CLIMATE CHANGE CHAPTER

2015 REGIONAL MASTER PLAN

For the Rockingham Planning Commission Region

Climate Change

Contents

Cover photo credits: Highest tide of the year, Portsmouth, Steve Miller, NH Fish & Game Department (top left).

Climate Change

Introduction

Changes in New Hampshire's climate are well documented in local records of sea level, growing seasons, range of flora and fauna, precipitation and temperature. Similar to national trends and projections of previous climate models, the state has experienced more extreme weather events including floods, drought and rising tides.

Some degree of future impact will be influenced by changes to the atmosphere and warming of land, atmosphere and oceans already in progress. Longer term impacts will reflect decisions made today that influence how climate may change further into the future. Such decisions include energy choices such as fossil based versus renewable sources, land use and environmental protection, and transportation systems.

New Hampshire and its municipalities have many opportunities and time to prepare and adapt to a changing climate. This effort will require understanding of recent climate projections and assessments, applying technology and data to solve problems, and learning from other states and communities that have successfully implemented effective strategies and solutions.

What Changes Are Projected For the Region?

- ***Sea Level Rise and Higher Coastal Storm Surge***
- ***Increased Precipitation During Extreme Events***
- ***Increased Winter and Summer Temperatures***
- ***Changes in Snow and Rainfall Patterns***
- ***Shifts in Flora and Fauna Ranges***

This chapter will provide an overview of climate change, regional and statewide activities, describe existing conditions, and discuss key challenges in planning for the future.

Climate Assessments

Climate projections contained in reports prepared by the Intergovernmental Panel on Climate Change (IPCC AR, 2014) and the National Climate Assessment (NCA, 2014) as well as regional and local studies yield valuable information to guide today's decisions and those we will make into the future. The report Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future (Wake et al 2011) details projected changes in the environmental parameter of climate for southeast New Hampshire, including sea level rise, precipitation and temperature. In 2013, the City of Portsmouth contracted with researchers from the University of New Hampshire and Rockingham Planning Commission (RPC) to prepare a vulnerability assessment documenting the potential impacts of climate change, such as sea level rise and storm surge, on buildings, roads, infrastructure and saltmarshes. As part of the Granite State Future Regional Master Plan update project, climate assessments were also completed for the northern and southern regions of N.H.

However, with the exception of these studies, detailed analyses of potential impacts remain largely unmeasured across the state. Several regional and local efforts are currently underway in southeast and coastal areas to fill these knowledge gaps as described later in this chapter. These efforts were funded by grants from various federal agency programs including NOAA, EPA, and FEMA, and state, regional and non-profit organizations including the Gulf of Maine Council, NH Coastal Program and Kresge Foundation.

Enabling Statutes

How our state and region will respond to climate change depends largely on local municipal decisions and state level guidance, existing state statutes, and legislative actions. Long-standing statutes such as RSA 674:2 have addressed natural hazards through municipal master plans by allowing them to include

> "a natural hazards section which documents the physical characteristics, severity, frequency, and extent of any potential natural hazards to the community. It should identify those elements of the built environment at risk from natural hazards as well as extent of current and future vulnerability that may result from current zoning and development policies."

However, RSA 674:2 does not consider a future where environmental conditions may differ and natural hazards may change in frequency and intensity.

In 2013 legislation enabled coastal municipalities to include in their master plans "a coastal management section which may address planning needs resulting from projected coastal property or habitat loss due to increased frequency of storm surge, flooding, and inundation."

In 2013 legislation enabled formation of the Coastal Risks and Hazards Commission which is charged with evaluating the present and future impacts of climate change in the coastal watershed and preparing recommendations to address them. [Refer to the Existing Conditions Section for more detailed information about the Coastal Risks and Hazards Commission.]

A number of state agencies are taking steps to address climate change by evaluating their policies, regulations and standards with respect to mitigating and minimizing impacts and coordinating inter-agency strategies and programs. Future actions by state agencies including Department of Transportation, Department of Environmental Services, Division of Resources and Economic Development, Department of Health and Human Services, and Fish and Game and federal agencies including Fish and Wildlife, NOAA, EPA, HUD, USDA and FEMA may influence future responses to climate change within the region and by municipalities.

RPC Work in the Region

The RPC has lead and participated in many efforts to raise awareness and develop technical tools and guidance about climate change in the region. Efforts have covered a wide geography, reaching many municipalities and stakeholders interested in the issues surrounding climate change both present and future. Following is a brief summary of these efforts (specific details can be found later in this Chapter).

- Member of the New Hampshire Coastal Adaptation Workgroup (ongoing)
- Member of the state's Coastal Risks and Hazards Commission (ongoing)
- Outreach and engagement projects through grants from the NH Coastal Program (ongoing)
- Tides to Storms Coastal Vulnerability Assessment funded by NH Homeland Security and Emergency Management through a grant from FEMA (ongoing)
- Project Manager for City of Portsmouth Coastal Resilience Initiative project (2013)
- Pilot project funded by the NH Coastal Program - *Adaptation Strategies to Protect Areas of Increased Risk From Coastal Flooding Due to Climate Change in Seabrook* (2009)

While these collective efforts demonstrate substantial interest, further research, assessments and strategic planning will be needed to achieve a more climate resilient future for the region.

Challenges and Impacts

As a result of climate change both present and future, New Hampshire municipalities are and will continue to be confronted by land use, environmental and public health and safety concerns. Natural hazard management issues associated with climate change include extreme weather events, storm surge, flooding, erosion, and damage to key ecosystems and habitats. These issues are only intensified by recent increases in the frequency and intensity of extreme storm events and increases in annual average precipitation and the amount of rainfall associated with storm events. Increased flooding has the potential to place riverine floodplain and coastal populations at risk, threaten infrastructure, and ultimately disrupt or cause damage to homes, businesses, public infrastructure, drinking water supplies, recreation areas, public space, wetlands and

ecosystems. As experienced in recent decades, storm-related impacts to the "built environment" can be significant and will likely continue in high risk areas unless actions are taken to protect assets and investments. In addition, rising temperatures may bring health impacts including heat and respiratory related illness, and diseases transmitted by insects such as mosquitoes and ticks.

Map CC1 shows areas influenced by daily tides in the six coastline municipalities and five inland tidal municipalities in the region.

Coastal Communities

New Hampshire coastal municipalities are confronted by a particularly challenging set of land use and hazard management concerns that include extreme weather events, storm surges, flooding, coastal erosion, and loss of key coastal habitats. These issues are exacerbated by changes in climate that result in an increase in the frequency and intensity of storms and an increasing rate of sea level rise. These effects are compounded by growth and development through increasing stormwater runoff and flooding. Sea level rise has the potential to displace coastal populations, threaten infrastructure, intensify coastal flooding and ultimately lead to the loss of homes, businesses, public infrastructure, recreation areas, public space, coastal wetlands and salt marsh. Residential and commercial structures, roads, and bridges may be more prone to flooding. Sea level rise may also reduce the effectiveness and integrity of existing seawalls, which have been designed for historically lower water levels.

New Hampshire Climate Action Plan

In 2009, the Governor's Climate Change Policy Task Force released the NH Climate Action Plan, containing 10 overarching strategies necessary to meet the states greenhouse gas reduction and climate change related goals. Goal 9 states "Plan for how to address existing and potential climate change impacts". Chapter 3 Adapting to Climate Change describes in greater 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 plan was intended to act as a broad guide to examine projected future conditions and needs, and adjust our actions as needed to maintain a high quality of life in our state.

The NH 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. Currently, there is limited funding and staff at the state level to assist with implementing the recommendations of the plan. The plan envisions that all stakeholders throughout the state would contribute to implementation of its recommendations. Organizations like the NH Coastal Adaptation Workgroup and others have made progress toward implementing recommendations from the Climate Adaptation Chapter of the Plan.

What the Region Said About Natural Hazards and Preparedness

The outreach events and surveys conducted as part of RPC's Regional Master Plan update did not specifically address climate change and its impacts over the long term. Given that only a handful of municipalities in the region have begun discussions and evaluations of the potential impacts of climate change, it is difficult to anticipate the impacts such changes may have to municipal and private assets, infrastructure, resources and populations over time without specific data and analyses to quantify and depict them.

However questions oriented toward natural hazards in the recent past and their impacts to the region shed light on what people are most concerned about during natural hazard events, their frequency and severity, and the risk such events pose to communities today. Following is a summary of input about these issues collected from regional outreach events and the statewide and regional surveys.

Statewide and Regional Surveys

Questions about Emergency Preparedness

Nearly three-quarters of residents (74%) are concerned (34% "very concerned" and 40% "somewhat concerned") with snow or ice storms in their community followed by power outages (73%), wind damage (61%), flooding (48%), drought (30%), and wildfires (23%).

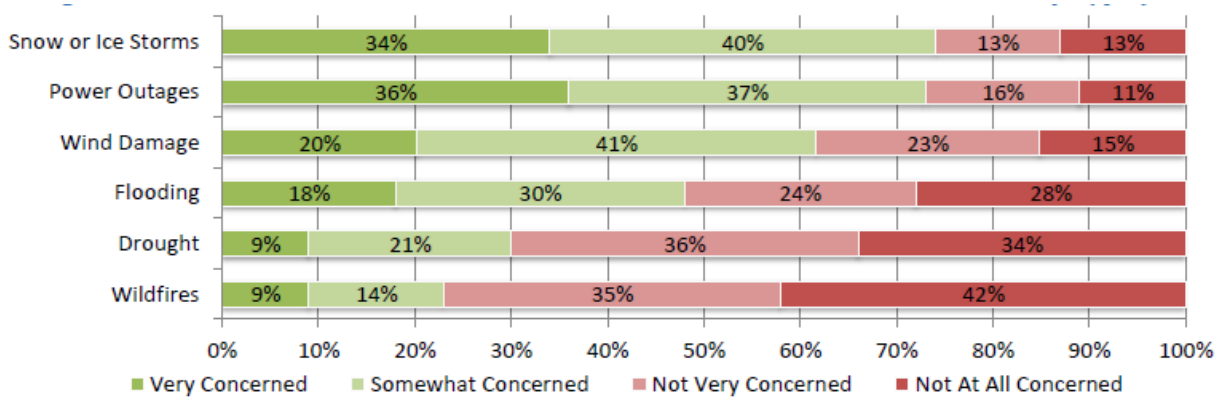


Figure CC 1. Question - Concern About Weather Related Events In Your Community? (q14)

Only 12% of residents are very concerned about their community's level of preparedness in weather-related situations, while 35% are somewhat concerned, 35% are not very concerned, 17% are not at all concerned and 1% said they don't know.

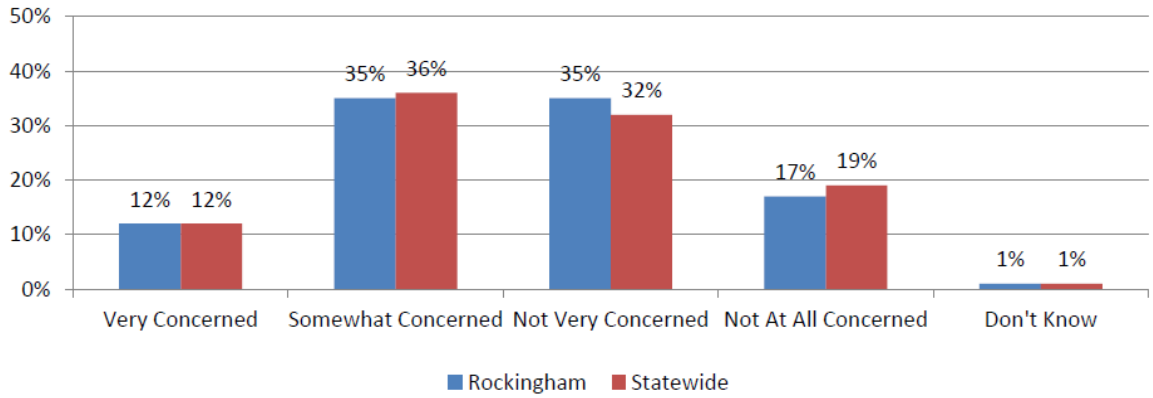


Figure CC 2. Question - Concern about Your Community's Level of Preparedness? (q15)

RPC Online Survey Results

Respondents expressed a mixture of concern for community emergency preparedness and most respondents indicated they were concerned with power outages and snow storms more than flooding, drought, wind damage, or wildfires.

Regional Visioning Sessions

The table below summarizes common ideas and concerns expressed at topical listening sessions held throughout the region in 2013 about the occurrence of hazards and hazard preparedness.

Table CC1. Report of public input about the impact of hazards and hazard preparedness in the region.

Question *– Have you or your community been affected recently by severe weather events or changes in seasonal weather patterns?*

- Damage to trees, power lines, buildings and private property. - Flooding near rivers and in areas not typically prone to flooding. - Road damage from undersized culverts, drainage infrastructure. - Flooding caused from inadequate drainage infrastructure. - Changes to crop production/harvest and growing seasons. - Increased frequency and intensity of severe weather events. - Prolonged dry periods between storms. - More extended periods of power outages over wide areas. - More residents and businesses are equipped with generators.
Question – *How could your community be better prepared to respond to and adapt to changes in seasonal weather patterns, extreme weather and more frequent storm events?*
- More community based emergency centers and shelters. - Inventory municipal infrastructure and prioritize improvements for under-performing sites. - Invest in new infrastructure that is more resilient. - Improve drinking water management to increase storage capacity. - Improve business resilience and continuity planning. - Educate public, citizens, decision makers and land use boards/commissions. - Improve power distribution systems, create back-up systems.
Question *– What investments, assets, resources or populations are most at risk due to changes in seasonal weather patterns, extreme weather and more frequent storm events?*
- High risk, vulnerable populations and need for services. - Damage to coastal shorelands and structures. - Fisheries, winter recreation, agriculture. - Flood damage to infrastucture and buildings in floodplains. - Water quality and water pollution. - Increase in tick and mosquito borne diseases and cases in NH.

