare for the current and projected impacts that a changing climates poses to New Hampshire’s residents, visitors, communities, and natural resources.

In response, the NHDES incorporated the need to address climate change in its 2010-2015 Strategic Plan goals. The NHDES Climate, Land-Use, Energy And Natural Resources (CLEANR) Team convened in 2010 as an ad-hoc cross-media staff working group, representing all three divisions and the commissioner's office, to support the implementation of the interrelated land-use and climate goals contained in the strategic plan. The team played an invaluable role in guiding the early implementation of the strategic plan through a phased-in approach that built on the success of small pilots to pave the way for more extensive projects and activities.

In 2013, under the guidance of the CLEANR Team and with the full support of its senior leadership, NHDES launched the "Department Climate Initiative" (DCI) to engage agency leadership, middle management and key staff in a strategic review of NHDES's programs and activities. The goal of the DCI is to make coordinate changes to department outreach activities, grants, and regulatory programs that: account for changing climate and environmental conditions; and promote the reduction of greenhouse gases (e.g., carbon dioxide, methane, ozone, black carbon) from all sources. To do so, each bureau in the department has been assessing their programs and activities in order to identify actions they can take to reduce emissions of greenhouse gases within New Hampshire and prepare for the impacts of a changing climate.

Even as the department-wide planning effort has been underway, considerable progress has been made across the agency. The document is the first periodic review of NHDES's efforts to incorporate considerations of climate change into all of its programs and activities. The purpose of the review is to reflect on the work done during 2014 and previously related to the goals NHDES has set for climate change, land use and energy in the 2010-2015 Strategic Plan.

New Hampshire Department of Homeland Security and Emergency Management

The New Hampshire Department of Homeland Security and Emergency Management (HSEM) is responsible for preparing the state's hazard mitigation plan, coordinating the state's response to natural disasters, and administering Hazard Mitigation Assistance programs that fund development of comprehensive hazard mitigation plans and projects to protect citizens, and their property from exposure to all hazards including: natural, human caused, and technological. The New Hampshire Multi-Hazard Mitigation Plan⁶⁴, (last updated in 2013) lays out goals and recommendations to protect the state, municipalities and residents from impacts from natural and human caused hazards. In 2009 the Plan incorporated for the first time goals to address climate change impacts including technical support, planning, assessment of risk and vulnerability, and adaptation statewide. For more information about programs and assistance refer to the Homeland Security and Emergency Management HSEM website at <http://www.nh.gov/safety/divisions/hsem/>. Key goals and objectives from the NH Multi-Hazard Mitigation Plan relating to climate change are:

- Reduce the potential impact of natural and human caused disasters on New Hampshire's Critical Support Services, Critical Facilities and Infrastructure.
- Sustain the NHDES Coastal Program's participation and support of the Coastal Adaptation Workgroup to address hazard and mitigation needs relative to state and community infrastructure.
- Address the challenges posed by climate change as they pertain to increasing risk to the state's infrastructure and natural environment.
- Support efforts to characterize and identify risks posed by climate change especially as it relates to changing precipitation patterns, storm event frequency, and sea-level rise.
- Encourage coastal communities to incorporate mitigation planning in master plans, zoning, land use and resource regulations and other planning studies and initiatives that address the existing and potential future threats related to climate change and sea-level rise.

New Hampshire Department of Transportation

Transportation excellence in New Hampshire is fundamental to the state's sustainable economic development and land use, enhancing the environment, and preserving the unique character and quality of life. The New Hampshire Department of Transportation (NHDOT) will provide safe and secure mobility and travel options for all of the state's residents, visitors, and goods movement, through a transportation system and services that are well maintained, efficient, reliable, and provide seamless interstate and intrastate connectivity. NHDOT uses guidance from the FHWA (see above). The NHDOT also puts forward several manuals for designing structures, including:

- Bridge Design Manual – [Design Guide](#)
- Manual on Drainage Design for Highways

The NH Department of Transportation (NHDOT) has conducted an assessment of its assets, programs, policies, and activities to determine what is at risk due to changing climate stressors. The NHDOT issued a plan that identifies short-, mid-, and long-term steps to develop adaptive strategies to counter the effects. An internal climate change committee meets quarterly to discuss state and federal activities dealing with resiliency and adaptation plans.⁶⁵

New Hampshire Department of Administrative Services

The Department of Administrative Services (DAS) oversees energy efficiency and renewable energy efforts in all of the state facilities, coordinating the development of the agency energy conservation plans and the state energy conservation plan. They also oversee energy-use data management by tracking energy consumption and cost for all state agencies, and analyze and report on the State's progress in achieving its goal of reducing fossil-fuel energy-use intensity by 25 percent by 2025 as laid out in Executive Order 2011-131 and Senate Bill 73 (2010).⁶⁶

New Hampshire Office of Energy & Planning

The NH Office of Energy & Planning (NHOEP) is collaborating on a variety of energy efficiency and renewable energy efforts, and is working with local communities and property owners to implement changes to the Federal Emergency Management Agency (FEMA) flood maps, and to educate the public about the associated risks and insurance implications. The NHOEP Energy Division is tasked with: promoting energy efficiency to reduce energy usage and costs; administering federally-funded fuel assistance and weatherization assistance programs; working to make state government buildings more efficient; exploring opportunities to expand the use of renewable, domestic energy resources such as biomass, wind and solar energy; and administering state and federal programs related to energy.

The Floodplain Management Program offers technical assistance to all stakeholders regarding floodplain management regulations, flood insurance, and floodplain mapping. NHOEP is also charged with assisting municipalities with planning issues, supporting implementation of state smart growth policies, and supporting land conservation, all valuable tools in minimizing the causes of climate change and providing protection from its impacts.⁶⁷

New Hampshire Department of Health and Human Services

In 2013, the Division of Public Health Services (DPHS) in the NH Department of Health and Human Services (DHHS) received a Center for Disease Control and Prevention (CDC) grant to further prepare New Hampshire for the health impacts due to climate change. The grant is part of a CDC-funded national collaboration called the Climate Ready States and Cities Initiative (CRSCI). The goal is to help local communities prepare for climate-related public health impacts such as pollen and asthma, extreme heat, or changing habitat and Lyme disease by assessing the connections between climate change and health impacts and helping public health networks develop plans to keep our citizens prepared and healthy. The DPHS is collaborating with the NHDES Coastal Program and the USGS to assess the impact of climate change on watersheds in the state, and estimate the state's changing vulnerability to flood or drought over the next century.⁶⁸

New Hampshire Department of Cultural Resources

The NH DCR Division of Historical Resources (DHR) is offering a new grant program to repair historical properties that were damaged by Superstorm Sandy in October 2012. Grants will support projects that repair damage caused by the storm. Properties receiving funds must be listed on or eligible for listing on the National Register of Historic Places. Another important component of the disaster planning program will be the creation of a statewide online Geographic Information System of historical properties throughout the state. An important component of the program in the upcoming grant round will be a focus on pre-disaster planning for historic and cultural resources. DHR will be looking for proposals that increase community awareness of historic and cultural resources through initiatives that identify vulnerable historic properties and that develop strategies to protect a community's historic assets.⁶⁹

New Hampshire Fish & Game Department

The NH Fish and Game Department is engaged in an update to its Wildlife Action Plan with assistance from other natural-resource-based organizations in New Hampshire. The update includes the impacts from climate change on ecosystems and various species that are more vulnerable. The update is based on the Commission's amendment to a 2006 Plan: the Ecosystems and Wildlife: Climate Change Adaptation Plan. This amendment was created with input from 59 state and federal agencies, researchers, non-profits, consulting biologists and towns and addresses actions to assist wildlife and ecosystems in staying healthy in the face of climate change.

New Hampshire Coastal Adaptation Workgroup

The New Hampshire Coastal Adaptation Workgroup (NHCAW) is a collaboration of 22 partners and organizations working to help communities in southeastern New Hampshire prepare for the effects of extreme weather events and other effects of long term climate change. Since inception in 2010, NHCAW has led numerous projects and events that have elevated discussions about climate preparedness at municipal, state, and regional levels. NHCAW partners incorporate peer-reviewed science and research in the development of tools and technical guidance, and outreach in the coastal watershed to help communities better prepare for the effects of a changing climate in order to protect their social, economic, human and environmental health. For more information, refer to NHCAW's website at www.nhcaw.org.

