Climate Adaptation Chapter:

Developing Strategies to Protect Areas at Risk from Flooding due to Climate Change and Sea Level Rise

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Final

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The 2013 Town of Durham Leadership Committee

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I. Introduction and Project Goal

Just as it's done for millions of years, the Earth's temperature continues to naturally fluctuate over time. However the scientific community has seen drastic changes during the last century. While the debate continues on as to what is causing the rise in temperature, evidence has shown that the current climate system shift is due largely in part to human activities – including the burning of fossil fuels for energy, clearing of forested lands for agriculture, and raising livestock – as opposed to past cyclical changes. According to the Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future Report [1], it is this change in climate that will be the catalyst for a wide range of indicators experienced by coastal New Hampshire, such as: an increase in temperature (specifically in winter); increase in overall precipitation and an increase in the number of extreme precipitation events[2]; an increase in the rain-to-snow precipitation ratio and a decrease in snow cover days; earlier ice-out dates; earlier spring runoff; longer growing season; and sea level rise.

There is a growing consensus that projected sea level rise will contribute to the gradual inundation of coastal areas, enhanced flooding of coastal infrastructure, increased coastal erosion, saltwater contamination of freshwater ecosystems, and loss of salt marshes. Due to changes in precipitation patterns, stronger hurricanes and super storms (like Sandy, which has cost New York and New Jersey an estimated $60 billion), and flooding from coastal storms, New Hampshire's coastal communities are particularly vulnerable to rising sea levels.

Local governments must plan and act accordingly to address these issues and impacts from climate change. This preparation includes: identifying public infrastructure along the shoreline; identifying critical wildlife habitats and ecosystems that are directly threatened by storms and coastal inundation; and providing local decision makers the information and recommendations needed to develop and implement policies and regulations.

The Strafford Regional Planning Commission (SRPC) received funds from the New Hampshire Coastal Program to assist the Town of Durham in developing a climate adaptation chapter. This chapter will provide adaptation strategies to protect areas of Town that are at risk of flooding due to climate change. The purpose of this project was to: conduct research on present climate change and sea level rise estimates using the Piscataqua/Great Bay Report as a backbone; review approaches taken by other states, communities, and agencies in responding to this threat; develop a series of maps identifying areas of increased risk to flooding due to sea level rise specific to Durham; develop strategies that protect areas at risk from flooding due to climate change and sea level rise; and identify various regulatory and non-regulatory options that can be considered by the Town. With collaboration from municipal officials, Durham residents, the University of New Hampshire, and other state and local agencies, the goal is to increase the Town's resiliency against coastal hazards and flooding due to sea level rise by addressing potential impacts and developing options to help protect Durham from this potential risk.

This chapter will be adopted as a subset of their existing Hazard Mitigation Plan (2012), which will be recommended to be incorporated into the Master Plan.

[1] Wake, Cameron P., Katharine Hayhoe, Anne Stoner, Chris Watson, and Ellen Douglas. *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future*. Rep. Durham: Carbon Solutions, 2011. Print.

[2] There are four categories of extreme precipitation events: (1) greater than one inch in 24 hours, (2) greater than two inches in 24 hours, (3) greater than two inches in 48 hours, and (4) greater than four inches in 48 hours.

II. Scientific Research and Information

There are a number of scientific resources and documentation that touch upon the impacts of climate change, all of which are frequently revised and updated as research progresses. For the purpose of this chapter, SRPC focused and reviewed findings and recommendations made from the following resources:

1. Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future Report
2. The New Hampshire Climate Action Plan
3. New Hampshire StormSmart Coasts Network: Climate Preparedness
4. NOAA Coastal Services Center: Hazards and Climate Adaptation
5. Georgetown Climate Center: Adaptation
6. FEMA Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards

A complete list of resources and references can be found at the end of the chapter. Local decision makers are urged to review this information. SRPC will continue to provide interested communities with new information and scientific evidence regarding the impacts of climate change on New Hampshire's coastal communities.

Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future

As stated in the Piscataqua/Great Bay Report, climate variations over the course of Earth's history have been driven by natural causes. However, scientific evidence has shown that since the Industrial Revolution, atmospheric concentrations of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have been rising due to emissions of heat-trapping gases from human activities. Currently, atmospheric levels of carbon dioxide are now higher than they have been at any time in at least the last 800,000 years, which if levels continue to rise, have the potential to cause dramatic changes in our climate system. These changes in climate over the past several decades have already been experienced by New Hampshire's coastal communities; the significant impacts on ecosystems and society within the coastal watershed will continue over the next century in a variety of ways. In order for municipalities to continue to reduce their vulnerabilities from a changing climate, they will need smart planning and will require adaptive measures to ensure that our society and environment will be able to adapt in the future. The hope is that the data and recommendations presented in this adaptation chapter will provide local policy makers with relevant information and options to lessen the impacts of climate change and sea level rise.

Future Climate Change

In order to predict and evaluate future changes in climate, scientists use atmosphere-ocean general circulation models (AOGCMs), which are simulations driven by future emission scenarios. These scenarios use assumptions about population, energy use, and technology to build a picture of how the future might look.

In the Piscataqua/Great Bay Report, simulations from four different AOGCMs were used to predict future changes in climate based on several criteria including: well established models in the peer-reviewed scientific literature; encompassing a wide range of uncertainty in climate sensitivity[3]; and

[3] Climate sensitivity is defined as the temperature change resulting from a doubling of atmospheric carbon dioxide concentrations relative to pre-industrial times, after the atmosphere has had years to adjust to the change.

simulations of temperature, precipitation, and other key variables availability for both the higher (A1fi) and lower (B1) emission scenarios derived from the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emissions Scenarios (SRES).

Future Temperature

While the degree of expected warming will depend on which emissions pathway is followed, temperatures in the Piscataqua/Great Bay region and surrounding areas will continue to rise. However, temperature increases under the higher emissions scenario would be nearly twice that expected under the lower emissions scenario by the end of the 21st century (2070-2099). Overall, the NH Coastal watershed can expect to see increases in annual maximum and minimum temperature ranging from +4.5°F to +9.0°F over the next 100 years. To put that in perspective, a four degree (F) change is equivalent to moving from a Boston to a Philadelphia winter.

With regard to climate impacts, the projected increases in Durham winter maximum and minimum temperature would likely push regional average winter temperatures *above* the freezing point. With average winter temperatures above freezing, the region can expect to see a greater proportion of winter precipitation falling as rain (as opposed to snow), earlier lake ice-out dates, and a decrease in the number of days with snow cover. Warmer summer temperatures will also lead to increased drought, heat waves, more frequent and extreme convective precipitation events, and an increase in invasive pests and weeds.

Future Extreme Temperature

As temperatures increase in the Piscataqua/Great Bay region, extreme heat[4] is expected to become more frequent and severe. Projected future extreme temperature statistics described in the Piscataqua/Great Bay Report are summarized below:

- During the historical baseline period 1970-1999, Durham experienced about 9 days above 90°F each year.
    - By 2070-2099, Durham could expect 30 days per year with daytime maximum temperatures above 90°F under the lower emissions scenario and over 70 days per year under the higher emissions scenario, nearly eight times the historical average.
- Between 1970-1999, extreme daytime maximum temperatures above 95°F were historically rare, occurring on less than two days per year.
    - Under the lower emissions scenario, Durham could expect to see between 5 and 10 days per year above 95°F. Under the higher emissions scenario, the number of days above 95°F is expected to increase to 30 days, more than 10 times the historical average.
- As the number of extremely hot days per year increases, the average daytime maximum temperature on the hottest day of the year is also expected to increase.
    - In Durham, the average maximum temperature on the hottest day of the year over the period 1970-1999 was typically around 94°F. Over the next 100 years, the temperature on the hottest day of the year could climb to 97.5°F under the lower emissions scenario and upwards of 99°F under the higher emissions scenario.