Climate Change Goals

Goal 1

Municipalities and regional partners plan and prepare for, and effectively respond to climate change.

Goal 2

Actions are taken that reduce risk and vulnerability, enhance community resiliency, and protect critical infrastructure and natural resources.

Goal 3

Potential future impacts from climate change are better understood through regional and local assessments.

Goal 4

Climate-focused collaborative partnerships and networks of professionals, practitioners, and researches are maintained and supported.

Goal 5

Adaptation to climate change is integrated across all planning for the region.

Climate Change Goals	**Regional Goal** Promote the efficient use of land, resources and infrastructure that:				
	Creates a high quality built environment while protecting important natural and cultural resources.	Promotes positive effects of development and minimizes adverse impacts.	Promotes economic opportunities and community vitality.	Enhances the coordination of planning between land use, transportation, housing and natural resources.	Considers and incorporates climate change into local and regional planning efforts
CC Goal 1	S	S	TBD	S	S
CC Goal 2	S	S	TBD	S	S
CC Goal 3	S	S	TBD	S	S
CC Goal 4	S	S	P	S	S
CC Goal 5	S	S	S	S	S

S = Goal supports the Regional Goal.
P = Goal partially supports the Regional Goal.
TBD = Goal applicability to support the Regional Goal is not yet known.
N/A = Goal does not apply to the Regional Goal.

Climate Change Goals	NH Livability Principles					
	Traditional Settlement Patterns & Development Design	Housing Choices	Transportation Choices	Natural Resources Function & Quality	Community & Economic Vitality	Climate Change & Energy Efficiency
CC Goal 1	S	P	P	S	S	S
CC Goal 2	S	P	P	S	S	S
CC Goal 3	S	P	S	S	S	S
CC Goal 4	P	P	P	S	S	S
CC Goal 5	S	S	S	S	S	S

S = Goal supports the NH Livability Principle.
P = Goal partially supports the NH Livability Principle.
TBD = Goal applicability to support the NH Livability Principle is not yet known.
N/A = Goal does not apply to the NH Livability Principle

Existing Conditions

Climate Change Past and Present

Over the last 20 years, southeast NH has experienced extreme events related to changes in environmental conditions and the regional climate of the northeast U.S. These events include drought, severe precipitation/storms, coastal flooding, and warmer temperatures particularly increases in the hottest temperatures of summer and decreases in the coldest temperatures in winter. While many of these events did not result in long-lasting impacts to human and natural systems, small-scale changes have been observed such as changes in lake ice-out dates, shifts in growing seasons, increase in ticks and Lyme disease, shifts in peak foliage season, and rising sea level. In the short term some effects – such as the effects of sea level rise - may pose limited risk today, however in the long term the risk becomes greater as sea level continues to rise and impacts from storm surge and severe storm events become more frequent and damaging to coastal communities and natural systems.

Atmospheric Carbon Dioxide Levels

The graph below is a record of carbon dioxide concentrations dating back 800,000 years before present. The data is a compilation of air samples collected from ice cores from the Antarctic ice sheet as reported from NOAA's National Climate Data Center and carbon dioxide levels based on continuous measurements taken at the Mauna Loa Observatory in Hawaii. At 395.6 PPM, the amount of carbon dioxide currently in the atmosphere is unprecedented within the record shown. The amount of carbon dioxide in the atmosphere is strongly correlated to temperature and glaciation. When the concentration is below 240 ppm, extensive glaciers covered most of Europe, Canada and northern United States. (Planet For Life, 2014)

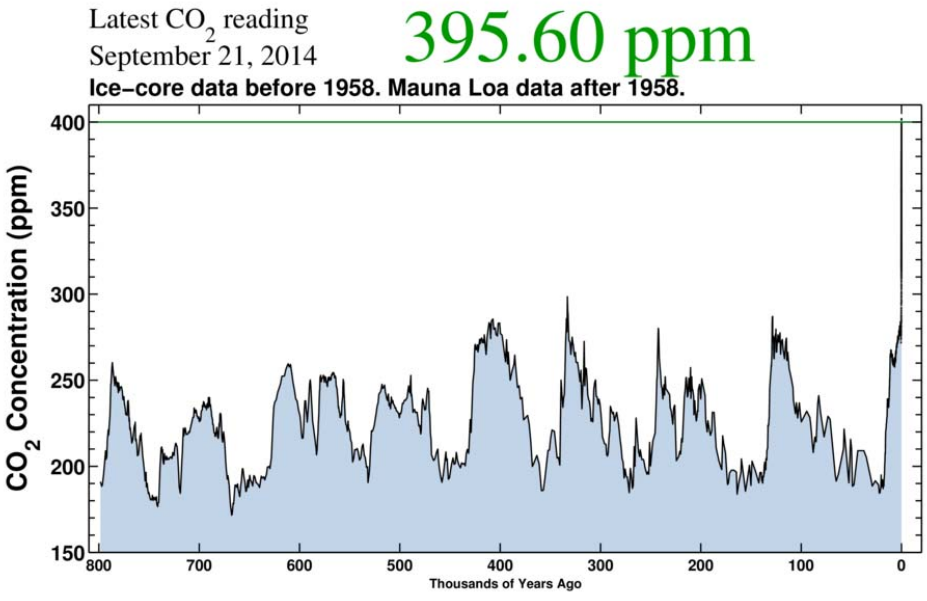


Figure CC3. Global record of carbon dioxide concentrations from ice core data and Mauna Loa Observatory, Hawaii. [Source: Scripps Institution of Oceanography at https://scripps.ucsd.edu/programs/keelingcurve/]

The vast majority of climate scientists are concerned that the most recent dramatic rise in carbon dioxide is causing warming of our atmosphere, oceans and land. As a result, changes in future environmental conditions may include sea level rise, shifting precipitation patterns, expansion of areas affected by drought, increasing numbers of severe heat waves, and more intense precipitation events. Scientists are also concerned that carbon dioxide absorbed by the ocean from the atmosphere is increasing the acidity of seawater. This change in ocean chemistry interferes with the ability of marine plants and animals to build their shells which comprises the health of marine ecosystems and could lead to extinctions of marine species in certain areas or worldwide. (National Oceanic and Atmospheric Administration, Understanding Climate)

Historical and Current Trends

The environmental parameters used to evaluate changes in climate over time are well documented. Clear trends are established indicating a steady increase in the severity of weather, rising seas and increased variability in seasonal temperatures. Refer to the following graphics showing past and future changes in temperature, sea level, and precipitation (rainfall and snowfall). The graphics below show increases in storm-related frequency and damages that illustrate the magnitude of change in our climate as experienced in New Hampshire since the mid 1900's.

Sea Level Rise

As reported by Wake (2011), relative sea level has been recorded at the Portsmouth Harbor (Seavey Island) tidal gauge only since 1926 (NOAA 2011). For the period 1926 to 2001, sea level rose nearly half a foot (5.3 inches), at a rate of about 0.693 inches per decade.

The annual values reported in the graph represent the annual mean of the monthly mean sea level data. The dashed blue line is the linear trend (regression) applied to the time series data. The gaps represent years with missing data. [Source: Sea Level Rise chapter from Wake et al. (2011) *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future]*

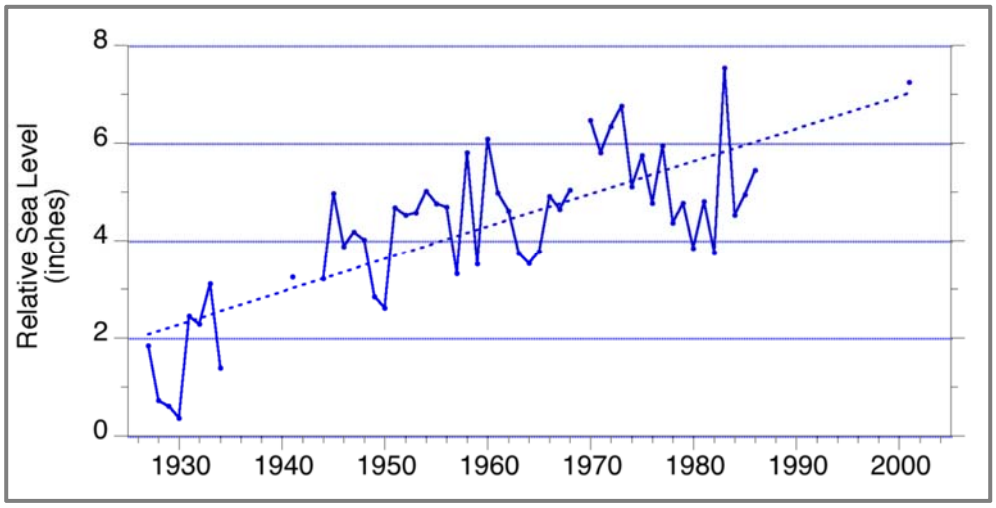


Figure CC4. Annual mean sea level measured at the Seavey Island, Portsmouth Harbor tidal gauge, 1927-2001 (NOAA 2011).

Precipitation

Since the 1990's the magnitude and frequency of extreme precipitation events have increased compared with the historical trends since 1950. The graph shows these trends based on data collected from stations located in Lawrence, MA, Portland, ME and Durham, NH. Although data analyses from these stations show no significant trends for the one-inch and two-inch precipitation events, when four-inch events are summed by decade, it becomes clear that four inch precipitation events are occurring more frequently in the past two decades than in the previous four decades (from Wake et al, 2011).

Northeast Regional Climate Center (NRCC)

Established in 1983 and funded by National Oceanic and Atmospheric Administration, the Northeast Regional Climate Center (NRCC) is located in the Department of Earth and Atmospheric Sciences at Cornell University. The mission of the NRCC is to facilitate and enhance the collection, dissemination and use of climate data and information, as well as to monitor and assess climatic conditions and impacts in the twelve-state, northeastern region of the United States: Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. The NRCC works cooperatively with the National Climatic Data Center, the National Weather Service, state climate offices, and other interested scientists to acquire and disseminate accurate, up-to-date climate data and information. The NRCC has published new extreme precipitation data for New Hampshire which shows for the southeast region substantial increases in the amount of rain associated with large precipitation events (i.e. the 25-, 50-, and 100-year storms). The NRCC online database is available online at: http://precip.eas.cornell.edu/.

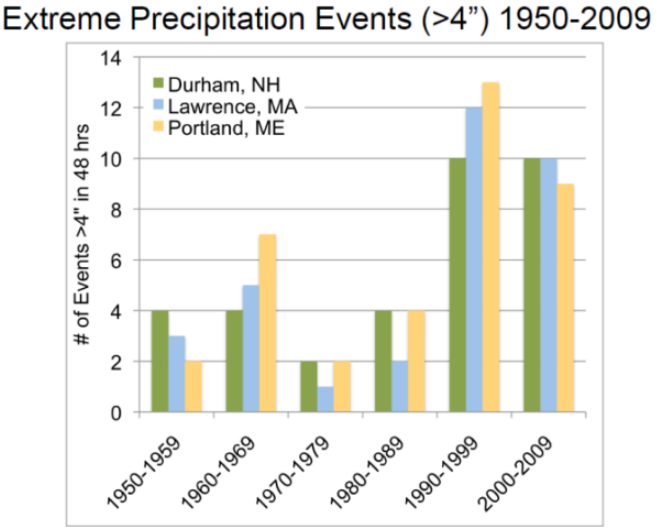


Figure CC5. Total number of events with greater than four inches of precipitation in 48 hours per decade since 1950 (Wake et al, 2011).

In 2014, the Department of Environmental Services incorporated NRCC's new precipitation data as part of its Alteration of Terrain permit program, requiring site development and stormwater management plans to design infrastructure to account for increased rainfall and runoff. Some municipalities in the region are using this data in the design and planning of road and stormwater infrastructure improvement projects.

Below is a comparison of rainfall data interpolated from Technical Review Paper No. 40 (TP40) Rainfall Frequency Atlas of the Easter United States (previous atlas comprised of data collected prior to 1957) and the current Atlas of Precipitation Extremes for the Northeastern United States by Cornell University, Northeast Regional Climate Center (2013). The 2014 National Climate Assessment reports that heaviest precipitation (1% chance event) has increased in the Northeast by 71 percent from 1958 to 2012.

Location	50-year storm Precipitation (old)	50-year storm Precipitation (2013)	100-year storm Precipitation (old)	100-year storm Precipitation (2013)
Portsmouth	5.8	7.39	6.5	8.85
Seabrook	5.8	7.64	6.5	9.19
Exeter	5.8	7.5	6.4	9.0
Sandown	5.7	7.10	6.4	8.52
Epping	5.2	7.21	6.4	8.64
Precipitation reported in inches				

Figure CC6. Comparison of previous and current extreme precipitation data for the region.

Impacts of Severe Storm Events

The graph at right shows the frequency and related costs of declared disasters and emergency declarations have increased since the late 1990's.

Although the specific factors for such increases in costs related to such events have not been determined, certain trends can certainly play a role including increased population in floodplains, increased investment and infrastructure in high risk areas, increased precipitation across the region, and the frequent occurrence of extreme weather events in the past decade.