Regional Planning Commissions and Municipal Efforts

The Rockingham Regional Planning Commission and the Strafford Regional Planning Commission have been working directly with coastal communities since 2009 to provide downscaled data related to coastal risks and hazards from climate change that can be used by town official for planning purposes. In many cases the planning commissions have played instrumental roles in providing technical and planning expertise to municipal governments for updating Hazard Mitigation Plans, Master Plans, and other planning efforts. In other cases communities have applied for external grant sources to fund community vulnerability assessments that incorporate sea-level rise mapping. For a list of local climate change adaptation planning projects along with other project-based efforts, see [Appendix H](#).

Other State Guidance and Activities on Climate Change

Guidance and activities in several other states, including New York, Delaware, and Maryland, informed the Commission recommendations. As one example of this guidance, the Maryland Coast Smart Guidelines are summarized here.

Maryland Coast Smart – Construction and Infrastructure Siting and Design Guidelines

In 2014, the State of Maryland released its CoastSmart guidelines for the design, siting and construction to be used for new construction, reconstruction and rehabilitation of State structures and major infrastructure improvements within the State's defined coastal zone. It also called for similar measures to be applied to non-State projects if they are partially or fully funded by State agencies or located on State lands. These guidelines are tied to the State's Sea-level rise Projections made in 2008 and revised in 2013 by the Maryland Climate Change Commission. The key design guidelines include the following:

- New and reconstructed state structures are to be avoided within areas likely to be inundated [daily] by sea-level rise in 50 years, and should be designed to avoid or minimize future impacts over their design life.
- New State critical or essential facilities shall not be constructed within NFIP Special Flood Hazard Areas and should be designed such as to be protected from damage and loss of access resulting from a 500-year (0.2-percent-annual-chance) storm.
- New, reconstructed and rehabilitated State structures shall be constructed with a minimum of two (2) feet of freeboard above the 100-year (1-percent-annual-chance) base flood elevation, as defined by NFIP.
- Ecological features that buffer future impacts from sea-level rise and storm-surge shall be identified protected and maintained.

The Maryland example, like the FFRMS, also incorporates a process by which exceptions to these guidelines can be made under certain circumstances.

New York – Community Risk and Resiliency Act

New York State enacted the Community Risk and Resiliency Act in 2014 to strengthen preparedness for the effects of climate change and to help protect communities against severe weather and sea-level rise. The legislation requires that applicants for state funding or permits consider impacts from storm surge, sea-level rise and flooding. It is the only legislation in the nation that requires climate impacts to be considered in all state planning, permitting, and funding approval processes. The law charges the State's environmental agency (Department of Environmental Conservation) to:

- Adopt a set of sea-level projections and update them every five years.
- Adopt regulations establishing science-based state sea level rise projections based on NOAA predictions and recommendations from a state Sea Level Rise Task Force.
- Develop model climate change adaptation zoning laws for use by municipalities;
- Require companies and communities seeking certain state permits or funding to incorporate the adopted sea level projections, as well as forecasts covering heavy rainfall and storm surges, into project designs.

In addition the law amends numerous other state statutes and state agency rules to require the explicit consideration of future climate change risk, in the administration of laws governing such subjects as agriculture, public infrastructure, energy and waste facility siting and acquisition of land for the conservation of open space, recreation and natural, cultural or historic resources.

APPENDIX D: Science and Technical Advisory Panel (STAP) Report Summary

2014 SCIENCE AND TECHNICAL ADVISORY PANEL REPORT SUMMARY

Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends

Climate change is expected to have significant impacts on critical infrastructure and natural and cultural resources in coastal New Hampshire over the next century and beyond.

This report is intended to help municipal and state decision-makers prepare for projected sea-level rise and other coastal hazards and minimize the risks those hazards pose to municipalities and state assets.



Photo credit: Steve Miller

SEA-LEVEL RISE

Global sea levels have been rising and are expected to continue rising well beyond the end of the 21st century. Rising seas pose significant risks to our communities and ecosystems, cultural resources and other coastal property and infrastructure.

PROJECTIONS

Forecasting rates of global greenhouse gas emissions is challenging, but research shows that current greenhouse gas concentrations and current or accelerated emissions will continue to influence sea levels in the future.

PRECIPITATION

Mean annual precipitation in the northeastern United States increased by approximately 5 inches (more than 10%) between 1895 and 2011.

PROJECTIONS

Annual precipitation is expected to increase by as much as 20% between 2071 and 2099 compared to the late 20th century. Most of the precipitation increases will be in winter and spring in the form of rain or snow. Fall and summer will experience less of an increase.

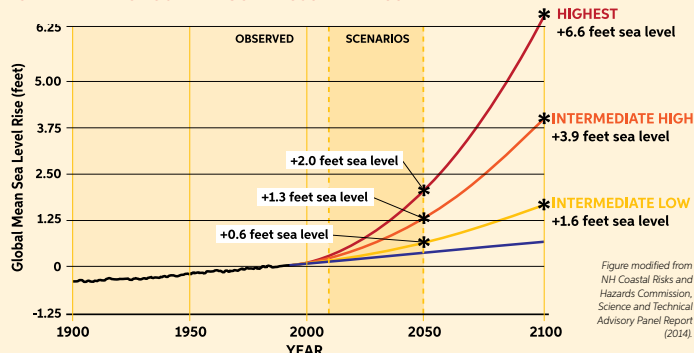
EXTREME PRECIPITATION

The Northeast experienced a 50% increase in total annual precipitation from storms classified as extreme events between 1901 and 2012. Here, "extreme" is defined as the number of times each year that the 24-hour rainfall amount exceeds the largest 1% of precipitation events in that year.

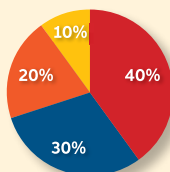
PROJECTIONS

Extreme precipitation events are projected to increase in frequency and in the amount of precipitation produced. In particular, the rainfall amount produced by hurricanes is projected to increase. However, current climate models and analyses are not as good at projecting future changes in the frequency or magnitude of extreme precipitation events.

SEA-LEVEL RISE SCENARIOS AT 2050 AND 2100



PROCESSES CAUSING SEA LEVELS TO RISE



- 40% Ocean warming or thermal expansion
- 30% Melt of land-based glaciers
- 20% Melt of Antarctic and Greenland ice sheets
- 10% Vertical land movements, shifts in Earth's gravity field and ocean dynamics

STORM SURGE

The New Hampshire coast is significantly impacted by both Nor'easters and hurricanes. Winds from these storms drive ocean water towards the land, resulting in the short-term rise in water levels called storm surge. The actual height of a flood is determined by factors such as storm intensity, forward speed, storm area size, coastline characteristics, and angle of approach to the coast, in addition to tide height. Nor'easters can impact the region for several days and produce a storm surge with or without the addition of inland runoff from heavy precipitation. Over the past ten years the largest storm surges observed in New Hampshire occurred during Nor'easters.

PROJECTIONS

Considering changes in water levels due to sea-level rise alone, today's extreme storm surge events (i.e. 100-year flood) will have a greater inundation extent and occur more frequently over time. Due to increased coastal development, there has been a significant increase in impacts from hurricanes nationwide over the 20th century. However, there is some uncertainty in the projection of trends in hurricane frequency and intensity in any given region, and no research consistently finds a trend in the frequency and intensity of Nor'easters.

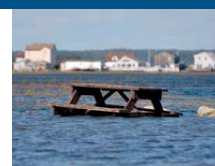


Photo credit: Ron Sher

To access this document, go to <http://nhblog.stormsmart.org/files/2015/05/STAP-Report-Summary-WEB.pdf>

USING THIS REPORT:

How to Prepare for the Changing Climatic Conditions in Coastal New Hampshire

PREPARING FOR SEA-LEVEL RISE

For coastal locations where the need to protect existing coastal development, infrastructure or ecosystems is high, sea level estimates should be applied as follows:

1. **Determine the time period** over which the system is designed to serve (either in the range 2014 to 2050, or 2051 to 2100).
2. **If the design time period is 2014-2050**, commit to manage to 1.3 feet of sea-level rise, but be prepared to manage and adapt to 2 feet if necessary.
3. **If the design time period is 2050-2100**, commit to manage to 3.9 feet of sea-level rise, but be prepared to manage and adapt to 6.6 feet if necessary.
4. **Be aware that the projected sea-level rise ranges may change** and prepare to adjust design considerations if necessary. The choice of management strategies can include strategies to protect, accommodate or retreat from the flood risk.