[4] Extreme heat is calculated using three metrics: (1) number of days above 90°F, (2) number of days above 95°F, and (3) average temperature on the hottest day of the year.

Future Precipitation

Future trends in annual and seasonal precipitation point toward wetter conditions in the Piscataqua/Great Bay region over the next 100 years. Under the higher emissions scenario, Durham's annual precipitation is projected to increase over 17% by 2070-2099, relative to the historical baseline period 1970-1999. The expected increase in annual precipitation under the lower emissions scenario is only slightly less, about 13% for Durham. Overall the higher emissions scenario shows a much wider range of variability across models illustrating the uncertainty of how precipitation will respond to increases in greenhouse gases. With regard to flood risk, it is also important to examine changes in the magnitude and frequency of precipitation events.

Future Extreme Precipitation

Annual precipitation is expected to increase slightly more under the higher emissions scenario compared to the lower emissions scenario by the end of the century. Projected future extreme precipitation statistics described in the Piscataqua/Great Bay Report are summarized below:

- Historically, Durham experienced about 11 events per year with greater than one inch of precipitation in 24 hours.
  - By 2070-2099, that could increase to 13 events under the lower emissions scenario and to just over 14 events for the higher emissions scenario.
- For events with greater than two inches in 24 hours, Durham averaged 1-2 days per year.
  - That could increase to 2-3 days per year depending on the emissions pathway
- The same pattern of increasing extreme precipitation events under lower emissions and even greater increases under higher emissions scenarios emerges for events greater than two inches in 48 hours and greater than four inches in 48 hours.
- Historically, Durham received on average 2.8 inches of rain on the wettest day of the year over the period 1970-1999.
  - By late-century, the wettest day of the year could deliver on average 3.7 inches of rain under the higher emissions scenario and 3.6 inches of rain under the lower emissions scenario. This represents about a 30% increase in the amount of rain on the wettest day of the year.

Sea Level Rise

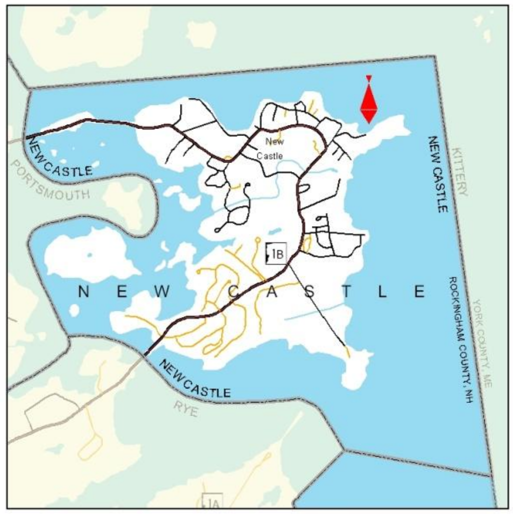
As discussed throughout this section, there is a vast body of scientific evidence that indicates the increase in globally averaged temperatures is likely due to human activities and greenhouse gas concentrations. Of all the potential impacts of this warming, the one that may have the biggest influence on coastal New Hampshire is an increase in sea level resulting from melting of land-based ice (glaciers and ice sheets) combined with the thermal expansion of the ocean. Relative sea level has been rising on the New Hampshire coast for the past 10,000 years. However, relative sea level has been recorded at the Portsmouth Harbor (Seavey Island) tidal gauge only since 1926. 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 combined effects of thermal expansion, increases in meltwater, a subsiding coast, and potential changes in ocean circulation make coastal New Hampshire particularly vulnerable to rising sea level. Increases in relative sea level contribute to enhanced flooding of coastal infrastructure, increased coastal erosion, saltwater contamination of freshwater ecosystems and loss of salt marshes. Low-lying shorelines such as sandy beaches and marshes are likely to be the most vulnerable to rising seas.