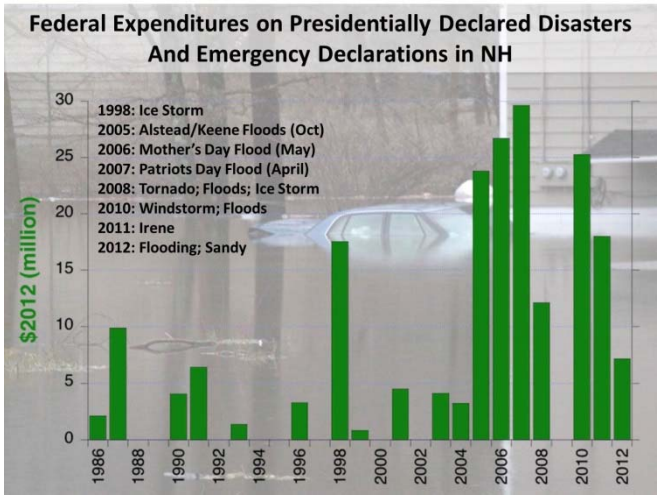


Figure CC7. Frequency and costs associated with past extreme weather events. [Source: Data compiled from the NH Multi-Hazard Mitigation Plan (2012, 2009)].

Riverine and Coastal Flooding

Nearly all communities in RPC's region have experienced significant flood events since 2000 in both riverine and coastal areas. Of these 26 municipalities, 18 are influenced by daily tides and 6 contain coastline bordering the Atlantic Ocean. The 6 coastline communities often experience both upland freshwater flooding and coastal storm flooding in the same event. The table below reports statistics of coverage, losses, and payments under FEMA's National Flood Insurance Program for properties located in the regulatory freshwater and coastal floodplains in the region.

FEMA reports that the RPC region has 3,414 NFIP policies and nearly $6.6 million in insured private assets. Given changes in sea level and the frequency and intensity of flood events, it is not surprising that coastal and tidal communities hold the most number of NFIP policies in the region. These statistics show that significant assets lie in high risk areas that with time could become more vulnerable and experience greater damages due to future changes in sea level rise, coastal storms and other types of flooding. Refer to the complete table as presented in the Natural Hazards Chapter.

Table CC2. FEMA National Flood Insurance Program Disaster Report – National Flood Insurance Program (NFIP) policy summary for municipalities in RPC's region.

Municipality	# of Policies	Insurance $ In Force	Total # Paid Losses	Total $ Paid	Repetitive Loss Buildings	Repetitive Loss Payment $
Totals	3,414	677,081,800	1,467	13,369,316	119	6,592,543

Note FEMA NFIP information does not reflect insurance coverage and damage to municipal assets. Properties that have a lien or other form of loan or mortgage attached to them are almost always required to have flood insurance. Individuals owning property outright make their own choice about whether to have flood insurance.

Taking Action on Climate Change

Over the last five or so years, discussions have become more common place here in New Hampshire and among the northeast states about the potential consequences of climate change. With this increased awareness has also come funding by federal agencies, non-profits and other groups to assist states, regional planning commissions, municipalities and other practitioners to better understand how climate change could alter human and natural systems, and how best to adapt to these changes.

Municipal Actions

Many municipalities in RPC's region have partnered with federal agencies, researchers and planners to evaluate how, when and where climate change could impact their municipal infrastructure and assets, the local economy, property and business owners, at risk populations, and natural systems. These initiatives represent a confident step by municipalities to plan for their current investments and decisions as well as their long-term futures. The table below summarizes the work being done by municipalities to address current and future impacts of climate change.

Table CC3. Summary of municipalities in the region who have previously or are currently engaged in climate assessment and/or adaptation projects.

Municipality	Date	Project/Study	Action
Seabrook	2009	Adaptation Strategies to Protect Areas of Increased Risk From Coastal Flooding Due to Climate Change in Seabrook, NH	High-risk areas considered priority for land conservation
Hampton-Seabrook Estuary communities (Hampton, Hampton Falls, Seabrook)	2012	*COAST** in Action: Projects from Maine and New Hampshire	Municipal education and awareness about the economic implications of impacts from sea level rise and storm surge to municipal infrastructure and critical facilities
Newfields	2013	Completed the NOAA Roadmap engagement process to identify short-term actions to address climate change impacts	Town made a bulk purchase of generators which were made available for purchase by residents. Planning Board adopted updated stormwater regulations to address local flooding issues.
Portsmouth	2013	Coastal Resilience Initiative	*Ongoing Project.* Informing update of the City's Master Plan, infrastructure management, and public outreach
Exeter	2013	Climate Adaptation Plan for Exeter (CAPE)	*Ongoing Project*
Rye	2014	Preparing For Climate Change in Rye: Gaining Insights and Charting a Course	Steering Committee and workshops participants identified key issues to work on relating to stormwater management, economic continuity and health
Seabrook-Hamptons Estuary Alliance	2014	Resilient New Hampshire Coasts: Assistance With Planning for Coastal Flood Hazards and Climate Change Impacts	*Ongoing Project*

* COAST is the Coastal Adaptation to Sea Level Rise modelling tool.

New Hampshire Coastal Adaptation Workgroup

The New Hampshire Coastal Adaptation Workgroup (NHCAW) is a collaboration of 20 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, CAW has led numerous projects and events that have elevated discussions about climate preparedness at municipal, state, and regional levels. CAW partners have received 18 grants totaling over $2.75 million dollars to conduct research, analyses, develop tools and implement outreach in the coastal watershed including municipalities, decision makers and practitioners. CAW projects are typically multi-faceted, incorporating science-based research, development of tools and guidance, and stakeholder outreach and engagement. NHCAW helps communities learn about and utilize existing resources and locate additional assistance to better prepare for the effects of a changing climate in order to protect their social, economic, human and environmental health. NHCAW provides communities with education, facilitation and guidance. NHCAW's yearly workshop series *Water, Weather, Climate and Community* focus on information to help communities acquire technical knowledge, gain access to resources, and learn from each other's experiences in order to prepare for the impacts of climate change.

RPC has been a participating member of NH CAW for over five years, providing staff time, technical resources and regional collaboration. RPC has partnered with member agencies and organizations to implement workshops, apply for funding, prepare advisory and guidance documents, and give presentations at national, state, regional and local events. For more information refer to CAW's website on the Storm Smart Coasts network at http://nh.stormsmart.org/.

Tides to Storms - Coastal Vulnerability Assessment and Hazard Mitigation Planning Project

New Hampshire coastal municipalities are confronted by land use and hazard management concerns that include extreme weather events, storm surges, flooding, coastal erosion, and damage to key assets. These issues are only intensified by recent increases in the frequency and intensity of extreme storm events and increases in sea level. Increased flooding has the potential to place coastal populations at risk, threaten infrastructure, intensify coastal hazards and ultimately damage homes, businesses, public infrastructure, recreation areas, public space, coastal wetlands and salt marsh.

To better understand the future of our coast, Rockingham Planning Commission received funding from NH Homeland Security and Emergency Management through FEMA to evaluate the potential impacts of climate change on New Hampshire's coastal municipalities. The project called Tides to Storms will provide the following products to coastal New Hampshire communities:

- Maps and Data - Detailed maps, risk and impact analyses, mitigation strategies, and recommendations for municipal Hazard Mitigation Plans.
- Informational Materials - Informational outreach materials and tools to help plan future actions and inform public and private investments.
- Coastal Vulnerability Assessment - A regional-scale vulnerability assessment report and map set for NH coastal communities.
- Town Vulnerability Assessment Summary - A report for each community summarizing the impacts of climate change on land, natural resources and infrastructure based on projections of future of sea level rise and storm surge.

The vulnerability assessment will quantify and map impacts to three broad themes which include multiple assets and resources as described below. The project will provide a regional assessment of impacts and municipal profiles of impacts based on the three themes and six flood scenarios.

Natural Resources	Transportation
Surface Water	Roads, Highways
Aquifers, Well Protection Areas	Bridges, Culverts, Dams
Wetlands (freshwater, tidal)	Transit Routes and Facilities
Wildlife Habitat	Bike Paths
Conservation Lands	Ports, Harbors, Marinas
Agricultural Soils	Long Range Transportation
State and Municipal Parks	Plan Projects
Infrastructure - Utilities - Critical Facilities	
Water, Wastewater	Emergency Shelters
Wells (public)	Emergency Services
Utilities (electric, gas, telecom)	Evacuation Routes
Historic and Cultural Landmarks	Hospitals, Healthcare Centers
and Structures	High Risk Areas and Populations

Table CC4. List of elements to be mapped and analyzed with respect to flood elevations depicting sea level rise scenarios and 100-year/1% chance storm surge: Natural Resources, Transportation and Infrastructure-Utilities-Critical Facilities.

The three themes will be evaluated under three global sea level rise scenarios and flooding associated with coastal storm surge projected to 2100. The project will also apply the Sea Level Affecting Marsh Migration Model (SLAMM) tool to evaluate the potential for inland marsh migration resulting from sea level rise. The analysis will be performed by the New Hampshire Fish and Game Department (NHFG). Refer to the section *Estuarine and Coastal Watershed Tools* for more information on SLAMM and marsh migration.

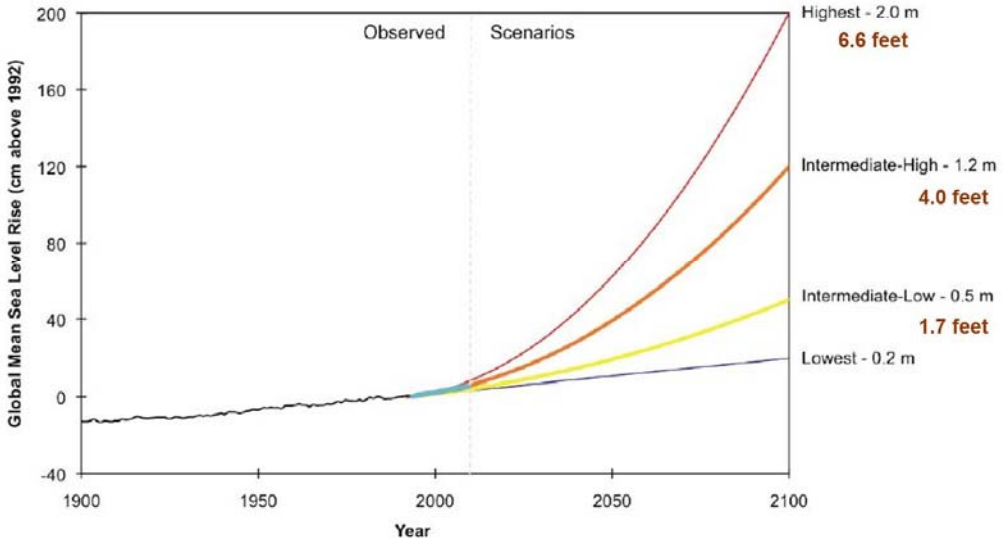


Figure CC8. Past and Projected Changes in Global Sea Levels (Parris, et al., 2012)

FLOOD SCENARIOS

Sea Level Rise

1.7 feet Intermediate Low
4.0 feet Intermediate High
6.3 feet Highest

Sea Level Rise + Coastal Storm Surge (CSS)

1.7 feet + storm surge
4.0 feet + storm surge
6.3 feet + storm surge

Note: Height of 100-year 1% chance coastal storm surge varies throughout the coastal region.

Refer to Appendix B Maps CC1 and CC2 for (draft) sample depictions of sea level rise and coastal storm surge flood potential and its impact on roads, upland and the coastal region.

This project will raise awareness across many sectors about the broad spectrum of impacts that coastal municipalities might encounter in the future. The project is intended to assist coastal NH communities to take actions to prepare for increase flood risk, including:

- Enhance preparedness and raise community awareness of future flood risks.
- Identify cost-effective measures to protect and adapt to changing conditions.

- Improve resiliency of infrastructure, buildings and investments.
- Protect life, property and local economies
- Protect services that natural systems provide
- Preserve unique community character

With support from the NH Coastal Adaptation Workgroup, RPC will work closely with the seven coastal municipalities to evaluate their risk and vulnerability to flooding from sea level rise and storm surge, and identify practical approaches to protecting municipal and private assets, public safety and natural resources. This information will be used to prepare a draft Climate Change and Adaptation Chapter for their local hazard mitigation plans.

Hamptons-Seabrook Estuary Coastal Adaptation to Sea Level Rise Project

Background

Emergency managers and community leaders need to understand the risks associated with these threats and develop local, practical solutions aimed at ensuring public safety, properly locating critical infrastructure, and conserving sensitive natural areas. Given that coastal hazard risks are increasing, community leaders require science-based evaluation of management options that incorporates the economic costs and benefits of various community planning choices. New Hampshire coastal communities have experienced widespread flooding events in recent years. Some low lying areas along the NH coast are flooded by seasonal high tides.

Project Overview

In 2011 the Hamptons-Seabrook Estuary Coastal Adaptation to Sea Level Rise Project was funded by the Piscataqua Region Estuaries Partnership through a grant from EPA's climate Ready Estuaries Program. The project goal was to evaluate impacts of future sea level rise and storm surge using the Coastal Adaptation to Sea Level Rise Tool (COAST) in a stakeholder driven process.