EXAMPLES OF PREPARING FOR SEA-LEVEL RISE

A building or facility with an anticipated lifespan beyond 2050 could be constructed today:

- For the highest sea-level rise scenario of 6.6 feet (the most protective approach).
OR
- For 2 feet of future sea-level rise —but designed to allow modifications sometime in the future to protect against 3.9 or 6.6 feet of sea-level rise.

HISTORIC SEA LEVELS

Based on local tide gauge data, sea levels in New Hampshire have been rising by an average of **0.7 inches per decade since 1900**. The rate of sea-level rise has increased to approximately **1.3 inches per decade since 1993**.

FUTURE SEA LEVELS

Using 1992 sea levels as a baseline, New Hampshire sea levels are expected to rise **0.6 – 2.0 feet by 2050** and **1.6 – 6.6 feet by 2100**.

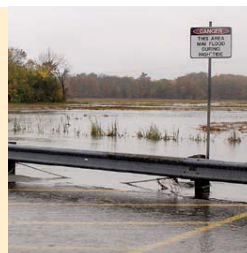


Photo credit: Ticia Miller

PREPARING FOR CHANGES IN PRECIPITATION

Consideration of historical increases in precipitation and projected future precipitation should be applied as follows:

- Buildings and infrastructure should be designed to withstand storm intensities based on the most current precipitation data.
- Infrastructure should be designed to manage a 15% increase in the frequency of extreme precipitation events after 2050.

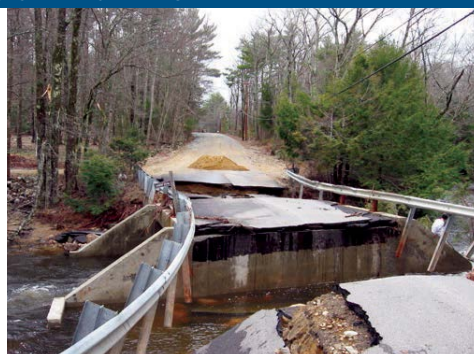


Photo credit: UNH Stormwater Center

PREPARING FOR CHANGES IN STORM SURGES

Coastal projects should be designed to consider future flood risks by adding projected sea-level rise heights to current storm surge heights, as measured by the 100-year and 500-year floods.



Photo credit: UNH Stormwater Center

ABOUT THIS REPORT AND THE NEW HAMPSHIRE COASTAL RISKS AND HAZARDS COMMISSION

This Science and Technical Advisory Panel report is intended to guide the New Hampshire Coastal Risks and Hazards Commission in its development of recommendations to assist in planning and preparation for the changing climatic conditions in coastal areas of the state.

The New Hampshire Coastal Risks and Hazards Commission was established by the New Hampshire Legislature on July 2, 2013 by RSA 483E. The Commission is required to consider key scientific research on current and future coastal risks and hazards and is charged with recommending legislation, rules and other actions.

The Commission created a Science and Technical Advisory Panel to review available scientific information about coastal hazards and flood risks in New Hampshire.

The Panel analyzed the latest published data on historic trends and projections for the years 2050 and 2100 for sea-level rise, coastal storms, and extreme precipitation.

These findings were summarized in a peer-reviewed report, which the Commission will use to develop recommendations in 2015 and 2016. The Panel suggests this assessment and report be updated at least every two years as new research and data become available.

To learn more about the New Hampshire Coastal Risks and Hazards Commission, go to nhcrhc.stormsmart.org.

Commission meetings are open to the public and posted on the website.

For information or questions about the Commission, contact Cliff Sinnott, Commission Chair at **603-778-0885** or csinnott@rpc-nh.org.

To download the complete Science and Technical Advisory Panel report, go to nhcrhc.stormsmart.org.

THE DESIGN AND PRINTING OF THIS SUMMARY WERE PAID FOR IN PART BY A GRANT FROM THE NEW HAMPSHIRE CHARITABLE FOUNDATION.

To access this document, go to <http://nhblog.stormsmart.org/files/2015/05/STAP-Report-Summary-WEB.pdf>

APPENDIX E: Other Hazards and Risks

Appendix E summarizes some of the limited information known about several important hazards and risks posed to coastal New Hampshire as a result of changes in climate. Existing and emerging science and assessments should be reviewed further in future updates to the Science and Technical Advisory Panel report or in other venues.

Temperature, Drought, Snowfall, and Seasonal Shifts

As our climate continues to change we can expect warmer winters with 25-50 fewer days per year below freezing and 20-60 day increase in summer days with temperatures above 90 degrees Fahrenheit.⁷⁰ In addition to the extreme changes in temperature will lead to a shorter winter and a longer growing season.⁷¹ The coastal watershed is expected to experience an increased frequency of hot days. On those days heat stress and its associated heat injuries and deaths become more probable.⁷² Even with changes in precipitation trends, shifting seasons and extreme temperatures, New Hampshire's coastal watershed is expected to see only a slight decrease to no change in the frequency of drought.⁷³

As noted in the STAP, there is an anticipated increase in extreme precipitation events. This could translate to an increase in extreme snow events and total winter snow fall. However, the combination of warmer winter and spring temperatures will lead to a decrease in the number of winter days with snow cover. In addition, as winters continue to warm over the century, a larger portion of winter precipitation will likely fall as rain. The Piscataqua/Great Bay region is expected to see a three-week to one-month decrease in snow covered days.⁷⁴

Due to the combination of warmer temperatures and a longer growing season, New Hampshire is expected to see an increase in number of unhealthy air quality days. The unhealthy air quality days will result from an increase in pollen production and ozone (a form of air pollution) and lead to an increase in asthma cases and cardiorespiratory illnesses respectively.⁷⁵

Saltwater Intrusion and Groundwater Tables

Sea-level rise combined with land subsidence are already resulting in incidents of saltwater intrusion where saline ocean water infiltrates the groundwater table along the coast. This issue needs further study to identify how saltwater is likely to change the salinity of existing freshwater sources along the coast. Additionally, as sea levels rise, groundwater table elevations are pushed upward, resulting in higher groundwater elevations at significant distances from the coast. Ongoing groundwater modeling at the University of New Hampshire is investigating the effects of climate change, including sea-level rise, precipitation and temperature, on groundwater levels and the impacts to roads in coastal New Hampshire. The groundwater modeling study will have broader applications as it can be expanded to investigate the effects of climate change on drinking water supply, base flow to streams, and the hydrology of wetlands.

Ocean Chemistry

Ocean acidification in the Gulf of Maine is the result of at least two factors: increasing CO²—carbon dioxide levels in the atmosphere, and more intense and frequent rain events.⁷⁶ The ocean absorbs more carbon dioxide from the atmosphere as carbon dioxide levels increase in the air, and this causes the pH of the sea water to decrease. Recent studies have shown that the Gulf of Maine may be particularly sensitive to watershed influences on ocean acidification. In acidic seawater conditions it is difficult for organisms to build and maintain shells.⁷⁷ Up to 90 percent of the marine resource economy of the region is dependent on harvesting shelled animals like lobsters, clams, and oysters.

Impacts to Our Well-Being and Assets

These coastal hazards will result in impacts to a variety of resources and assets in the state of New Hampshire. Increases in average temperature and resulting seasonal shifts will have impacts on agriculture, tourism, and other industries. These climatic changes will lead to more invasive species and expanded ranges for vector-borne diseases like Lyme disease and other pests, not to mention general shifts in native species composition and ecological diversity. Access to clean drinking water will likely be impacted by saltwater intrusion. Additionally, rising groundwater tables will result in more vulnerable roads and new freshwater wetlands where the groundwater table is already close to the surface. Water quality issues arising from changes in ocean chemistry and temperature are likely to arise, including increased instances of cyanobacteria at beaches and nuisance algae growth in estuarine waters. This list of impacts is not exhaustive and there are likely many impacts that researchers and others have yet to predict, therefore additional research and analysis is needed to identify, understand, and prepare for both known and unknown impacts.⁷⁸

APPENDIX F: Preliminary Desktop Analysis of Vulnerable Roadways in Great Bay Municipalities under 6.3 Feet Sea-Level Rise Scenario

The table below summarizes a preliminary desktop analysis of vulnerable roadways in Great Bay municipalities. The analysis was conducted by the Strafford Regional Planning Commission and the Rockingham Planning Commission and highlights key transportation assets that may be at risk from flooding under 6.3 feet of sea-level rise. This analysis will be improved upon in the ongoing C-RiSe project and results will be updated as they are made available.