Future Changes in Sea Level and Coastal Flooding

As sea level rises due to global and regional influences, coastal flood elevations will also increase, leading to larger areas of flooding during coastal storms. Staying consistent with the rest of this document, the two emission scenarios (higher A1fi; lower B1) were combined with an estimate of the current 100-year flood (stillwater[5]) elevations and anticipated increases in global and regional sea level to generate future projections of coastal flooding in Portsmouth. The Piscataqua/Great Bay Report used the maximum extents of the range of global sea level rise by 2100 relative to 1990: 31 inches for the lower (B1) scenario, and 75 inches for the higher (A1fi) scenario. These values were estimated using the sea level rise projection curve[6] and include a ±7%.

Figure 1: Fort Point Tide Gage - New Castle, NH



The Piscataqua/Great Bay Report makes two future estimates on potential sea rise. The first projection estimates (in feet) the future 100-year flood stillwater elevations at Fort Point under lower and higher emission scenarios by years 2050 and 2100, based on the statistical analysis presented in the Piscataqua/Great Bay Report. This projection calculated the total stillwater elevation by adding the sums of the estimated 100-year flood height[7], the global sea level rise projections, and the mean higher high water mark (MHHW)[8] together. The 100-year flood height at the Fort Point tide gauge was estimated to be 6.8 feet. The elevation of the mean higher high water mark was estimated to be 4.4 feet. The results are an estimated 11.2 feet of stillwater elevation relative to the North American Vertical Datum[9] (NAVD), before adding the global sea level rise factor. A summary of these components are provided in Table 1.1.

Table 1.1: Estimates (in feet) of future 100-year flood stillwater elevations at Fort Point under lower and higher emission scenarios – **Based on the statistical analysis presented in the Piscataqua/Great Bay Report**

	2050		2100	
	Lower	Higher	Lower	Higher
Current Elevation of MHHW (a,b)	4.4	4.4	4.4	4.4
100-Year Flood Height	6.8	6.8	6.8	6.8
Global Sea Level Rise	1.0	1.7	2.5	6.3
Total Stillwater Elevation (a,c)	**12.2**	**12.9**	**13.7**	**17.5**

a - NAVD: North American Vertical Datum of 1988

b - MHHW: Mean Higher High Water at Fort Point, NH

c - Total Stillwater Elevation may not equal total of components due to rounding

Source: Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future (2012)

[5] Stillwater elevation is the elevation of the water surface that does not account for waves and run-up.
[6] Projection curve based on temperature projections for three different emission scenarios.
[7] The result of the statistical analysis of the historical Seavey Island and Fort Point tide gauge data (not FEMA).
[8] The average of the higher high water height of each tidal day; values are provided by NOAA.
[9] The current engineering standard for vertical datum and is used by FEMA for all new Flood Insurance Risk Maps.

The second projection estimates (in feet) the future 100-year flood stillwater elevations at Fort Point under lower and higher emission scenarios by years 2050 and 2100, based on the FEMA base flood elevation. There are two major differences with these projected estimates: (1) the current elevation of mean higher high water was not considered and (2) the 100-year flood height was based on the FEMA base flood elevation, not historical data from the Seavey Island and Fort Point tidal records. Given that the global sea level rise factor remains constant throughout all scenarios, the biggest change is the FEMA 100-year flood elevation was estimated to be 8.4 feet relative to the NAVD. A summary of these components are provided in Table 1.2.