Lack of Necessary Information	- Current floodplain maps are inaccurate - Need maps of projected sea level rise and storm surge at regional and local scales
Project Purpose	- Examine the potential economic impacts from coastal storms - Evaluate measures to reduce risk and vulnerability
Project Benefits and Results	- A "decision tool" to weigh different courses of action against time and level of risk -
Next Steps	- Evaluate results against existing policies, plans and regulatory requirements – are changes necessary?

Staff from the New England Environmental Finance Center worked with the NH Coastal Adaptation Workgroup, municipal staff, elected officials, and other stakeholders to select specific locations, vulnerable assets, and adaptation actions to model using COAST. Applying the COAST model tools, representatives from the three towns – Hampton, Hampton Falls and Seabrook – selected a resource or asset to evaluate, in this case municipal facilities. The facilities modelled include:

Hampton:	Sewage Pump Station, Police Station, Wastewater Treatment Plant, High School
Hampton Falls:	No municipal facilities located in coastal areas.
Seabrook:	Wastewater Treatment Plant, Middle-Elementary School

Other high priority concerns identified by stakeholders in the three towns focused on: neighborhoods, roads and evacuation routes, emergency response facilities, energy utilities and infrastructure, environment and natural resources, businesses and real estate value.

Outputs of the COAST model showed which municipal facilities were vulnerable to flooding and what timeframe action might be needed to protect them. Results of the analysis found that:

- Implementation of adaptation actions (construction of berms in all cases) in every flood scenario modeled for Seabrook, Hampton and Hampton Falls has at least a 2:1 benefit to cost ratio.
- In the least-flooded scenario of low sea level rise, adaptation actions provide an 8:1, 3:1 and 10:1 benefits to costs ratio for Hampton, Seabrook and Hampton Falls, respectively, providing savings of nearly $260 million between the three towns by 2100 compared to "No Action" scenarios.
- Protection of public assets resulted in benefit to cost ratios as high as 10:1 for Hampton and 25:1 for Seabrook.
- Nowhere in the models, where the adaptation actions are implemented, do costs of adaptation outweigh benefits in dollars of damage avoided.
- Not all facilities require adaptation actions today and most can delay protective action to the 2050 or beyond timeframe.

State Plans and Initiatives

NH Climate Action Plan

In 2009, the Governor's Climate Change Policy Task Force released the N.H. Climate Action Plan, containing 67 overarching strategies necessary to meet the states greenhouse gas reduction, economic, environmental, and climate change related goals. The Plan's Task Force recommended that New Hampshire strive to achieve a long-term reduction in greenhouse gas emissions of 80 percent below 1990 levels by 2050.

The recommended strategies are organized into the following 10 overarching plan goals:

1. Maximize energy efficiency in buildings.
2. Increase renewable and low CO_2-emitting sources of energy in a long-term sustainable manner.
3. Support regional and national actions to reduce greenhouse gas emissions.
4. Reduce vehicle emissions through state actions.
5. Encourage appropriate land use patterns that reduce vehicle-miles traveled. Reduce vehicle-miles traveled through an integrated multi-modal transportation system.
6. Protect natural resources (land, water and wildlife) to maintain the amount of carbon fixed or sequestered.
7. Lead by example in government operations.
8. Plan for how to address existing and potential climate change impacts.
9. Develop an integrated education, outreach and workforce training program.

New Hampshire's Climate Action Plan presents an opportunity to:

- Avoid the significant costs of responding to a changing climate to the state's infrastructure, economy, and the health of our citizens; and
- Preserve the unique quality of life that makes New Hampshire an outstanding place to live, work, and raise a family.

Specifically Chapter 3 Adapting to Climate Change recommends statewide actions to address existing and future challenges relating to economics, human health, natural systems, and infrastructure.

> "The state will need to plan for these impacts with the best understanding of the resources that are available to address the issue at the state, regional and national level. This would require more comprehensive and integrated planning with a variety of stakeholders and should begin immediately and continue into the future."

Coastal Risks and Hazards Commission

The Coastal Risks and Hazards Commission was created effective July 2, 2013 through adoption by the Legislature of RSA 483-E. The commission is charged with recommending 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. The commission will review National Oceanic and Atmospheric Administration (NOAA) and other scientific agency projections of coastal storm inundation, and flood risk to determine the appropriate information, data, and property risks. The Commission is required to submit annual reports of 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 of each year through its conclusion in 2016.

The Commission's membership includes representatives from the House of Representatives, state agencies, regional planning commissions, municipalities, University of New Hampshire, NH Coastal Adaptation Workgroup, and other private sector and non-profit stakeholders from the coastal watershed. Cliff Sinnott, RPC's Executive Director, currently serves as Chair of the Commission. In the fall of 2013, the Commission formed three workgroups – Coastal, Inland/Great Bay and State Agency/Legislative - to capture the needs and issues of specific geographic areas and state and legislative functions and jurisdictions. The workgroups will evaluate information and prepare recommendations for deliberation by the full Commission and inclusion in their interim and final reports.

For more information refer to the CRHC website hosted by the NH Coastal Adaptation Workgroup website on the Storm Smart Coast network at http://nhcrhc.stormsmart.org/.

NH Homeland Security and Emergency Management – N.H. Multi-Hazard Mitigation Plan

For the first time the 2009 update of New Hampshire's Multi-Hazard Mitigation Plan incorporates new goals about addressing climate change including technical support, planning, assessment of risk and vulnerability, and adaptation statewide. RPC staff in collaboration with NH CAW members and the Coastal Program assisted with preparation of climate change goals and recommendations for the Plan update. Below are key goals and objectives from the NH Multi-Hazard Mitigation Plan relating to climate change.

Table CC5. Goals supporting climate change planning and adaptation from the N.H. Hazard Mitigation Plan (2013).

Goal	Objective / Action
Goal #2. Reduce the potential impact of natural and human caused disasters on New Hampshire's Critical Support Services, Critical Facilities and Infrastructure.	Objective H: Develop strategies to address coastal flooding and protection of infrastructure against storm surge. Action 1. 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.
Goal #7. Address the challenges posed by climate change as they pertain to increasing risk to the State's infrastructure and natural environment.	Objective A. 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. Objective B. Support strategies for adaptation to climate change. Objective C. 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.

The N.H. Multi-Hazard Mitigation Plan and a link to Federal Mitigation Resources are available on the Department of Safety, Homeland Security and Emergency Management website at: http://www.nh.gov/safety/divisions/hsem/HazardMitigation/planning.html.

N.H. Department of Environmental Services - Environmental Planning

The Department of Environmental Services (DES) has incorporated climate change into its 2010-2015 Strategic Plan and launched a two-year effort, "the Department Climate Initiative" (DCI), to engage agency leadership, middle management and key staff in a strategic review of DES's programs and activities. The goals of the DCI are to make changes to its outreach activities, grants, and regulatory programs that: account for changing climate and environmental conditions; and reduce DES's energy use while promoting the reduction in fossil-fuel consumption by others. This internal effort complements DES efforts to collaborate with other state agencies as well as other northeast states and eastern Canadian provinces to reduce the causes and prepare for the effects of climate change.

Public Health

Climate change affects human health and well-being in many ways, including impacts from increased extreme weather events, rising temperatures in both cold and warms months, wildfire, decreased air quality, threats to mental health, and illnesses transmitted by food, water, and disease-carriers such as mosquitoes and ticks. Human health impacts are intensified with increasing levels of exposure which are likely to worsen with climate variability and change. (Melillo, Richmond, & Yohe, 2013) For example, changes in the hydrologic cycle with increasingly variable precipitation and more frequent drought may lead to increases of airborne dust, which will trap ozone and other airborne pollutants near the ground causing exacerbations of respiratory disease. Increasing exposure to environmental pollutants and atmospheric emissions in recent decades has caused concern over its effect on public health, environmental ecosystems and climate worldwide. (Center for Disease Control and Prevention: Airway Diseases)

Table CC6. Possible health effects resulting from climate change impacts to air, water and exposure levels.

Potential Climate Change Health Effects		
Environment/Weather	**Air and Water**	**Toxic Exposure**
Heat Stress Illness and Mortality Extreme Weather-Related Injury, Illness, Mortality	Respiratory/Airway Disease Asthma and Allergies Vectorborne and Zoonotic Diseases	Foodborne Disease due to safety and availability of food and water supplies Neurological Disease/Disorder Cancer
Mental Health and Stress-Related Disorders, Cardiovascular Disease, Stroke Nutrition, Human Developmental Effects		

[Source: Summarized from the Centers for Disease Control and Prevention: Climate and Health Effects at http://www.cdc.gov/climateandhealth/effects/default.htm]

The most vulnerable populations - children, elderly people, those living in poverty, people with underlying health conditions, people living in certain geographic areas - are at increased health risk from climate change. The table below summarizes the linkages between human health impacts and changes in climate.

Heat Stress

Heat exposure has a range of mild to severe health effects and can aggravate chronic diseases, including cardiovascular and respiratory disease. Heat also increases ground-level ozone concentrations, causing direct lung injury and increasing the severity of respiratory diseases such as asthma and chronic obstructive pulmonary disease. Higher temperatures and heat waves increased demand for electricity and thus combustion of fossil fuels, generating airborne particulates and indirectly leading to increased respiratory disease. (Center for Disease Control and Prevention: Climate and Health)

Asthma and Respiratory Disease

Climate change will affect air quality through several pathways including production and impact of airborne allergens such as pollen and mold spores and increases in regional ambient concentrations of ozone, fine

particles, and dust. Some of these pollutants can directly cause respiratory disease or exacerbate respiratory disease in susceptible individuals. (Center for Disease Control and Prevention: Climate and Health)

As reported by the N.H. Department of Health and Human Services in the NH State Asthma Plan 2009-2014, New Hampshire data consistently show statistically significant increasing trends in adult asthma from 2000 to 2008, and it appears asthma is increasing faster in some groups than in others, further explaining health disparities:

- 13.8 times faster among adult women than men
- 4.7 times faster among individuals whose household income is less than $25,0000
- 4.7 times faster among the uninsured times faster among those with less than a high school education

Additional statistics about asthma reported include:

- Among New Hampshire children less than 18 years old, age and household income are the most important factors affecting higher asthma prevalence.
- 45% of adults and 34% of children with current asthma in New Hampshire have 'not well' or 'very poorly' controlled asthma
- Nearly 1/3 of adults and over 2/3 of children with asthma do not meet recommended guidelines for physical activity

CDC's Building Resilience Against Climate Effects (BRACE) Framework

The CDC's Building Resilience Against Climate Effects (BRACE) framework is a five step process that supports the development and implementation of a unified climate and health adaptation strategy to more effectively anticipate, prepare for and respond to climate sensitive health impacts. (Centers for Disease Control)

5 steps in the BRACE Framework:

Step 1: Forecasting Climate Impacts and Assessing Vulnerabilities

Step 2: Projecting the Disease Burden

Step 3: Assessing Public Health Interventions

Step 4: Developing and Implementing a Climate and Health Adaptation Plan

Step 5: Evaluating Impact and Improving Quality of Activities

Lyme Disease in New Hampshire

How Climate Effects Distribution of Deer Ticks

The first cluster of disease was recognized in Connecticut in the mid-1970s; health experts estimate that there are now around 300,000 cases of Lyme disease annually in the United States. Historically, deer ticks (*Ixodes scapularis)* and incidents of Lyme disease were present in southern portions of the Northeast and are now heavily present throughout the region due to its moderate climate. (Mole, March 19, 2014)

Climate change have the following effects on Lyme disease: an acceleration of the tick's developmental cycle, a prolonged developmental cycle, increased egg production, increased population density, and a broader range of risk areas. An adult tick may become active on warm winter days, yielding a larger nymph population the following year. (Mole, March 19, 2014)

With an earlier winter thawing, nymph stage ticks will become active sooner. The warmer winters will also allow for a higher survival rate of the white-footed mouse, a popular host for the ticks, meaning an increased tick population in the spring and summer. (National Association of Geoscience Teachers)

Occurrence of Lyme Disease in New Hampshire

According to the Centers for Disease Control and Prevention, New Hampshire and specifically Rockingham County have one of the highest occurrences of Lyme's Disease in the country and among the New England states. Lyme disease, is transmitted by the bite of the black-legged tick (*Ixodes scapularis*), formerly known as the deer tick. (NH Department of Health and Human Services)

The most effective way to protect against the disease is through education and awareness, and implementing precautionary measures such as wearing appropriate clothing, applying repellent, and carefully checking for ticks on clothing and body. Other measures include properly removing ticks when bitten, screening for possible infections, and getting proper treatment when infected. (NH Department of Health and Human Services)

Reported Cases of Lyme Disease in New Hampshire, 2008-2013

	2008		2009		2010		2011		2012		2013	
County¶	Cases	Rate*	Cases	Rate*	Cases	Rate*	Cases	Rate*	Cases	Rate*	Cases	Rate*
Belknap	23	38.2	20	33.2	34	56.6	42	69.7	29	48.1	47	78.1
Carroll	16	33.3	19	39.8	35	73.2	53	111.2	48	100.9	60	126.3
Cheshire	36	46.5	36	46.6	29	37.6	61	79.3	43	56.0	72	94.0
Coos	2	*	3	*	5	15.1	10	30.6	5	15.6	2	*
Grafton	18	20.3	19	21.4	45	50.5	40	45.0	43	48.2	78	87.0
Hillsborough	451	112.9	438	109.5	425	106.1	388	96.6	429	106.5	499	123.5
Merrimack	103	70.0	90	61.3	110	75.1	108	73.7	125	85.2	147	100.1
Rockingham	681	230.9	585	198.2	498	168.7	422	142.5	550	184.7	526	175.8
Strafford	263	214.8	191	155.2	139	112.9	155	125.1	172	138.6	212	170.2
Sullivan	15	34.3	23	52.6	22	50.3	22	50.6	16	37.1	39	90.7
Total Cases	**1,615**	**122.7**	**1,425**	**108.3**	**1,342**	**101.9**	**1,301**	**98.7**	**1,460**	**110.5**	**1,689**	**127.6**
Confirmed	1,222		1,002		834		887		1,009		1,323	
Probable	393		423		508		414		451		366	

* Rate per 100,000 persons. Rates calculated on events <20 are considered statistically unreliable and should be interpreted with caution. Rates not calculated for counties with 1-4 cases due to instability of the rate calculation.