MUNICIPALITY	LOCATION	ROADWAY	ADDITIONAL IMPACTS
DOVER	Dover Point at Pomeroy Cove	US 4/NH 16/Dover Point Rd/Park Rd/Hilton Dr/Bike Path	Potential for tidal flooding of neck portion of Dover Point, impacting principal highways, local roads, and bike and pedestrian infrastructure.
	Varney Brook (tidal) under Dover Point Rd (between Ivan's Lane and Old Dover Point Rd)	Dover Point Rd	Potential for increased erosion from tidal flooding through stream crossing. Significant local connector road (used to bypass US16 tolls at Dover)
	Gulf Rd over Fresh Creek	Gulf Rd	Creek goes through very narrow culvert/bridge (flooding bottleneck). Potential for tidal/storm surge buildup and erosion of culvert/road structures.
	NH/ME 101 (Dover Eliot Rd) bridge over Salmon Falls River.	NH/ME 101 (Dover Eliot Rd).	Approach on Dover side of bridge extends into tidal flats/estuary on a long point of land. Potential erosion of bridge approach from rising tidal waters.
DURHAM	Bridge over Johnson Creek	US 4 (Piscataqua Rd)	Potential for flooding or submergence of infrastructure.
	Bridge over Bunker Creek	US 4 (Piscataqua Rd)	Potential for tidal flooding or submergence of infrastructure.
	US and local roads on Cedar Point and near Royalls Cove (partial Madbury)	US 4 (Piscataqua Rd) / Back River Rd	Potential for tidal flooding overtopping local connection (Back River Rd) to primary arterial (US 4)
	Bay Rd bridge over Crommet Creek	Bay Rd	Potential for increased erosion around bridge structures (e.g. headwalls).
	Bay Rd bridge over Lubberland Creek	Bay Rd	Potential for increased erosion around bridge structures (e.g. headwalls).
	Adams Point	Adams Point Rd	Potential for tidal flooding of neck portion of Adams Point Road that provides access to UNH Jackson Lab.
EXETER	Exeter-Squamscott River	Routes 108, 101,111	Potential impacts to wastewater treatment plant
GREENLAND	Winnicut River	Route 33, Bayside Road, Newington Road	Portsmouth Country Club

MUNICIPALITY	LOCATION	ROADWAY	ADDITIONAL IMPACTS
GREENLAND & STRATHAM	Great Bay	Local roads servicing residential areas	
MADBURY	US and local roads on Cedar Point and near Royalls Cove (partially in Dover)	US 4 (Piscataqua Rd) / Back River Rd	Mapped threats to roads within Durham municipal boundaries, but threats to popular, local alternate route shared by Madbury and Dover residents.
NEWFIELDS	Squamscott River	Routes 85 and 108	Potential impacts to wastewater treatment plant
NEWINGTON	Little Bay	Routes 16 and 4, Newington, Road, Little Bay Road, Foxpoint Road,	Great Bay Wildlife Refuge
	Piscataqua River	River Road	Deep water port facilities, Newington Station
NEWMARKET	Parking, access points, and structures along water frontage downtown mill.	Several/unknown	Potential tidal flooding/storm surge impacts to build infrastructure along downtown water frontage.
ROLLINSFORD	Sligo Rd along Salmon Falls River (between Pinch Hill Rd and NH 4 (Portland Ave))	Sligo Rd	Potential tidal flooding of roadway. Site is along outer edge of a bend in the Salmon Falls River (high erosion potential)
STRATHAM	Squamscott River	Routes 108	
	Great Bay, Mill Brook, Jewell Hill Brook	Route 33 & Squamscott Rd	

APPENDIX G: State of New Hampshire Comments on the Draft Guidelines for Implementing the Federal Flood Risk Management Standard



MARGARET WOOD HASSAN
GOVERNOR

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Fax: (603) 271-2615



May 6, 2015

Regulatory Affairs Division
Office of Chief Counsel
Federal Emergency Management Agency
500 C Street, SW
Washington, DC 20472

Re: Docket ID No. FEMA-2015-0006, Comments on the Draft *Guidelines for Implementing the Federal Flood Risk Management Standard*

Dear Office of Chief Counsel,

On behalf of the State of New Hampshire, the Office of Energy and Planning is submitting for your consideration comments on the draft *Guidelines for Implementing the Federal Flood Risk Management Standard* developed by the New Hampshire Coastal Risks and Hazard Commission, which includes representatives from the New Hampshire State Legislature, the New Hampshire Department of Transportation, the New Hampshire Department of Environmental Services, the New Hampshire Office of Energy and Planning, the New Hampshire Division of Historic Resources, and the New Hampshire Department of Resources and Economic Development, among other state, regional and local stakeholders.

In New Hampshire, we have experienced a number of significant flooding events in recent years and the new standard proposed by President Obama in Executive Order 13690 is a crucial step to improving our preparedness and resilience. The State of New Hampshire appreciates the opportunity to provide comments prior to the implementation of the Federal Flood Risk Management Standard. If you need additional information please contact Jennifer Gilbert, New Hampshire's National Flood Insurance Program Coordinator at 603-271-1762 or Jennifer.gilbert@nh.gov.

Sincerely,

Meredith A. Hatfield
Director

Enclosure: State Comments

TDD Access: Relay NH 1-800-735-2964

COMMENTS TO THE FEDERAL EMERGENCY MANAGEMENT AGENCY
ON THE DRAFT GUIDELINES FOR IMPLEMENTING
THE FEDERAL FLOOD RISK MANAGEMENT STANDARD

WHEREAS, New Hampshire faces increasing flood risk due to several factors including land use change, extreme precipitation, storm surge and sea level rise, it is imperative that its communities, agencies, institutions and businesses prepare for these conditions by creating greater resilience to flooding; and

WHEREAS, it is essential for communities to begin acting now to adapt to these projected conditions, and to do so using multiple measures, including resilient building, landscape and infrastructure design, protection and enhancement of natural shoreline features, and strategic shoreline protection or retreat; and

WHEREAS, creating more resilient communities, both in the built and natural environment, will help protect life, and property and economic vitality from the effects of future flood risk; and

WHEREAS, to establish greater resiliency, the design and construction of public infrastructure that is built or rebuilt from this point forward should anticipate future flood conditions to ensure that such investments are not subject to unnecessary damage or loss; and

WHEREAS, higher flood management standards will increase the short term capital costs for building and infrastructure, if the standards are reasonably established and based on sound science, they will also reduce the long term costs for maintaining, repairing and replacing buildings and infrastructure due to flood damage; and

WHEREAS, in 2013 the State of New Hampshire established a Coastal Risks and Hazards Commission (CRHC) under RSA 483-E to advise the state and its coastal municipalities on policies and actions with regards to increasing coastal flood hazards; and

WHEREAS, the New Hampshire Coastal Risks and Hazards Commission subsequently established a Science and Technical Advisory Panel (STAP) to advise it on the expected sea level rise and other future flood hazards specific to New Hampshire based on the best currently available climate science, and that Panel issued its report in August 2014; and

WHEREAS, it is advisable to establish state and national standards for flood risk management to protect public investment in infrastructure, and to ensure consistency in planning and design across agencies and localities;

THEREFORE, the State of New Hampshire supports the establishment and implementation of new Federal Flood Risk Management Standards:

1. We affirm the need for a Federal Flood Risk Management Standard (FFRMS) and support the proposed framework which allows flexibility in choosing the standard that will apply in specific circumstances (including the climate-informed science approach, the freeboard value approach and the 500 year flood elevation approach). We also support the inclusion of exceptions to the standards for certain emergencies, mission critical actions, national security concerns, and where application of the standard is 'demonstrably inappropriate'.

2. The FFRMS should incorporate the timeframe of anticipated increases in flood risk along with the design life and risk sensitivity of the facility or action being proposed to determine appropriate flood management standards.
3. The FFRMS should include periodic revaluation of the standards to incorporate updated science based understanding and projections of sea level rise and other sources of flood risk.
4. Increased cost of project design and construction resulting from higher flood standards should be accommodated in the available federal funding for such projects.
5. Clear guidance should be provided for qualifying a state or region-specific 'climate science based standard' (such as the CRHC STAP report) into the FFRMS and clarifying under what circumstances higher state or local standards will take precedence over Federal standards.
6. Special attention should be given in the FFRMS implementing guidelines concerning how the standards will be applied to regulated actions pertaining to historic and archeological properties and sites.
7. The guidance to Federal agencies provided through FFRMS should seek to avoid the development of rules and standards that conflict when applied to projects that are subject to the jurisdiction of multiple agencies.