Table 1.2: Estimates (in feet) of future 100-year flood stillwater elevations at Fort Point under lower and higher emission scenarios – **Based on the FEMA base flood elevation**

	2050		2100	
	Lower	Higher	Lower	Higher
100-Year Flood Height	8.4	8.4	8.4	8.4
Global Sea Level Rise	1.0	1.7	2.5	6.3
Total Stillwater Elevation (a,c)	**9.4**	**10.1**	**10.9**	**14.7**

a - NAVD: North American Vertical Datum of 1988

b - MHHW: Mean Higher High Water at Fort Point, NH

c - Total Stillwater Elevation may not equal total of components due to rounding

Source: Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future (2012)

The results presented in Tables 1.1 and 1.2 show that we can expect the 100 year flood height to range from 9.4 to 12.9 feet by 2050, and to range from 10.9 to 17.5 feet by 2100. Therefore, even under the low emissions scenario, we can expect the 100 year flood height to increase several feet over the next 90 years. This increase in the 100 year flood height would result in more severe flooding in coastal New Hampshire in the future.

Using GIS shapefiles, which were generated as part of the Piscataqua/Great Bay Report, a series of maps that focus on Durham's coastal areas were produced to help illustrate the impact of the higher 100-year flood elevations in the future. These maps show stillwater flood depths over land for flood elevations of six feet, nine feet, and twelve feet above mean higher high water. These maps are based on detailed LiDAR (Light Detection and Ranging) topographic data that was collected during the spring of 2011.

Note that the maps are provided for discussion and research purposes only. It is not appropriate to use the maps for detailed analysis (i.e., at the parcel level).

III. Mapping

Project Maps

A series of four 11”x17” color maps are included at the end of this chapter. The Town of Durham was also provided with large scale 36”x36” color copy print outs to be used for planning purposes.

- **Critical Facilities and Key Resources** – this map recognizes the list of community assets located within 500-ft of the 2100 projected sea level rise data. These resources were identified in the Multi-Hazard Mitigation Plan Update (2012) and are categorized by: Emergency Response Services, Non-Emergency Response Facilities, Facilities and Populations to Protect, Potential Resources, and Water Resources.

- **Aerial Imagery** – this map shows high resolution, leaf-off, color, aerial photography of the Town of Durham overlaid with the 2100 projected sea level rise data. This data layer was part of the 2010 NH Statewide Aerial Imagery Acquisition Project, which collected 1-foot pixel resolution imagery for the entire state in the spring and fall of 2010.

- **Land Cover** – this map shows the digital land cover data layer within 500-ft of the 2100 projected sea level rise data. This data layer provides information about New Hampshire’s vegetative and physical features and was completed by the NH GRANIT staff at Complex Systems Research Center, University of New Hampshire, as part of the New Hampshire Land Cover Assessment created in 2001. The intention of this map is to provide more information on the potential impacts to wildlife habitats due to climate change and projected sea level rise.

- **Zoning** – this map shows the current zoning districts overlaid with the 2100 projected sea level rise data. The intention of this map is to show which zoning districts could be impacted by future seal level rise and to provide more information to local decision makers on the potential adverse effects of development in these areas.

Note: All maps include 2100 projected sea level rise data based on the higher (A1fi) emission scenario, which is referenced throughout the plan.

IV. Policy Options

As mentioned throughout the Great Bay Report, climate change and the resulting rising sea level will put New Hampshire's coastal properties, infrastructure, natural resources and public health at risk. It will be the responsibility of communities and local governments to review and revise regulatory and non-regulatory programs in order to accommodate the expected rate of 1 to 6.3 ft. of sea level rise by 2100.

According to the overall vision for the future, taken in part from the results of the January 28, 2011 Master Plan Visioning Forum and May 2011 Master Plan Survey, the citizens of Durham have consistently voiced support for a resilient, efficient, and environmentally responsible community. While efforts around energy use for the long term will be a challenge shared across the country, Durham has placed a high value on energy planning that focuses on energy efficiency and conservation as a significant contribution to their quality of life.

In summary, the vision for the future of Durham's energy use is one in which the municipality, commercial property owners, and homeowners realize cost savings while reducing the Town's carbon emissions, thereby increasing the Town's resiliency and sustainability relative to energy use.