Note: Data beginning with 2008 include confirmed and probable cases to be consistent with the 2008 Lyme Disease case definition adopted by CDC and CSTE. Data beginning in 2012 are based on the latest 2011 Lyme Disease case definition. Changes in case definition over time make it difficult to compare incidence across years as it is unclear how these changes altered the number of reported cases classified as probable or confirmed in New Hampshire.

¶ Data on county of residence are incomplete or not available for 7 cases in 2008, 1 case in 2009 and 7 cases in 2013.

Figure CC9. Statistics of reported cases of Lyme disease in N.H. by county.

Environment and Ecosystems

NH Wildlife Action Plan

IN 2013, The N.H. Wildlife Action Plan was updated to include evaluation of climate change impacts on ecosystems and habitats. (Ecosystems and Climate Change Adaptation Plan, 2013) N.H.'s coastal habitats are expected to be the most immediately affected by climate change due to sea level rise, which will inundate habitat, change salinities and increase the damaging effects of storm surge. For freshwater habitats, more precipitation occurring in stronger storms, and longer summer droughts will change stream flooding and wetland recharge. Increasing temperature will also affect marine and aquatic species ranges and reproductive cycles. In terrestrial habitats, species composition will shift as species track their preferred temperature and moisture ranges, potentially resulting in altered food webs and other natural process. The Plan identifies critical action-oriented strategies necessary to address impacts of climate change on wildlife, habitats and ecosystems.

- Conserve Areas for Habitat Expansion and/or Connectivity
- Habitat Restoration and Management
- Restore Watershed Connectivity
- Protect Riparian and Shoreland Buffers
- Invasive Species Plan
- Comprehensive Planning
- Stormwater Policy and Flood Response
- Revise Water Withdrawal Policies
- State Energy Policy
- Funding
- Modeling, Research and Monitoring
- Technical Assistance and Outreach

Three broader themes outlined in the plan encompass commonalities among actions that otherwise apply more specifically to individual habitats or vulnerabilities, and that also address some of the most pressing current needs related to climate change.

Short-term Implementation (short-term, small scale): Despite the need for further assessment and ongoing planning, there are things that can be done now to minimize the effects of climate change on both ecosystems and humans.

Landscape Assessment and Conservation (long-term, large scale): Any response to climate change should take advantage of existing and emerging knowledge to identify areas that are more resilient, more likely to adapt, or that are at highest risk.

Partnerships: Because climate change occurs at a large scale, it is imperative that agencies, NGOs, planners, researchers and municipalities work together towards common solutions. (Ecosystems and Climate Change Adaptation Plan, 2013)

Estuarine and Coastal Watershed Tools

Sea Level Affecting Marshes Model (SLAMM)

In the summer and fall of 2014 New Hampshire Fish and Game Department (NHFG) conducted modelling of inland marsh migration in response to sea level rise for all of coastal New Hampshire. As the sea level changes, coastal dynamics and ecosystems change with it. Under the right conditions, marshes have the capacity to migrate inland with a rising sea level.

NHFG used the Sea Level Affecting Marshes Model (SLAMM), a tool that simulates the processes that affect how coastal ecosystems naturally change over time and where natural and man-made barriers will inhibit these changes. This tool can help users visualize and understand how coastal ecosystems will likely shift and adapt over time under a range of projected sea level rise conditions. These model outputs will be accessible through the New Hampshire Coastal Viewer by 2015. NHFG staff worked with four communities, Hampton, Hampton Falls, Seabrook, and Portsmouth to explore how SLAMM can aid local decision making. Possible applications of SLAMM include supporting decision about citing future infrastructure, habitat restoration, land conservation, and the development of land use regulations (e.g. buffers and setbacks).

Following are additional resources about marsh migration:

Marshes on the Move, by NOAA Coastal Services Center and the Nature Conservancy at http://www.csc.noaa.gov/publications/Marshes_on_the_move.pdf

Ecosystems and Wildlife Climate Change Adaptation Plan Chapter, New Hampshire Fish and Wildlife Action Plan, New Hampshire Fish and Game at http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/climate_change/Eco_Wildlife_CC_Adapt_Plan.pdf

Coastal Viewer Web-Based Tool

With funding support from NOAA, NH GRANIT has worked with the NH Department of Environmental Services and a team of partners to develop the NH Coastal Viewer, a web-based mapping tool that provides access to geospatial data sets focused on coastal climate change adaptation. Priority data layers incorporated into the Viewer include projected sea level rise inundation layers, floodplain data, fluvial erosion hazards data sets, culvert assessments, land use data, and marsh migration model outputs. These are supplemented by a suite of data sets that provide geographic context for the Coastal Viewer data series, including standard base map layers (town boundaries, road centerlines, surface waters, etc.) and topographic and aerial image products. Tools to view and interact with the data allow users to navigate the map layers to select specific geographic areas, query individual data sets, show custom buffers from features (e.g. surface waters, wetlands), upload and display local data formatted as GIS files, and export maps for local printing. The Viewer provides a tool for New Hampshire's coastal communities and regional planning agencies to assist them in visualizing and understanding coastal resources, current and potential coastal climate change impacts and vulnerabilities, and options for coastal adaptation strategies. The Coastal Viewer Tool will be available on the GRANIT website in 2015.

Water Management

In 2012, the New Hampshire Water Sustainability Commission issued its report highlighting the most important issues that we need to address and identifying those strategic goals and recommendations that will chart a course toward ensuring the long-term sustainability of our water resources.

Everyone in the state relies on water to meet basic needs, while others need water for commercial uses, production of food, recreational and tourism businesses, and as a commodity that is mined and sold. Water is the resource that allows us to live, recreate and enjoy a high quality of life.

Ultimately, a future oriented toward climate change adaptation will present challenges to attaining the seven goals identified by the Water Sustainability Commission.

Refer to the Natural Resources Chapter for more detailed information about drinking water, groundwater resources, surface water resources, and stormwater.

7 Strategic Goals from the New Hampshire Water Sustainability Commission Report (2012)

1. The people of New Hampshire will be **knowledgeable, engaged, and careful consumers and stewards** of our water resources.
2. Flexible and coordinated **water management programs and practices** will be designed and implemented to ensure that New Hampshire has an **adequate quantity and quality of water** to support ecological and human health and economic activity.
3. Management and planning for New Hampshire's **water quality and quantity will be integrated** at appropriate state, watershed and sub-watershed levels.
4. The infrastructure for delivering our **drinking water, cleaning our wastewater, and managing storm water and water storage** will protect human and environmental health and safety in an affordable manner.
5. **Runoff from rain and snow**, and the pollution it carries, will be minimized and effectively managed.
6. Our **watersheds, communities, and built infrastructure** will be robust, resilient, and able to adapt to changing weather patterns.
7. Adequate public and private funding will be available for managing water resources effectively and efficiently.

Agriculture

Department of Agriculture

The Climate Change Program Office (CCPO) coordinates USDA's responses to climate change, focusing on implications of climate change on agriculture, forest ecosystems, grazing lands, and rural communities. The USDA Climate Change Adaptation Plan presents strategies and actions to address the effects of climate change on key mission areas including mitigation of greenhouse gas emissions, agricultural production, food security, rural development, and forestry and natural resources conservation. The Plan provides a detailed vulnerability assessment, reviews the elements of USDA's mission that are at risk from climate change, provides specific actions and steps being taken to build resilience to climate change, and integrates climate change adaptation planning into the actions of the Department. (U.S. Department of Agriculture: Office of the Chief Economist)

USDA Regional Climate Hub in New Hampshire

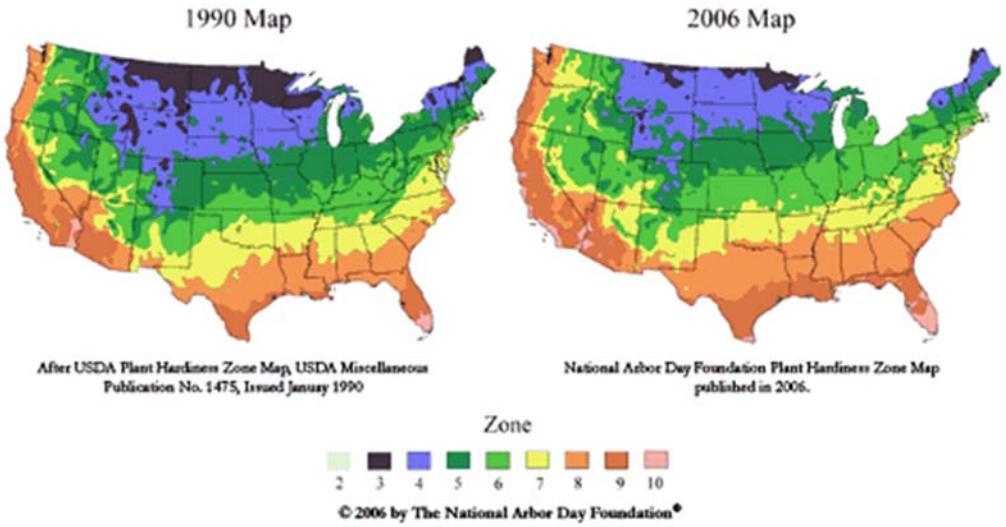
In 2014, the USDA created regional hubs to deliver information to farmers, ranchers and forest landowners to help them adapt to climate change and weather variability at regional and local scales. The Northeastern Regional Climate Hub (NERCH)in Durham, N.H. This multi-agency effort (Agricultural Research Service, Forest Service, and Natural Resources Conservation Service) is being led by David Hollinger, Plant Physiologist at the Forest Service Northern Research Station. The Hub will deliver science-based knowledge and practical information to farmers, ranchers, and forest landowners that will help them to adapt to climate change by coordinating with local and regional partners. The Hub will provide:

- Technical support for land managers to respond to drought, heat stress, floods, pests, and changes in growing season.
- Regional assessments and forecasts for hazard and adaptation planning.

- Outreach and education for land managers on ways to mitigate risks and thrive despite change. (U.S. Department of Agriculture: Regional Climate Hubs)

U.S. Plant Hardiness Zones

Compared with the 1990 version, zone boundaries in this edition of the map have shifted in many areas. The new PHZM is generally one half-zone warmer than the previous PHZM throughout much of the United States, as a result of a more recent averaging period (1974–1986 vs. 1976–2005). However, some of the changes in the zones are the results of the new, more sophisticated mapping methods and greater numbers of station observations used in this map, which has greatly improved accuracy, especially in mountainous regions. These changes are sometimes to a cooler, rather than warmer, zone.



Climate changes are usually based on trends in overall average temperatures recorded over 50-100 years. Because the USDA PHZM represents 30-year averages of what are essentially extreme weather events (the coldest temperature of the year), changes in plant hardiness zones alone are not conclusive evidence of widespread warming.

Figure CC10. Maps showing changes to plant hardiness zones in the U.S. from 1990 to 2006.

The recent climate assessment for southeastern New Hampshire(Wake et al, 2012) reports regional changes in climate change across in a wide range of indicators that include increases in temperature (especially in winter), increase in overall precipitation, an increase in the rain-to-snow precipitation ratio, a decrease in snow cover days, earlier ice-out dates, and earlier spring runoff. Combined these changes have resulted in longer growing seasons for native plants - earlier spring bloom dates for lilacs - and agricultural crops.

Key Issues and Challenges

One of the key issues and challenges with respect to climate change revolves around making sound decisions today that consider potential future conditions and what impact they may have on natural and human systems. We can observe today our existing challenges with respect to a changing climate as well as historical trends; however predicting future conditions poses far more challenges due to limitations of technology and the multitude of economic and societal conditions that may or may not occur.

Historic flooding risk is not a good predictor of the level of risk communities will face moving into the future: there is a need to plan proactively for more flooding.

Projecting Future Conditions

Climate science provides insight into future conditions through complex models that produce "climate projections". Projections are based on scientists' understanding of how the climate system works and on computer models designed to simulate Earth's climate. A climate projection is a statement about the likelihood that something will happen several decades to centuries in the future if certain environmental and behavioral/societal conditions occur. Climate projections specifically allows for evaluating a range of conditions, such as an increase in greenhouse gases, which might influence the future climate. For projections extending well out into the future, scenarios are developed of what could happen given various assumptions and judgments regarding fossil fuel use and greenhouse gas emissions. (World Meteorological Organization) (National Oceanic and Atmospheric Administration: Climate.gov)

National Climate Assessment

The Intergovernmental Panel on Climate Change (IPCC's) Fifth Assessment Report or AR5 (2014) and the National Climate Assessment – Northeast Chapter (NCA, 2014) provide knowledge on the scientific, technical and socio-economic aspects of climate change based on a range of greenhouse gas emission scenarios.