APPENDIX H: Related Projects

Since 2009, partner organizations of the New Hampshire Coastal Adaptation Workgroup (NHCAW) have worked together and partnered with communities on 46 projects totaling \$5,452,077 in grant funding. This is a list of completed and ongoing projects that NHCAW partner organizations work on to help New Hampshire coastal communities become more resilient to coastal risks and hazards exacerbated by climate change. This is not a comprehensive list of all projects related to coastal risks and hazards in the New Hampshire region. For more information about NHCAW or any of the projects listed below, please contact the NHCAW co-chairs Sherry Godlewski of the New Hampshire Department of Environmental Services (sherry.godlewski@des.nh.gov) and Steve Miller of the Great Bay National Estuarine Research Reserve (steven.miller@wildlife.nh.gov).

Project Title: Tides to Storms 2 – Adaptation Implementation

Award Period: November 2015 – September 2016

Description: The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities to implement recommended strategies from the Tides to Storms Vulnerability Assessment. RPC is pleased to offer each municipality \$6,000 in direct technical assistance for services beginning November 9, 2015 through September 14, 2016. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Activities eligible for funding include update or preparation of plans, policy development, regulatory amendments, land conservation and restoration plans, and public outreach.

Project Title: Exploring the trends, the science, and the options of buffer management in the Great Bay Watershed

Period: September 2015 – August 2017

Description: This project's goal is to enhance stakeholder capacity to make informed decisions related to the protection and restoration of buffers around New Hampshire's Great Bay Estuary. The project will be integrating existing geospatial information and the best available buffer science with economic valuation data about the benefits of buffers. This watershed scale information will then be used to select a subwatershed to work within to determine what combination of incentive and regulatory solutions can best promote good buffers around Great Bay.

Project Title: PREPA Grant: Exeter, NH

Period: August 2015 – October 2016

Description: Nitrogen loading in the Great Bay Estuary and associated tributaries is a concern for many communities within the Piscataqua Region watershed. With increasing precipitation from climate change, Exeter aims to improve fertilizer application setbacks within their community to reduce nitrogen loading. This project address one of the four recommendations for Exeter, NH from the 2015 PREPA report.

Project Title: PREPA Grant: Greenland, NH

Period: August 2015 – October 2016

Description: Greenland, NH will be working to adopt the Southeast Watershed Alliance model stormwater ordinance. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance will increase resiliency within Greenland in response to climate change.

Project Title: PREPA Grant: Hampton, NH

Period: August 2015 – October 2016

Description: Hampton will strengthen its commitment to better floodplain management and implement positive measure to reduce flood risks associated with sea-level rise and coastal storms through participation in the FEMA Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program requirements. Additionally, participation in the CRS will create strong incentives among town residents to improve buffer protection and management—key PREPA action items identified for Hampton, NH.

Project Title: PREPA Grant: New Castle, NH

Period: August 2015 – October 2016

Description: The New Castle Conservation Commission proposes to focus on the top priority action to increase buffers to 100' for all waterbodies as listed under the 2015 PREPA recommendations. The Conservation Commission also proposes to increase protection efforts for the Lavenger Creek salt marsh that will involve proposing more stringent regulatory standards and/or prime wetlands designation. This project builds upon the work to reduce and manage invasive species cover around the Lavenger Creek salt marsh.

Project Title: PREPA Grant: North Hampton, NH

Period: August 2015 – October 2016

Description: The 2015 PREPA identified adoption of the Southeast Watershed Alliance model stormwater ordinance as one of the four priority actions for North Hampton, NH. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance is a proactive and cost effective way for the town to address stormwater pollution and increased runoff from projected increases in precipitation associated with climate change.

Project Title: PREPA Grant: Rollinsford, NH

Period: August 2015 – October 2016

Description: The 2015 PREPA identified adoption of the Southeast Watershed Alliance model stormwater ordinance as one of the four priority actions for Rollinsford, NH. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance is a proactive and cost effective way for the town to address stormwater pollution and increased runoff from projected increases in precipitation associated with climate change. Throughout the process Rollinsford also plans to inventory stormwater related issues and assess current stormwater management practices.

Project Title: PREPA Grant: Rye, NH

Period: August 2015 – October 2016

Description: Rye will institutionalize its commitment to better floodplain management—a critical focus as sea levels continue to rise and coastal storms intensify—through participation in the FEMA Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program requirements. Additionally, participation in the CRS will create strong incentives among town residents to improve buffer protection and management—key PREPA action items identified for Rye, NH.

Project Title: PREPA Grant: Somersworth, NH

Period: August 2015 – October 2016

Description: The City of Somersworth proposes to complete a natural resource inventory to guide short and long term land conservation priorities. A natural resource inventory is a tool for communities to gain a better understanding of their existing natural resource values and to establish a sustainable approach for land use planning and management in response to climate change.

Project Title: PREPA Grant: Stratham, NH

Period: August 2015 – October 2016

Description: Stratham proposes to explore all four of the proposed recommendations from the 2015 Piscataqua Region Environmental Planning Assessment and adopt as appropriate. The four recommendations are: (1) increase buffers to 100' for tidal wetlands; (2) increase septic and structure setbacks to 100' for freshwater wetlands; (3) adopt fertilizer application setbacks for all waterbodies; and (4) adopt model stormwater management regulations. Each of these goals will increase protection for water quality and build resiliency for the Town of Stratham in response to increase precipitation associated with climate change.

Project Title: Climate Ready Culverts and Coastal Communities: Vulnerability Assessment for Coastal Communities

Period: September 2015 – March 2017

Description: This project team is assessing climate change impacts to natural systems and the built environment for ten coastal municipalities. Results of the assessment will help municipalities apply climate impact data directly into programmatic changes such as facilities (infrastructure upgrades and priorities), permit processes, codes, and regulations. The project results will be built into a developing web-based platform (NH Coastal Viewer). The UNH Stormwater Center, Rockingham Planning

Commission and Strafford Regional Planning Commission will assess the impact of climate change on culvert performance, and natural resources and infrastructure due to tidal changes from sea-level rise and storm surge and produce mapping and assessment tools to inform municipal plans and decision making. RPC and SRPC will complete a vulnerability analysis of sea-level rise and storm flooding, working closely with each of their municipalities to incorporate information into hazard mitigation plans. The UNH Stormwater Center will complete a culvert analysis based on future climate conditions including projected increases in the frequency and magnitude of extreme precipitation events.

Project Title: Climate Adaptation for Road Infrastructure in Coastal New Hampshire

Period: October 2014 – September 30, 2016

Description: This research will assess the impacts of climate change and sea-level rise on road infrastructure in Coastal New Hampshire. Specific attention is given to reduction in pavement performance with rising ground water, temperatures, and extreme precipitation events. The research will develop the data and tools needed to assess climate impacts on roadways and will investigate various adaptation strategies through case studies. A NH Seacoast Transportation Climate Working Group consisting of regional planners, transportation engineers and road agents has been established to inform the research and to make the results available and useful for regional stakeholders.

Project Title: RiskMAP FY14 – Developing Areas of Mitigation Interest and Conducting Discovery

Period: October 1, 2014 – September 30, 2016

Description: This award comprises two distinct project activities. The first activity is to generate an “Areas of Mitigation Interest” data set for the 13 communities in Rockingham County and 4 communities in Strafford County that are within the footprint of the NH Coastal Mapping project described above. The flood risk data are being developed based on accessing existing statewide, regional, and community data sets, as well as collecting current localized knowledge from community officials. Once complete, the data will be incorporated into the FEMA Flood Risk Database for each county and will be accessible from the FEMA Map Service Center. The second activity is to conduct “Discovery” in the 13 communities in Rockingham, Strafford, and Carroll Counties that are part of the Piscataqua/Salmon Falls Basin but outside of the footprint of the NH Coastal Mapping project. The goal of this effort is to work closely with the individual communities to help identify areas at risk for flooding and possible solutions for reducing that risk. New Zone A (approximate) flood zone boundaries will be generated as part of this effort and will be compared to the effective data. This information, along with additional input provided by the project communities, will be used to determine priorities for future floodplain mapping.

Project Title: Assessment of Hydrologic Change due to Climate Change in New Hampshire: Simulation of Current and Future Water Streamflow, Snowmelt, and Groundwater Recharge Using the Precipitation Runoff Modeling System

Period: February 1, 2015 – June 30, 2016

Description: This project builds on work already completed that developed a watershed runoff model for the Long Island Sound Watershed, including the Connecticut, Thames, and Housatonic Rivers (Bjerklie and others, 2011), and a U.S. Geological Survey (USGS) New England Regional Precipitation Runoff Modeling System (PRMS) model that has been developed as part of a USGS effort to build a continental scale National Hydrology Model (Lauren Hay and Steve Markstrom, personal communication 2014). The models run in New Hampshire for current and future climate change scenarios, giving users an enhanced understanding of possible changes to streamflow, snowmelt, and groundwater recharge to be expected in New Hampshire as a result of climate change.