See Climate Change Impacts in the United States: Northeast Chapter, The Third National Climate Assessment. U.S. Global Change Research Program –(NCA, 2014) at http://nca2014.globalchange.gov/report/regions/northeast and the 2014 IPCC AR5 report and other resources at http://www.ipcc.ch/.

The National Climate Assessment (2014) and recent assessments conducted in New Hampshire project our state may be affected by future changes in climate across many sectors.

The recent climate assessment for southeastern New Hampshire *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future* (Wake, et al., 2011) reports historical trends and future projections for temperature, sea level, rain and snowfall resulting from climate change. Such changes may include warmer winters and hotter summers, more frequent and severe upland and coastal flooding, more extreme precipitation events, and less snow and more rain. Refer to Figure CC13 on page 27 for a summary from the Wake et al (2011) report.

NH Coastal Risks and Hazards Commission, Science and Technical Advisory Panel Report

The NH Coastal Risks and Hazards Commission, Science and Technical Advisory Panel reviewed scientific literature, reports and assessments on climate change to identify likely conditions New Hampshire should prepare for by 2050 and 2100. The report "outlines the projected impacts likely to be experience in the next few decades and out into the end of the century and recommends a number of assumptions and projections for the Commission to use. It is intended to specifically advise the Commission which will in turn develop specific recommendations to assist in planning and preparation for the changing climatic conditions." The Science Advisory Panel's report (July 2014) offers the following projections of future climatic conditions for the region (Kirshen, Wake, Huber, Knuuti, & Stampone, 2014).

<table>
<tr><th>Conditions</th><th>Projections</th></tr>
<tr><td>Sea Level Rise</td><td>The range that best covers plausible sea-level rise increases to 2050 and 2100 are those prepared for the US National Climate Assessment and include the “Highest”. “Intermediate High”, “Intermediate Low” and “Lowest” scenarios based on varying greenhouse gas emissions and other climate responses:

<table>
<tr><th>Time Period*</th><th>Lowest</th><th>Intermediate Low</th><th>Intermediate High”</th><th>Highest</th></tr>
<tr><td>2050</td><td>0.3 feet</td><td>0.6 feet</td><td>1.3 feet</td><td>2.0 feet</td></tr>
<tr><td>2100</td><td>0.7 feet</td><td>1.6 feet</td><td>3.9 feet</td><td>6.6 feet</td></tr>
</table>
*using mean sea level in 1992 as a reference (Parris et al., 2012)

Source: Table ES.1. Sea-Level Rise (in feet) provided for the National Climate Assessment, 2014. (Parris, et al., 2012)</td></tr>
<tr><td>Storm Surge</td><td>Given the uncertainties associated with future storm surge changes, recommend that projects continue to use the present frequency distributions for 100-year and 500-year storms (as depicted in the 2014 FEMA Flood Insurance Rate Maps for Rockingham and Strafford Counties).</td></tr>
<tr><td>Precipitation</td><td>Projected increases in annual precipitation are uncertain but could be as high as 20% in the period 2071-2099 compared to 1970-1999, with most of the increases in winter and spring with less increase in the fall and perhaps none in the summer.</td></tr>
<tr><td>Extreme Precipitation</td><td>While unable at present to assign with confidence future changes in extreme precipitation events, recommend at a minimum that all related infrastructure be designed with storm volumes based on the current Northeast Regional Climate Center (Cornell) precipitation atlas to represent current conditions and be designed to manage a 20% increase in extreme precipitation events after 2050 and that a review of these projections be continued.</td></tr>
</table>

Table CC7. Projected climatic conditions to 2100 for sea level, storm surge, precipitation and extreme precipitation for the region. Source: (Kirshen, Wake, Huber, Knuuti, & Stampone, 2014)

Figure CC11. Summary of past and projected future climate change in southeastern New Hampshire.

New Hampshire's Climate:
PAST AND FUTURE CHANGES

CARBON SOLUTIONS NEW ENGLAND
CarbonSolutionsNE.org

Earth's climate has varied throughout time and it will continue to change. However, according to a 2011 research report from the University of New Hampshire, the rate of change has increased over the last four decades, with New England getting warmer and wetter.

TEMPERATURES

WHAT HAVE WE SEEN SINCE 1970?

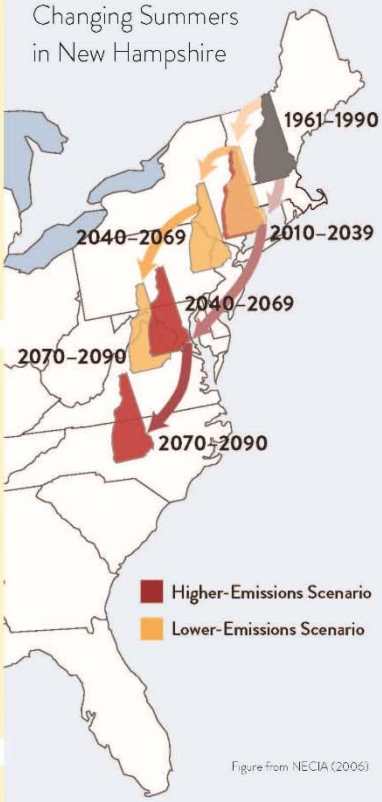
- Annual and seasonal temperatures have warmed by almost 2°F
- Lake ice-out dates are occurring earlier

WHAT CAN WE EXPECT?

- Warmer winters: 25-50 fewer days per year below 32°F
- Hotter summers: 30-70 days per year above 90°F (compared to about 10 per year during the period 1970-1999)

CLIMATE ON THE MOVE

Changing Summers in New Hampshire



Yellow arrows track what summers are projected to feel like under a lower emissions scenario, while red arrows track projections for a higher emissions scenario. For example, under the higher emission scenario, by late this century residents of New Hampshire would experience a summer climate more like what occurs today in North Carolina.

SEA-LEVEL RISE

WHAT HAVE WE SEEN SINCE 1970?

- Sea level in Portsmouth has risen almost six inches since 1926

WHAT CAN WE EXPECT?

- Sea level will continue to rise an additional two to six feet by 2100
- Increased extent of coastal flooding and storm surge

RAIN AND SNOWFALL

WHAT HAVE WE SEEN SINCE 1970?

- Annual precipitation has increased 5-20%
- The frequency and magnitude of extreme precipitation events has increased.

WHAT CAN WE EXPECT?

- Less snow and more rain
- More frequent and severe flooding
- More precipitation (annual average will increase by 12-17%) and more extreme precipitation events.

Source: Information flyer for the publication Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future (2011). (Wake, et al., 2011)

Change Through Mitigation

Climate change mitigation centers on reduction of greenhouse gas (GHG) emissions achieved through energy efficiency and conservation, use of renewable and alternative energy sources, and CO_2 sequestration in biomass. In order to be effective and result in positive changes, mitigation must be performed by all sectors at the state, regional and local levels including individuals, businesses and municipalities. In order to move toward the long-term GHG reductions goals outlined in the NH Climate Action Plan and provide the greatest economic opportunity to the state of New Hampshire, the Plan recommends 67 actions to:

With respect to climate change, ***mitigation*** is the reduction of greenhouse gas (GHG) emissions achieved through energy efficiency and conservation, use of renewable and alternative energy sources, and CO_2 storage in forests and biomass.

- Reduce emissions from buildings, electric generation, and transportation.
- Protect our natural resources to maintain the amount of carbon capture and storage (sequestration).
- Support regional and national initiatives to reduce greenhouse gases.
- Develop an integrated education, outreach and workforce training program.
- Adapt to existing and potential climate change impacts

At the regional level, RPC can directly mitigate GHG emissions through implementation of strategies in its transportation planning activities including the Long-Range transportation Plan, Transportation Improvement Plan, and use of federal and state funding programs to implement alternative transportation and roadway improvement projects. RPC also offers technical assistance and grants to municipalities to implement local studies and projects that can be geared toward GHG emissions reductions. RPC can also assist municipalities with amending land use zoning and regulations to reduce GHG emission through subdivision and site development practices, providing property with incentives to build structures and select utilities with energy efficiency in mind, and aligning land conservation goals to maximize carbon sequestration.

Refer to the Transportation section below for more information about how transportation can help achieve mitigation goals for greenhouse gas emissions reductions.

Regional Greenhouse Gas Initiative (RGGI)

Regional Greenhouse Gas Initiative, Inc. (RGGI, Inc.) is a 501(c)(3) non-profit corporation created to support development and implementation of the Regional Greenhouse Gas Initiative (RGGI) in the northeast. RGGI is a cooperative effort among nine states – Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont – to reduce greenhouse gas emissions. RGGI, Inc.'s exclusive purpose is to provide administrative and technical services to support the development and implementation of each RGGI State's CO_2 Budget Trading Program. RGGI, Inc.'s activities include:

- Development and maintenance of a system to report data from emissions sources subject to RGGI, and to track CO_2 allowances
- Implementation of a platform to auction CO_2 allowances
- Monitoring the market related to the auction and trading of CO_2 allowances
- Providing technical assistance to the participating states in reviewing applications for emissions offset projects
- Providing technical assistance to the participating states to evaluate proposed changes to the States' RGGI programs

Refer to the Energy Efficiency and Green Building Chapter for more detailed information about RGGI.

Transportation

The largest single contributor to greenhouse gas emissions in New Hampshire is derived from the transportation sector. However, many other external factors influence transportation emissions including land development patterns, land cover conversion, individual preferences and behavior, convenience and pricing. All of these factors combined must be considered in the context of climate change and the degree to which emissions will drive human behaviors and environmental change.

Continued and sustained efforts toward reducing greenhouse gas contributions across all sectors must be made to keep atmospheric emissions at safe limits. Examples such as those at right provide a coordinated framework from which to achieve this goal.

Reduce Greenhouse Gas Emissions in All Sectors

Reduce Vehicle Miles of Travel

Produce More Low-Emission Energy in New Hampshire

Encourage Energy Efficiency and Conservation to Reduce Consumption

Expand Renewable Energy Choices and Availability

Support Efficient Growth and Development Patterns

Implement Adaptation Measures That Protect Infrastructure and Property

Adopt Climate Adaptation Measures to Sustain Natural Resource Services

Reduce Vehicle Miles of Travel

The transportation sector contributes roughly 28 percent of the total U.S. greenhouse gas emissions each year. As of 2012, transportation accounts for 43 percent of greenhouse gas emissions in New Hampshire (Skoglund), which is significantly higher than the national average.

New Hampshire has had consistently declining per capita Vehicle Miles of Travel **(**VMT) since 2007 and current levels are below those seen in 2004. The main reasons for sustained decline in VMT are:

- Fuel prices continue to fluctuate and on average have remained high since the early 2000's. (Note: As of the publication of this Chapter, fuel prices have recently trended downward.)
- Technology is replacing the need for some trips (e.g. digital services and internet access).
- Youth, as a group, are choosing more cost effective ways to travel over single occupancy vehicles.

Reduce Greenhouse Gas Emissions

The NH Climate Action Plan recommends that New Hampshire strive to achieve a long-term reduction in greenhouse gas emissions of 80 percent below 1990 levels by 2050. This goal is based on the reductions that climate scientists believe are necessary to stabilize greenhouse gases in the atmosphere at or below 450 parts per million of carbon dioxide. Stabilizing the concentrations of greenhouse gases at this level may keep environmental conditions below critical thresholds thus minimizing the most severe potential impacts of climate change.

Refer to the Existing Conditions section of the Energy Chapter for more detailed information about VMT, greenhouse gas emissions and energy use in New Hampshire.

In addition to carbon dioxide and other greenhouse gases, ozone and particulate matter have a significant warming effect on the atmosphere, and pose serious public health implications. ***Refer to the Public Health section of this Chapter for additional information on the health impacts of greenhouse gas emissions.***

Implementation of State Plans

Additional reductions in greenhouse gas emissions may be achieved by aligning existing transportation program activities with goals from the N.H. Climate Action Plan and State Energy Strategy. Transportation planning is featured as a critical component of both of these plans. These plans focus broadly on what is referred to as the "3-legged stool" linking climate change to emissions, fuel choice and efficiency (travel less using less fuel and creating fewer emissions) with the goal of reducing greenhouse gas emissions.

Alternative Fuels	Access to electric vehicle charging stations, alternative fuels and fueling stations, clean vehicle technology
Energy Efficiency	Expand open road tolling, congestion management planning, advanced roadway technology (intelligent systems management)
Transit and Multi-Modal	Maximize use of alternative modes by creating transportation *choices* that are *accessible* to the majority of commuters, *affordable* for everyone and *convenient* to and from employment and services
Compact Growth and Development	Significantly decrease VMT and GHG emissions by adopting compact land use and development standards

RPC's Role as a Metropolitan Planning Organization

As part of its function as a Metropolitan Planning Organization (MPO), the RPC implements the federal and state transportation planning process in the 27 municipalities in the region. The RPC coordinates local, state and federal plans ensuring that local and regional transportation needs are accounted for in the statewide transportation and project planning process and in the prioritization of federally funded projects. The RPC strives to utilize guidance from the Federal Highways Administration (FHWA), Federal Highway Administration (FHA) and other sources to incorporate climate change data and analyses in future project and programmatic initiatives including coordination between the transportation, land use and environmental planning sectors.

Refer to the Key Issues and Challenges section of the Transportation Chapter for more detailed information about VMT, greenhouse gas emissions climate related issues in New Hampshire.

Planning and Program Tools

Several existing programs administered under the MPO can actually help achieve further reductions in vehicle miles of travel and greenhouse gas emissions by implementing efficiency measures and alternative choices in the region's transportation systems. These programs allow transportation planning to address many of the cross-cutting issues stated previously by establishing linkages between transportation, land use and energy.