Project Title: Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed

Period: March 1, 2015 – June 30, 2016

Description: Moonlight Brook is an important tributary of the Lamprey River drainage basin. Several flood resiliency and risk studies have been performed in the Lamprey River watershed including the Moonlight Brook subwatershed. The project team is conducting a two part effort to: 1) to study flood risk associated with climate change as well as how future development and build out of the community affect these risks, and 2) design robust green infrastructure practices within the Moonlight Brook watershed to help reduce risk of flooding while reducing pollutant load into the Brook and further downstream into the Lamprey River and ultimately Great Bay.

Project Title: Analysis of Water Resources to Supplement the Land Conservation Plan for New Hampshire’s Coastal Watershed

Period: March 2015 – May 2016

Description: This project builds upon and provides an update to The Land Conservation Plan for New Hampshire’s Coastal Watersheds (2006), which identified land protection priorities on a watershed scale. The purpose of this project is to conduct

spatial analyses to identify lands that, if protected, will (1) benefit water quality in the coastal watershed, (2) attenuate flood flows and mitigate flood risks, and (3) secure public drinking water supplies. The results of this project include new data showing land protection priorities that would mitigate flood risk, reduce pollution and improve the protection of drinking water supplies for planners, municipal staff, volunteer board members, land trusts, agency staff, and others.

Project Title: Implementing Phase I of the Lubberland Creek Culvert Restoration and Initiating the Development of NH's Tidal Culvert Assessment Protocol

Period: February 1, 2015 – May 31, 2016

Description: Task 1 – Phase I : Culvert replacement at the Bay Road crossing of Lubberland Creek in Newmarket achieves three primary goals: (1) restoration of aquatic connectivity at the system's tidal/freshwater interface allowing diadromous fish passage at the perched Bay Road culvert, (2) enhancement of the resilience of Lubberland Creek salt marsh by removal of the existing tidal restriction at Bay Road with a structure that allows upstream salt marsh migration as sea levels continue to rise, and (3) remediation of the flood hazard of this road-stream crossing, which overtops during major flood events and thereby compromises public safety. Task 2 – Initiation of the Development of NH's Tidal Culvert Assessment Protocol: Creation of a tidal culvert assessment protocol via review of best practices for tidal culvert assessments through existing literature, computer models and expert interviews, as well as the assembly of a group of experts in an effort to build consensus and justification for characteristics measured as part of a field-based tidal assessment protocol.

Project Title: New Hampshire Great Bay Estuary Ecosystem Services Assessment

Period: September 2013 – May 2016

Description: This project helps to build a spatial planning framework for the Great Bay estuary, with an emphasis on successfully utilizing ecosystem services modeling to better integrate and scale-up ongoing estuarine habitat restoration work while minimizing conflicts with siting and permitting decisions pertaining to other space-dependent estuarine uses (e.g. mooring fields, marinas, aquaculture leases). The project integrates existing spatial information on climate change vulnerability into the estuarine spatial planning framework. This objective ensures that a recently completed effort to generate high quality coastal vulnerability maps for every coastal town in New Hampshire under scenarios of sea-level rise and storm surge is incorporated into holistic spatial planning efforts for the state's estuaries.

Project Title: NH Coastal Mapping Project

Period: September 21, 2010 – December 31, 2015 (to be extended)

Description: This project will result in new Digital Flood Insurance Rate Maps (DFIRMs) and Flood Insurance Studies (FISs) for the downstream portions of the Piscataqua/Salmon Falls Basin (HUC 8 Watershed 01060003), including the ocean coastline in New Hampshire. The study area comprises 239 square miles, and includes the 17 communities that lie within New Hampshire's designated Coastal Zone. High resolution LiDAR topographic data is being used to support new and/or updated modeling and mapping of the study area.

Project Title: NH Coastal Risk MAP Product Development

Period: September 13, 2011 – December 31, 2015 (to be extended)

Description: This objective of this project is to produce a suite of non-regulatory, Risk MAP products to accompany the updated floodplain maps described above for the NH Coastal Mapping project. Collectively, they extend the utility of the maps and reports, encourage community utilization and understanding, and facilitate more efficient floodplain management. Products to be developed include Changes Since Last DFIRM (a comparison of the new floodplain data relative to the effective data), Limit of Moderate Wave Action (an informational layer on the floodplain maps that defines the limit of the 1.5-0 foot wave), Coastal Flood Depth Grids (containing coastal water depths for the 1 percent Base Flood Elevation), Riverine Flood Depth Grids (containing riverine water depths), Static Sea-level rise, and the results of Hazus analyses for Rockingham and Strafford Counties (showing potential annualized losses from flooding). These non-regulatory products will be entered into a Flood Risk Map, Report, and Database, all of which will be available from the FEMA Map Service Center.

Project Title: NH Shoreline Structure Inventory

Period: May 2015 – October 2015

Description: The NHDES Coastal Program is creating a spatial inventory of engineered shoreline structures along the New Hampshire tidal shoreline. This inventory will be developed for the NH Coastal Viewer, to include information about the structure type, elevation, and size, among other attributes. The inventory will be used to inform vulnerability assessments for these structures in the future.

Project Title: Tides to Storms

Period: November 2012 – September 2015

Description: This project includes 1) Production of a regional vulnerability assessment report and map set for NH coastal communities, utilizing the best available information to assess the impacts of climate change on land, natural resources and infrastructure, and provide detailed maps, risk and impact analyses, and adaptation and mitigation strategies to address the projected future effects of sea-level rise and storm surge; 2) Development of a model Coastal Flood, Hazards and Adaptation Chapter to be incorporated within coastal community Hazard Mitigation Plans; 3) Local Hazard Mitigation Plan updates in each eligible coastal community to specifically incorporate the vulnerability assessment including development of adaptation and mitigation strategies that address the projected future effects of sea-level rise and storm surge; 4) Development of outreach and guidance tools to enhance preparedness, create capacity and improve resiliency in the built environment, human health and safety, and natural systems; 5) Incorporation of Coastal Flood, Hazards and Adaptation Chapter into local Hazard Mitigation Plans and other state plans.

Project Title: The Hard and Soft of Shoreline Management: Conference and Follow-up Outreach

Period: May 2014 – August 2015

Description: In December 2014 the Great Bay National Estuarine Research Reserve, and our partners in CAW hosted a conference focused on improving shoreline management in NH. 121 individuals attended this conference including coastal decision makers from the NH Coastal Risk and Hazards Commission, state agencies, municipalities, and NOAA, as well as shoreline professionals and experts such as engineers, environmental consultants, and researchers. Conference participants learned about and discussed how and why we manage shorelines in NH and explored how we can better manage shorelines to protect the natural, cultural, and economic resources that are impacted by shoreline management decisions. The centerpiece of the conference was presentation on “living shoreline” treatments that have been tested in in New York and New Jersey. Conference development was informed by a needs assessment conducted by GBNERR. The conference was followed by a half day workshop where select partners, presenters, and conference participants debriefed the workshop and discussed what shoreline management topics still need outreach support in NH. To continue the dialog that was started at the conference, CAW has been and will continue holding workshops that target specific shoreline management topics including: wetland and shore and permitting in NH, protecting coastal cultural resources, and a field based workshop focused on the protection provided by dunes. More follow-up workshops are expected in 2016. Additionally, CAW members are publishing an ongoing Shoreline Management Story Series to highlight how and why shoreline management is done in coastal NH. These articles have been and will continue to be published on www.nhcaw.org.

Project Title: Hampton-Seabrook Estuary Sand Dune Restoration

Period: March 1, 2015 – June 30, 2015

Description: NH Sea Grant/UNH Cooperative Extension (NHSG/UNHCE) and the University of New Hampshire (UNH) work to build coastal resilience to climate change and enhance landforms and wildlife habitat through the restoration of several dune habitats in the Hampton-Seabrook Estuary watershed. Vegetation is critical to the growth and the stability of dunes; therefore, a revegetation program engaging community members and NH Sea Grant’s Coastal Research Volunteers focuses on the impacted areas. Efforts to limit pathways for beach access through all project areas include extensive outreach, educational signs, and structural fencing to divert pedestrians to designated pathways. Local citizens are engaged throughout the project in order to accomplish on the ground restoration goals and to create a network of informed citizens and landowners.

Project Title: Resilient NH Coasts

Period: October 1, 2013 – April 30, 2015

Description: This project advanced resiliency and adaptation planning for climate change related hazards by integrating tools, research, outreach, and technical assistance in the Hampton-Seabrook estuary, Dover, and Portsmouth. Outreach was also conducted to business groups throughout NH Seacoast communities. New information generated by this project included updated and expanded Sea Level Affecting Marsh Migration (SLAMM) model outputs, and current information about Fluvial Erosion Hazards. The project’s integrated and innovative approach enabled project partners to learn how communities want to use and access coastal data and GIS tools in hazards and climate adaptation planning, and what steps can be taken to ensure that climate related science is relevant to local needs. The project partners collaborated on a NH Coastal Viewer product that incorporates data to help planning state agencies, commissions, municipalities, and businesses visualize what areas in their communities are the most vulnerable to coastal hazards, including sea-level rise and river flooding.

Project website: <http://des.nh.gov/organization/divisions/water/wmb/coastal/resilient-coast.htm>

Project Title: Piscataqua Region Environmental Planning Assessment

Period: October 2014-March 2015

Description: The 2015 Piscataqua Region Environmental Planning Assessment (PREPA) is designed to provide an updated information base to inform ongoing and emerging planning and environmental protection efforts, and to identify gaps and inconsistencies in the standards of environmental protection reflected in the current ordinances, development regulations, and natural resource protection strategies in each of the 52 municipalities. The 2015 PREPA also gathered information on municipal land use policies and adaptation planning strategies designed to mitigate the impacts of climate change on the Piscataqua Region watershed.

Project Title: Climate Change and Human Health in New Hampshire: An Impact Assessment

Period: July 2013 – December 2014

Description: This report provides an overview of past and future climate across New Hampshire has changed, and the potential impact of future climate change on human health in New Hampshire based on the Centers for Disease Control and Prevention – Building Resilience Against Climate Effects (BRACE) framework. The report is organized by the type of health impact: Temperature, heat events, and heat stress injury/death, Extreme weather and injury/death, Temperature, air quality, and respiratory and cardiovascular illness, Pollen, mold, and allergies, Temperature, precipitation, and vector-borne diseases, Temperature, precipitation, severe weather, and foodborne diseases, Temperature, precipitation, and waterborne diseases, Climate change, health behaviors, and chronic disease, Climate change, mental health, and stress-related disorders

Report website: <http://www.climatesolutionsne.org/sites/climatesolutionsne.org/files/candhreport4.30.pdf>

Project Title: Preparing for Climate Change in Rye

Period: July 1, 2013 – December 31, 2014

Description: Project staff and a local steering committee organized a workshop series about climate change in Rye. The workshops introduced the science and local impacts of climate change, delivered an overview of planning tools to adapt to climate change, hosted a walking tour to understand how salt marshes are affected by sea-level rise and how they contribute to resiliency, and transitioned the towns participation into a follow up project (Tides to Storms). In addition to reported increases in knowledge, the community generated a list of prioritized concerns and began a dialogue about possible action items to adapt to climate change.

Project Title: Sustaining Champions of Climate Adaptation in Coastal Communities: A Northern New England Study

Period: June 2014 – September 2014

Description: In this study, community members identified by others as “climate adaptation champions” from coastal areas in northern Massachusetts to southern Maine were interviewed. The interviews were designed to reveal what motivates and sustains these champions, what challenges and accomplishments they claim and what professional adaptation assistance providers can do to help support champions in implementing climate adaptation at the local level. A total of eight findings were developed from the champions’ responses during the interviews as well as a set of recommendations for professional climate adaptation assistance providers. The study was conducted by a UNH undergraduate student, Alexandra Phillip, with assistance from four mentors affiliated with NH’s Coastal Adaptation Workgroup. Report link:

https://seagrant.unh.edu/sites/seagrant.unh.edu/files/media/pdfs/extension/climate_champions_2014.pdf

Project Title: Building the Capacity of Coastal Communities to Address Climate Change Risks Through the Use of Role-Play Simulations

Period: September 2012 – August 2014

Description: The Massachusetts Institute of Technology Science Impact Collaborative worked with four National Estuarine Research Reserve (NERR) sites, and the Consensus Building Institute to test an innovative way to help coastal communities understand and prepare for the potential impacts of climate change. The team engaged four at-risk New England towns in testing the use of role-play simulations as a means to educate the public about climate change threats and to help communities explore ways of decreasing their vulnerability and enhancing their resilience. The findings of this project provided valuable insights into techniques for engaging communities in public learning, risk management, and collaborative decision-making around science-intensive public disputes. They also informed the development of a model approach that communities in New England and elsewhere can use to address climate change. In NH, this project worked with the City of Dover.

Project Title: Collaborative Planning for Climate Change Adaptation: A Case Study in Great Bay National Estuarine Research Reserve

Period: September 1, 2012 – August 31, 2014

Description: The project undertook a collaborative planning effort to develop an integrated climate change adaptation plan for a land area exhibiting a range of land uses and location on a major tributary to the Great Bay Estuary. While the focus is on climate change, the project also considered the exacerbation, and remedies, for related challenges of stormwater, nonpoint source pollution, land use/development and the protection and restoration of habitat (marshes and fisheries habitat). The case study area is the Town of Exeter within the Exeter/Squamscott River Basin, which includes most of the town's area just upstream of Great Bay. However, because portions of other towns share the watershed, their contributions to the targeted impacts on the river system were assessed to provide a comprehensive analysis that will yield an integrated management strategy. Benefits include an adaptation strategy for Exeter that can be incorporated into zoning ordinances, and site regulations that benefits not only the town but also Great Bay, and serve as a transferable model for collaborative and integrated adaptation planning.

Project Title: Crossing Boundaries: Integrated Planning in the Exeter – Squamscott Watershed

Period: September 1, 2013 – August 31, 2014

Description: This project developed the foundation for an Exeter-Squamscott Watershed Integrated Plan for the communities of Exeter, Stratham, and Newfields in southern New Hampshire. The Plan helped communities meet new wastewater and stormwater permit requirements and improve water quality in the Squamscott River and the Great Bay, while supporting the economic viability of participating communities. This project developed a management plan for three communities that allows them to evaluate and manage water quality and climate impacts at the scale of the Exeter/Squamscott subwatershed project area.

Project Title: Green Infrastructure for Sustainable Coastal Communities

Period: September 1, 2012 – August 31, 2014

Description: The project proposed to build municipal capacity in coastal watershed communities for Green Infrastructure by engaging local and regional stakeholders in a planning and implementation process that was supported by technical resources and current, relevant information. The goal of creating a collaborative process was to build community resilience and improve capacity for managing water resources and related ecosystem services. The project provided a wide range of resources and numerous models and examples of regulatory and technical approaches for the implementation of green infrastructure (GI). Drawing upon knowledge gained from previously funded programs, we worked with local community leaders, regional officials, and representatives of the development community, local businesses, a local watershed entity, Low Impact Development (LID) experts, design firms and nurseries. The project implemented priorities identified by the intended users that would best develop municipal capacity for GI.

Project Title: Climate Adaptation Chapter: Town of Durham

Period: July 1, 2012 – June 30, 2013

Description: Strafford Regional Planning Commission assisted the Town of Durham in developing a climate adaptation chapter that was adopted as a subset of their Hazard Mitigation Plan. The chapter provides adaptation strategies to protect areas of the town that are at risk of flooding due to climate change and sea-level rise, and identifies various regulatory and non-regulatory options that can be considered by Durham from this potential risk. With collaboration from Town officials and staff from the University of New Hampshire, SRPC delivered a product that provided information on how best to plan and act to address the impacts of climate change, thus protecting coastal infrastructure and resources.

Project Title: Navigating from Concern to Action Using the NOAA Roadmap in New Hampshire's Small Coastal Communities

Period: July 2012 – June 2013

Description: This project helped a small NH coastal community (Newfields) with a volunteer-board government move climate preparedness from concern to action by using the NOAA Roadmap for Adapting to Coastal Risks (NOAA Roadmap). The Roadmap is a community-driven process that expanded capacity in Newfields to respond to climate preparedness through (1) increased knowledge about vulnerabilities of community assets, and (2) awareness of climate adaptation options. As a result, the community has updated their stormwater management regulations, implemented an emergency generator purchasing and installation program for community members, developed and distributed a local extreme weather preparedness calendar, and more.