Congestion Management

Traffic congestion is one of the many issues affecting the economic vitality and quality of life of the region. Environmental impacts from traffic congestion include air quality, ecological concerns and climate change. The Congestion Management Process (CMP) is a planning and project programming tool that aids in the effective management of the transportation system through development and implementation of operational and travel demand management strategies. It also provides system performance information to decision-makers to assess the effectiveness of implemented strategies as well as identify system investment priorities. A direct environmental benefit of the CMP is improved coordination between transportation, land use, economic development, and environmental planning.

Transportation Alternatives Program

The Federal Highways Administration (FHWA) funds state administration of the Transportation Alternatives Program (TAP). The TAP replaced the funding from pre-MAP-21 programs including the Transportation Enhancement Activities, Recreational Trails Program, and Safe Routes to School Program. The TAP program offers a wide range of options to implement local projects that reduce VMT and emissions. TAP projects include on- and off-road pedestrian and bicycle facilities, infrastructure projects for improving non-driver access to public transportation and enhanced mobility, community improvement activities, and environmental

mitigation; recreational trail projects; safe routes to school projects; and projects for planning, designing, or constructing boulevards and other roadways largely in the right-of-way of former divided highways.

Intelligent Transportation Systems

The SRPC and RPC ITS Strategic Plan provides an overall framework for ITS implementation to enhance the regions' transportation safety, security, mobility, and performance. The Plan goal is to apply advanced technologies and systems to improve interagency coordination and create opportunities for seamless integration of transportation services, both within the region and with adjacent regions."

Planning for Climate Change

Because climate change affects our entire state, regional collaborative approaches that address common infrastructure, natural resources, economies and services are needed to effectively address the future. RPC has been a leader in bringing resources, technical expertise and funding to our municipalites and other regional stakeholders for the purpose of better understanding of how climate change may affect the region. Given limited resources and capacity, RPC places particular focus on fostering regional and municipal collaboration around this critical issue.

New Hampshire has many state and municipal assets and resources that may be impacted in the future by climate change. State and municipalities with assets and resources in coastal and riverine floodplains have a distinct and pressing need to comprehensively address existing and future impacts, including sea level rise, land and natural resource protection, public health, and sustainability of local and regional economies. Without proactive solutions to address the expected impacts of climate change, coastal communities in particular face a multitude of challenges to ensure the security, health and welfare of its citizens and provide for a stable and viable economic future. However, actions to prepare and make sound choices will allow coastal communities to adapt to a changing climate and thrive with fewer economic, social, and environmental impacts.

Local Implementation

Many municipalities view climate change as a response activity focused on emergency management, public health and safety, and disaster or hazard based preparedness. Fewer municipalities address climate change and its future impacts in planning and policy documents such as their Capital Improvement Plans, Master Plans, infrastructure and/or road maintenance plans, or land and open space conservation plans.

> The "climate change lens" can be used to comprehensively fold targeted strategies into existing processes including policies, plans, regulatory frameworks, voluntary/advocacy initiatives, and private sector actions.

At the municipal level, implementation strategies to address current and potential future impacts from climate change can be incorporated into existing frameworks and mechanisms that can be modified by evaluating them under the "climate change lens" (i.e. consideration of short-term, sustained and long-term changes in environmental conditions).

Municipalities need help developing and implementing policies and regulations to plan for and adapt to the impacts of climate induced changes. Important first steps include: identifying areas most at risk from flooding and sea level rise; incorporating climate change adaptation and mitigation strategies in local hazard mitigation plans; putting regulations in place that decrease the vulnerability of buildings and infrastructure in areas subject to higher risk of flooding, particularly in the next 20 to 50 years (or within the life cycle of most existing facilities); and leveraging existing institutional practices - such as master plans, and capital improvement plans – to maximize use of available funds and implement comprehensive strategies to minimize and prevent impacts, and protect public and private investments.

Actions and strategies to address impacts from climate change can be incorporated into existing frameworks including:

- Zoning and Regulations
- Planning and Policy
- Funding Mechanisms and Plans
- Asset and Infrastructure Management
- Education, Outreach, Raising Awareness
- Natural Resource and Environmental Services Management

Refer to the detailed list Adaptation Strategies in Appendix A of this chapter.

Long-Term Planning and Collaborative Decision Making

The National Climate Assessment (NCA, 2014) report prepared by the U.S. Global Research Change Program (http://ncadac.globalchange.gov/) provides detailed climate information for the northeast region of the U.S as well as recommendations to address future conditions. Coordinated planning at all levels and across all sectors will be necessary to protect our quality of life and the safety and well-being of human and natural environments. "Key Messages" from the NCA Report, which focus on long-term planning and collaborative decision making, are summarized below.

- Create well-structured, transparent, and collaborative decision processes involving researchers and stakeholders is as important to effective decision-making as having good scientific information and tools. An effective process will better enable decision-makers to apply complex information to decisions, consider uncertainties associated with climate variability and change, assess the wide range of possible human responses, and engage institutions and individuals who are potentially affected.

- Utilize successful model decision frameworks and tools available to support and improve decision-making on climate change adaptation and ways to reduce future climate change.

- Steps to improve collaborative decision processes could include training more "science translators" to help bridge science and decision-making; integrating development of decision support tools into fundamental scientific research; and supporting practitioners who work to advance climate science and decision-making.

Adapting to Future Conditions

Solutions and opportunities to address climate change lie first in assessing current and potential future impacts across all sectors, and second in implementing sustained and long-term planning across all sectors. The goal of developing maps and other predictive tools – such as depicting the extent and magnitude of potential impacts of sea level rise, storm surge and severe storm events - is to reduce the amount of risk and vulnerability associated with future development and investments, both public and private, and minimizing impacts to natural systems. These tools can also inform adaptation and mitigation strategies that can help reduce risk and vulnerability of existing development and investments through structural improvements, protective measures, and advance planning for resource management, future growth, reconstruction or relocation.

Solutions and opportunities to address climate change lie first in assessing current and potential future impacts across all sectors, and second in implementing sustained and long-term planning across all sectors.

State and regional actions to address climate change will likely focus on response, mitigation by emissions reductions, and adaptation activities. Such actions will be designed to:

- Enhance preparedness and raise community awareness of future flood risks.
- Identify cost-effective measures to protect and adapt to changing conditions.

- Improve resiliency of infrastructure, buildings and investments.
- Protect life, property and local economies.
- Protect services that natural systems provide.
- Preserve unique community character.

Refer to Append B for a comprehensive list and descriptions of adaptation strategies.

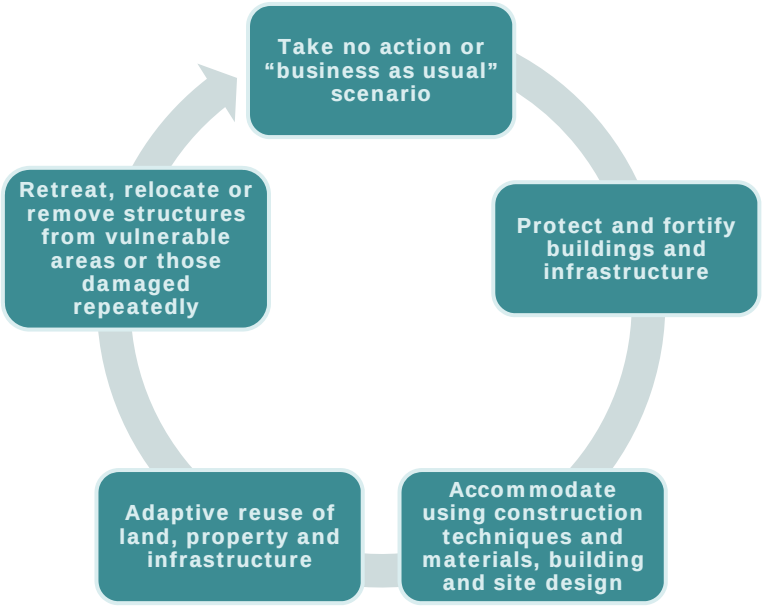
Adaptation

Adaptation is the deliberate and considered action taken to avoid, manage or reduce the consequences of a changing climate and to take advantage of the opportunities that such changes may generate. Successful adaptation requires several important elements:

- Flexibility in process, response and timeframes.
- Routine evaluation and adjustment of strategies of actions.
- Knowledge and application of the best available data and guidance.
- Clear short term and long term goals and objectives.
- Multi-phase implementation strategies.

Human and Built Environment

Adaptation actions that protect the human/built environment can be organized into five general categories:



There is no prescribed series of actions that will meet all needs, circumstances or conditions. Rather the actions taken to manage assets and resources at the federal, state and local levels will be site specific, dependent upon many factors including risk, cost, and capacity to implement, and weigh societal and environmental benefits.

Actions may follow a non-linear progression to reach an identified goal and may be revised or eliminated over time, as factors change and decisions that influence climate change unfold.

Figure CC12. Five general categories of adaptation actions that protect both the human and natural environments.

Natural Environment

Climate adaptation and conservation actions that protect the natural environment and ecosystems rely on human action and intervention. Below are conservation strategies recommended in the Wildlife Action Plan, Ecosystems and Wildlife Climate Adaptation Plan. (Ecosystems and Climate Change Adaptation Plan, 2013)

Ecological Approaches	Planning and Regulatory Approaches
Land Conservation for Habitat Expansion and/or Connectivity Ecosystem-Based Conservation Strategies (ecosystem services) Habitat Restoration and Management Invasive Species Management Plan	Watershed Connectivity and Restoration Riparian and Shoreland Buffer Protection Comprehensive Planning (land use and natural resources) Stormwater Policy and Flood Response Water Withdrawal Policies (protect aquatic habitats)

Table CC8. Approaches to climate adaptation and conservation of the natural environment and ecosystems.

Phased Adaptation

In preparing a phased adaptive management strategy, policy and decision makers must recognize the "tradeoffs" between selecting one action over another such as investing now to protect for the long term versus cost over time and risk associated with delaying such action. Sustained actions and investment need to be weighed against the probability of changing conditions over the long term with incremental investment to protect and accommodate changing conditions in the short-term. Economic benefit and cost effectiveness are not always the bottom line when "tradeoffs" are needed, particularly with respect to assets that are irreplaceable such as natural resources, ecosystems, and cultural and historical resources. Actions that build upon on another to cumulatively increase resiliency and decrease risk and vulnerability are preferred.

Adaptation often provides both co-benefits and no-regrets actions.

Co-Benefits – Integrated efforts to address climate change impacts through proactive actions and mitigation that result in building capacity, resiliency and protection of assets and resources that can also meet economic, societal and environmental needs.

No Regrets – Actions that by definition have negative net costs, because they generate direct or indirect benefits that are large enough to offset the costs of implementing the options (i.e. incorporating climate considerations in institutional practices, engineering and site designs and equipment purchases or greenhouse gas emissions reduction).

Adaptation actions may be implemented immediately or as iterative or delayed actions:

Here and Now Actions - Actions taken now to improve existing systems or construct new systems that are robust and resilient to a range of conditions, as well as preparation of plans to implement future anticipated actions (though action may delayed until necessary).

Prepare and Monitor Actions – Options are identified to preserve assets, and the climate and other conditions are monitored so that action can be taken when necessary (i.e. adaptive management).

Collaborative Multi-Sector Approaches

In order to achieve this level of integration, it is important to recognize the full spectrum of partners critical to ensuring the long-term stability and resiliency of our region, its resources and its municipalities. Key regional and municipal partners to include in the climate change discussion include members of and practitioners responsible for:

- Natural Resource Planning and Managers
- Land and Resource Conservation (Land Trusts)
- Historical and Cultural Resource Management
- Recreation and Tourism
- Economic Development (Chambers of Commerce, Rotary Clubs)
- Non-Profit and Advocacy Groups

Because ecosystems are bound by complex interactions and the built environment is superimposed on natural systems, the natural and built environments are inextricably linked. To incorporate climate change and adaptation planning into existing policy, planning, regulatory and non-regulatory frameworks in the region, a multi-sector approach of collaborative planning and decision making is key. The table below illustrates the cross-cutting issues surrounding climate change and describes the potential future impacts across all sectors of the human and natural environments.

Table CC9. Summary of planning sectors and their associated assets and resources most affected by a changing climate.

Sector	Potential Impacts and changes
Transportation	State and local roadway networks including flooding and heat impacts; infrastructure (bridges, culverts and drainage); emergency and evacuation routes; access to emergency services and facilities; movement of goods and services; access to employment centers; mitigation through reduction of greenhouse gas emissions.
Built Environment	Storm, flood and heat damage to private property, utilities, and municipal and state infrastructure; erosion and physical changes to riverine systems; periodic flooding, erosion and permanent inundation of tidal/coastal areas (particularly upland, dunes and beaches); increased seasonal cooling costs; reduction in tax revenue for damaged/vulnerable property; disruption to regional and local economy and business; increase in cost of property/flood insurance.
Land Use	Conversation to impervious surfaces; increases in stormwater management; loss of forests and natural vegetation for carbon sequestration and pollutant removal (water quality); development in high risk and vulnerable areas (land subject to flooding, fires, extreme heat); design of infrastructure and buildings without consideration of future changes in conditions/environment; stormwater management.
Natural Resources and Ecosystems	Conversion of saltmarsh to open water; conversion of freshwater wetlands to brackish/tidal systems; water-dependent habitats and species; shifts in plant and animal species and habitats; recreational and commercial fisheries and shellfish industries; tourism loss from environmental degradation; changes in commercial forestry and other harvested resources.
Water Resources	Flooding and erosion of river systems and coastal/tidal areas; water quality (drinking water and aquatic habitats); water quantity issues due to drought (drinking water, commercial/industrial uses, irrigation for crops); non-point source pollution.
Human Health	Air quality and respiratory illnesses, vector born disease (Lyme, EEE), heat stress, clean and adequate drinking water supply, contamination of property due to flooding.
Food Security	Agricultural production across the state; impacts to other parts of the U.S. and internationally can affect local food supply and security; loss of valuable agricultural lands to development; increased costs for production and consumers.
Cultural and Historical Resources	Coastal and riverine areas subject to flooding and erosion; place-based resources that may be compromised if relocated; diminished recreation and tourism; cost of relocating and/or archiving physical resources.