Project Title: Update of the Master Plan Vision Chapter: Town of Newmarket

Period: July 1, 2012 – June 30, 2013

Description: Strafford Regional Planning Commission (SRPC) assisted the Town of Newmarket in preparing an update of the Town's Vision Chapter of the Master Plan. The process was prepared collaboratively by SRPC and a designated Master Plan subcommittee. SRPC organized and facilitated two visioning forums to solicit comments and ideas from residents for addressing current issues and challenges pertaining to various aspects of the community, including: housing, recreation, land use, zoning, business and industry, community facilities, infrastructure, and natural and cultural resources. The community was asked to consider the integration of climate adaptation measures into municipal programs, policies, and operations to reduce community risk and vulnerability.

Project Title: Effects of anthropogenic change on salt marsh microbial structure and function

Period: June 1, 2012 – May 31, 2013

Description: The goal of this project was to expand our understanding of salt marsh microbial community structure and function and response to impending sea-level rise and increasing levels of nutrient pollution. The repercussions of human activities may combine (or counteract each other) to yield unexpected effects of altered microbial activity on salt marsh resiliency to change. This understanding informs management decisions by: 1) Guiding short-term management decisions on salt marsh preservation more effectively through improved understanding of ecological responses to stress; and 2) Shaping long-term management goals and activities through a better understanding of environmental changes and adaptation management tools that will build salt marsh resiliency against change.

Project Title: Stimulate innovation and increase the pace of municipal responses to a changing climate in the coastal zone of the Northeast and Bay of Fundy.

Period: September 1, 2011 – April 30, 2013

PIs: Jennifer Andrews (CA-CP), Susan Farady (RI Sea Grant Legal Program), and Wes Shaw (StormSmart Coasts Network)

Description: This project included three components: 1) Research and documentation of the best practice/innovative municipal adaptation approaches in the Northeast; 2) Municipal technical assistance through a small grant program; and 3) Adaptation/resilience communications development in collaboration with CA-CP and partners.

Project website: <http://www.cpo.noaa.gov/cpo>

Project Title: Coastal Flooding and Erosion Forecast – Hampton, NH

Period: February 2012 – December 2012

Description: An empirical relationship exists between storm tide, waves and coastal flooding or splash-over damage (NWS coastal flood study). Knowing this relationship helps predict when flooding and splash-over events (such as beach erosion) might occur based on forecast water level (tide height) and wave height data. Scientists from the University of Massachusetts at Boston, center for Coastal Environmental Sensing Networks (CESN) installed a state-of-the-art tide gauge at the Hampton Fire and Rescue pier on Hampton Harbor to support the project. The installation of the gauge was funded via a generous donation by NextEra Energy Seabrook Station. Working with the National Weather Service in Gray, Maine, NERACOOS and modelers in the Northeast region, a working prototype was developed using a water level model (NECOFS/FVCOM) and wave model (Wave Watch3). This prototype was working for Hampton, New Hampshire and Scituate, Massachusetts locations. We hope to expand to other regions depending on need. This product could be used by emergency managers, coastal homeowners and other users with interest and concern about beach erosion from large-wave storms. The capacity for the Coastal Flooding and Erosion Forecast system to predict damage days in advance of storms is extremely important to coastal property owners and emergency responders, resulting in dollars and lives saved.

Project website:

Sample site – Scituate, MA: http://www.neracoos.org/datatools/forecast/coastal_flooding_forecast/scituate

Real time tide gauge – Hampton Harbor:

http://p5.neracoos.org/products/modeldata/popup.html?page=popup&platform=hampton&model_type=NEC

Project Title: Portsmouth Coastal Resilience Initiative

Period: July 2012 – August 31, 2012, provisional funding through 2013

Description: This project utilized consulting services to supplement City staff hours to provide an inventory, analysis and recommendations that were easily integrated into the Master Plan update process (scheduled to start in July 2012), the building code, and the City's capital improvement plan. This project also utilized scenario planning to explore uncertainty about the future consequences of climate change on the City (both for the short-term and long-term.) This scenario planning approach sought to avoid adverse impacts on the built environment and natural resources by considering a few potential futures (in this case low, medium, and high risk scenarios). Scenario planning for this project incorporated both quantitative and qualitative information in the decision-making process. This process enabled the City to undertake a focused outreach around climate adaptation, without encumbering the Master Plan process.

Project website: <http://www.planportsmouth.org/cri/>

Project Title: New Flood Plain Maps for Coastal New Hampshire and Questions of Legal Authority, Measures and Consequence

Period: March 1, 2011 – February 28, 2012

Description: Questions of Legal Authority, Measures, and Consequences assesses various types of legal risks communities in the Lamprey River Watershed may be concerned about as a result of adopting new flood management regulations and policies. To assess these risks we identified four potential legal challenges related to: (1) municipal liability, (2) enabling authority, (3) the use of climate maps as evidence, and (4) takings. In general, the risk of municipal liability is low, so long as municipalities follow sound planning principles. Not only is the level of risk low, the federal government encourages communities to enact certain types of regulations designed to reduce flood hazards. This encouragement provides states and municipalities an additional layer of assurance with respect to adopting and defending revised or new flood regulations. Under federal floodplain guidelines, states and municipalities are encouraged to establish more stringent regulations above and beyond minimum federal requirements. For example, the Federal Emergency Management Agency (FEMA) advises communities to enact stricter regulations through a program called the Community Rating System.¹ This document, provides a list of additional regulatory and non-regulatory tools communities can use to both help reduce risk of flood hazards and avoid legal quandary.

Report website: http://100yearfloods.org/resources/pdf/2012_VermontLawSchool_LampreyRiverReport.pdf

Project Title: Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Changes in Climate and Land Use

Period: August 1, 2009 – July 31, 2011

Description: This project developed and refined a methodology for assessing flood risk associated with land use and climate change scenarios, implemented the methodology for the Lamprey River watershed of Great Bay, NH, and demonstrated the use of associated products to support land use decision-making in coastal communities. The core analyses and outputs for this project included maps at the watershed and municipality scale of the 100-year flood risk boundaries and river discharge at specific locations under selected scenarios. As a result, decision-makers and the public within the watershed have access to new information regarding local flood risk, and are educated about how past and potential future land use patterns and climate change will influence the frequency and spatial extent of flooding.

Project website: <http://100yearfloods.org>

Project Title: Assessment of Climate Change in Coastal New Hampshire

Period: August 2010 – July 2011

Description: Produced a detailed assessment of climate change for coastal New Hampshire that describes how the region's climate has changed over the past century, and how climate may change over the course of this century based on different global greenhouse gas emission scenarios. The results were detailed in a report and series of presentations titled "Climate Change in the NH Coastal Watershed: Past, Present, and Future". Adapting to a changing climate requires both data and information at a spatial and temporal scale that is relevant to decision making. Unfortunately, information provided by existing national and broad regional climate change impact assessments are not sufficiently detailed to provide municipal and regional decision makers with key decision relevant information. This climate assessment provided decision-relevant information on a regional scale to individual, municipal, regional, and state decision-makers. The information compiled in this climate assessment provides the foundation for developing local adaptation plans to a changing climate and this project disseminated this information to seacoast municipalities as well as regional and state organizations.

Project website: <http://CarbonSolutionsNE.org>

Project Title: Sea-level Rise and Storm Surge Adaptation Analysis via COAST

Period: 2011 – 2012

Description: The primary objective of this project was to provide support for climate adaptation planning processes in South Portland, ME and the Hampton/Seabrook estuary in NH. Working in partnership with PREP and CBEP, the New England Environmental Finance Center (EFC) provide visual, numeric, narrative, and presentation-based products based on the COAST decision-support tool. It was anticipated these products can help galvanize support for processes underway and represent specific action items stakeholders can evaluate. At public meetings of local stakeholder groups the EFC provided 1) single-event snapshot visualizations of 3D extruded values for each action and no-action scenario; 2) multi-decade tallies of cumulative expected damages under each adaptation scenario; and 3) interpretation of avoided costs associated with each adaptation action under consideration. Dialogue was solicited about implications for possible subsequent local action.

9. Endnotes

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4. New Hampshire Fish & Game Department (2014). Sea Level Affecting Marshes Model (SLAMM) for New Hampshire. <http://granitweb.sr.unh.edu/MetadataForViewers/NHCoastalViewer/Lite/SLAMM2014.html>
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