Climate Change Recommendations and Implementation

Recommendation 1

Strengthen state, regional and municipal capacity to understand risks and vulnerability to potential future impacts of climate change.

Actions

- Assist municipalities with application of assessments, data and technical guidance about climate change planning and climate adaptation strategies.
- Partner with federal and state agencies, regional partners and local organizations to apply for funding and technical support.
- Partner with federal and state agencies, regional partners and local organizations to expand resources and improve coordination.
- Support implementation of state, regional and local research, assessments and initiatives that fill gaps in climate change data, resources and tools.
- State agencies and municipalities commit resources and capacity to plan for climate change.

Recommendation 2

A. Encourage coastal municipalities to incorporate a Coastal Flood and Hazards Chapter in their Master Plan.

B. Encourage all municipalities to incorporate a Climate Adaptation Chapter in their Hazard Mitigation Plan.

Actions

- Seek new funding sources and align future RPC program funds to support municipal efforts.
- Assist municipalities with adopting the draft Climate Change Chapters from RPC's Tides to Storms project in updates to their Hazard Mitigation Plans.

Recommendation 3

Continue membership in the NH Coastal Adaptation Workgroup and other regional and statewide climate adaptation initiatives.

Actions

- Continue to partner with NH Coastal Adaptation Workgroup and its members to apply for funding and technical support for climate change initiatives.
- Continue support of collaborative partnerships and networks of professionals, practitioners, and researches that provide technical assistance and build capacity for municipal actions.

Recommendation 4

Adopt standards for management of state and municipal infrastructure with safety margins that consider future risk and vulnerability due to climate change.

Actions

- Incorporate benefit to cost analyses in new construction, replacement rehabilitation and reconstruction projects.

- Municipalities utilize FEMA pre- and post-disaster mitigation funds to protect existing infrastructure over its expected life cycle.

- Apply science-based projections of future sea level, storm surge, precipitation and temperature changes to state, regional and municipal policies, programs and regulations.

Recommendation 5

Provide guidance and recommendations to incorporate climate adaptation strategies and actions in municipal and regional policy, planning and regulatory sectors.

Actions

- Utilize existing funds and seek additional funding sources to support integration of climate change in RPC work program.

- Incorporate climate adaptation strategies and actions in RPC projects and plans.

- Work with municipalities to incorporate climate change strategies in hazard mitigations plans, open space and land conservation plans, zoning ordinances and land development regulations.

- Assist municipalities to implement climate change actions and adaptation strategies including adoption of policy, planning and regulatory measures.

- Encourage comprehensive land use planning, environmental planning and floodplain management that prevents and minimizes impacts.

Recommendation 6

Integrate protection of natural and constructed systems, social services, and historic and cultural resources into engineering and regulatory frameworks of shoreline management.

Actions

- Improve shoreline management to address the intensifying challenges posed by climate change, including management of development in high risk areas.

- Improve shoreline management to include measures that minimize coastal and floodplain erosion, and loss of natural resources that protect against flooding.

- Retain and expand dunes, beaches, wetlands, forests and natural vegetation to protect against coastal and riverine flooding.

- Discourage hardening of shorelines in favor of protecting existing natural shorelines and restoring them when feasible.

- Apply hard and engineered shoreline techniques only to protect essential infrastructure and evaluate the benefit to cost of maintaining these techniques in the future.

Recommendation 7

Apply results from the Tides to Storms Coastal Vulnerability Assessment to climate adaptation actions at the state, regional and local levels.

Actions

- Incorporate data, reports and maps from the Tides to Storms Coastal Vulnerability Assessment in state, regional, and municipal climate adaptation efforts.

- Assist municipalities with incorporating collaborative strategies to address regional resources, assets, and impacts identified in Tides to Storms assessment.

- Apply project information and findings to ongoing and future climate change projects by RPC and in collaboration with others.

- Provide access to Tides to Storms information and products through NH GRANIT database and Coastal Viewer (under development).

Recommendation 8

Integrate climate mitigation actions across all sectors of planning, transportation, land development and infrastructure projects.

Actions

- Attain reduction in vehicle miles travelled and overall greenhouse gas emissions in the region.

- Protect areas that serve as carbon storage such as forests, wetlands and other natural landscapes.

- Facilitate increase in use of low-carbon energy sources and installation and use of renewable energy sources.

With respect to climate change, ***mitigation*** is the reduction of greenhouse gas (GHG) emissions achieved through energy efficiency and conservation, use of renewable and alternative energy sources, and CO_2 storage in forests and biomass.

Recommendation 9

Implement outreach and engagement measures to raise regional and community-based awareness about climate change.

Actions

- Work with regional partners to promote and encourage land and resource conservation in high risk areas such as coastal and riverine floodplains and to protect surface and groundwater resources.

- State, regional and municipal decision makers work together to protect critical services and the health and safety of the public.

- Disseminate climate change informational resources through RPC staff and circuit riders, website, Commission meetings and other partners.

- Educate municipalities and property owners regarding options for protecting properties from flooding and erosion.

Climate Change Goals and Recommendations Matrix

	CC Goal 1	CC Goal 2	CC Goal 3	CC Goal 4	CC Goal 5
Recommendation 1	P	S	S	P	P
Recommendation 2	P	S	S	TBD	S
Recommendation 3	S	S	P	S	S
Recommendation 4	P	S	P	P	S
Recommendation 5	S	S	S	P	P
Recommendation 6	S	S	P	PS	P
Recommendation 7	S	S	S	S	S
Recommendation 8	PS	PS	S	PS	S
Recommendation 9	S	S	S	S	S

S = Recommendation supports the Climate Change Goal.
P = Recommendation partially supports the Climate Change Goal.
N/A = Recommendation foes not apply to a goal
TBD = Unknown if recommendation will support the Climate Change Goal due to lack of information or unknown future conditions.

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Appendices

Appendix A: Summary of Climate Adaptation Strategies

Adaptation Strategies

The following adaptation strategies were adapted from FEMA Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards (2013) and the Georgetown Climate Center Sea Level Rise Toolkit (2011).

ZONING AND REGULATIONS

FLOODPLAIN STANDARDS	Adopt floodplain standards beyond the minimum FEMA requirements and consider or sea level rise projections. Prohibit or limit floodplain development (i.e. density, scale, loss of flood storage) through regulatory and/or incentive-based measures. Require and maintain FEMA elevation certificates for all pre-FIRM, post-FIRM and new and improved buildings in the floodplain. Apply open space requirements for development to floodplains to preserve flood storage areas, and track acreage preserved.
FLOOD HAZARD OVERLAY DISTRICTS	Designate high-risk areas that are already subject to flooding or projected to flood in the future. Require a larger percentage of open space preservation and less impervious coverage in high risk areas.
STORMWATER MANAGEMENT	Adopt comprehensive stormwater management standards for all new and redevelopment. Design to retain or reduce natural runoff or zero discharge of runoff. Collect runoff for use as reclaimed water. Reduce volume of runoff generated from developed sites using techniques such as Low Impact Development and green infrastructure. Link flood hazard mitigation objectives with EPA Stormwater Phase II and MS4 permit requirements. Adopt a community-wide stormwater management plan. Implement an inspection and enforcement program to help ensure proper function and continued integrity of private stormwater management faciltities.
SITE DESIGN STANDARDS, DIMENSIONAL REQUIREMENTS AND BUILDING CODES	Retain trees and natural vegetation in flood hazards areas. Adopt ASCE 24-05 Flood Resistant Design and Construction (a referenced standard in the International Building Code) that specifies minimum requirements and expected performance design and construction in flood hazard areas. Adjust maximum building height requirements to accommodate elevation of structures above the base flood elevation or sea level rise projection. Adopt “freeboard” requirements (feet above base flood elevation or sea level rise projection) in the flood damage ordinance. Prohibit first floor enclosures below base flood elevation or sea level rise projection for all structures in flood hazard areas. Require standard tie-downs of fuel tanks.
AQUIFER AND GROUNDWATER PROTECTION	Infiltrate treated stormwater runoff to recharge groundwater, aquifers and surface waters
BUFFERS AND DEVELOPMENT	Require buffers to preserve flood storage areas adjacent to surface waters and wetlands. Require development setbacks to protect against flooding and erosion. Setbacks can be

SETBACKS	based on erosion rates/trends, sea level rise projections, 500-year floodplain and fluvial erosion hazard zones.

PLANNING AND POLICY

MASTER PLANS	Adopt a climate change and natural hazards chapter in the master plan. Insert specific adaptation recommendations in other parts of the master plan for municipal facilities, transportation and natural resources.
HAZARD MITIGATION PLANS	Participate in the FEMA's Community Rating System (CRS), or at minimum adopt CRS strategies where appropriate.
FEMA COMMUNITY RATING SYSTEM (CRS) AND NATIONAL FLOOD INSURANCE PROGRAM	Conduct NFIP workshops to provide information and identify incentives for property owners to acquire flood insurance. Designate a floodplain manager and/or CRS coordinator with Certified Floodplain Manager certification. ***Note: All municipalities in the RPC region participate in the NFIP.***
EMERGENCY RESPONSE PLANS	
RECOVERY PLANS	
ASSESSMENTS	Track cumulative impacts from flood events (high water marks, stormwater flooding, infrastructure damage, repetitive loss). Complete a hydrologic watershed based analysis of culverts, crossings and drainage infrastructure (based on buildout and climate change conditions).
FUNDING MECHANISMS AND PLANS	Use taxes, bonds and/or block grants to support a regulatory system of floodplain and infrastructure management and improvements. Use impact fees from development to help fund public projects including new and upgraded infrastructure. Create special tax districts to finance maintenance and improvements to drainage systems and capital improvements in high hazard areas. Create a community-wide stormwater utility to finance maintenance and improvements to drainage systems.

ASSET AND INFRASTRUCTURE MANAGEMENT

INFRASTRUCTURE PLANS (ROADS, UTILITIES, DRAINAGE, BUILDINGS, WASTEWATER)	Conduct regular inspections and maintenance of drainage systems and flood control structures to ensure proper function. Elevate structures with the lowest floor including the basement raised above the base flood elevation or sea level rise projection. Small berms or floodwalls can also be constructed. Relocate utilities and other electrical/mechanical systems above the base flood elevation or sea level rise projection. Install back-up generators for electrical systems. Flood proof (wet and dry) buildings containing critical materials and equipment. Elevate roads and bridges to accommodate flood levels (e.g. the 100-year and 500-year storm or projected sea levels).
CAPITAL IMPROVEMENT PLANS	Incorporate iterative infrastructure improvements to minimize impacts from natural hazards and climate change. Periodically revise strategies to respond to existing and projected conditions.
DRINKING WATER MANAGEMENT PLANS	Incorporate iterative management strategies, infrastructure improvements, and public education and conservation programs to minimize impacts from natural hazards and

	climate change.
REMOVAL OF STRUCTURES	Municipalities may remove structures from high hazard areas to minimize future loss and damage by relocating structures to more secure locations.

NATURAL RESOURCE AND ENVIRONMENTAL SERVICES MANAGEMENT

WATER MANAGEMENT PLAN	Adopt watershed-based plans that apply iterative water management strategies, water protection actions, and public education and conservation programs to minimize impacts from natural hazards and climate change.
OPEN SPACE AND LAND CONSERVATION PLANS	Adopt open space and land conservation plans that protect resources and environmental services while minimizing impacts from natural hazards and climate change. Include land acquisition, reuse and preservation in high hazard/risk areas. Secure conservation easements for land in high hazard/risk areas.
HABITAT PROTECTION PLANS	Adopt habitat protection plans that protect critical habitats and lands while minimizing impacts from natural hazards and climate change.
ENVIRONMENTAL SERVICES MANAGEMENT PLAN	Adopt plans that protect services provided by natural systems such as flood storage, recreation, tourism, commercial fish and shellfish. Implement restoration projects to enhance dunes and wetlands.

EDUCATION, OUTREACH, RAISING AWARENESS

STEWARDSHIP PROGRAMS	Encourage voluntary conservation easements on land in riverine and coastal floodplains.
DEMONSTRATION PROJECTS	Install demonstration projects on municipal lands and buildings to inform the public about flood protection and climate adaptation strategies.
INFORMATIONAL MATERIALS AND EVENTS	Encourage homeowners in high hazard/risk areas to purchase flood insurance. Distribute flood safety informational materials to home owners in flood prone areas. Educate residents and businesses about natural hazard preparedness and safety planning, flood-proofing and elevating buildings, and elevating electric systems and utilities above the base flood elevation.

Appendix B Maps CC1, CC2, CC3 and CC4. Maps of coastal flooding potential from Tides to Storms project.

Maps CC1, CC2, CC3 and CC4 are attached on the following pages.