Energy and Climate Change Regulatory Recommendations

Energy planning will bolster the diversity and health of Durham's natural and scenic environment. Lower reliance on fossil fuels will provide significant health benefits for citizens and lead to a more walkable and bikeable town. Alternative energy sources, when produced locally (wind or solar), can also contribute to local resiliency during regional power outages.

Recommendations Referenced in Durham's DRAFT Energy Chapter of the Master Plan

The following recommendations are specific to Durham's DRAFT Energy Chapter of the Master Plan:

- Building Design and Land Use
  - Use energy efficient building practices
  - Retrofit or replace energy inefficient housing
  - Concentrate future development to minimize travel distances to downtown
  - Retrofit or replace aging buildings and equipment
- Transportation
  - Increase use of bicycles and walking
  - Improve access and convenience of regional public transit
  - Increase use of energy-efficient vehicles
- Alternative and Renewable Energy Resources
  - Reduce vulnerability to volatile petroleum costs
  - Reduce environmental impacts of energy use
  - Encourage development and expansion of emerging energy technologies

These recommendations are broadly defined, which are followed by specific goals, recommended actions, and metrics to help Durham measure progress. More information can be found in the Energy Chapter of the Master Plan: 2012.

Climate Change in Existing and Future Land Use

During the development of this chapter in the Hazard Mitigation Plan, the Town was also updating a number of chapters within their Master Plan. While there will not be a separate chapter that speaks specifically to climate change and the impacts of sea level rise, the topic will be touched on in various chapters. The existing and future land use sections will likely discuss the land use implications of climate change and sea level rise as they relate to land use regulation.

Any findings and/or recommendations that come out of the work on the hazard mitigation update will be used as background support and direction for the Planning Board as they discuss these implications.

Managing Development in High-Risk Areas

The Town of Durham can mitigate future losses resulting from sea level rise by regulating development in potential hazard areas through land use planning.

- Use zoning, subdivision and site plan regulations, and/or a special overlay districts to designate high-risk areas and specify the conditions for the use and development including:
    - Extended Coastal Flood Hazard Overlay District – apply higher standards for building freeboard height (height above the recorded high-water mark of a structure) and other provisions, which would use Durham's existing Flood Hazard Overlay District (Article XV) as the framework for extending development and building regulations to lessen vulnerability of new buildings and facilities to flooding due to sea level rise.
    - Incorporating New Floodplain Maps for the Lamprey River Basin – mapping project funded by NOAA/UNH Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), which produced new floodplain maps for coastal communities based on current and projected land use patterns and precipitation amounts.
    - Update Durham's Shoreland Protection Overlay District – recommend prohibiting artificial hardening of estuary and river shorelines, with possible exceptions granted in the case of an imminent threat to a primary residence structure or critical public infrastructure. Increasing sea levels and increasingly extreme flood events will increase the demand for shoreland armoring[10], which has been well documented to negatively impact aquatic ecosystems.
- Recommend requiring that new or replacement road/stream crossings are designed in compliance with New Hampshire Stream Crossing Guidelines[11]. Designers of these crossings should calculate the design storm conveyance requirements of bridges/culverts based on updated precipitation data from the Northeast Region Climate Center[12]. This is both a regulatory and non-regulatory requirement. Regulatory in that it should apply to proposed private structures that require a Town building permit or site plan, and non-regulatory in that the same standards should be followed by the Durham Department of Public Works.
- Promote conservation and management of open space, wetlands, and/or sea level rise boundary zones to separate developed areas from high-hazard areas.
- Consider prohibiting the redevelopment of areas destroyed by storms or chronic erosion in order to prevent future losses.
- Establish setbacks in high-risk areas that account for potential sea level rise.

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[10] Erosion control practice that uses hardened structures (concrete walls and stone rip-rap) to stabilize the shore

[11] http://easternbrooktrout.org/resources/stream-crossing-guidelines/New%20Hampshire%20Stream%20Crossing%20Guidelines%20-%20Final.pdf/at_download/file

[12] http://precip.eas.cornell.edu/

Non-Regulatory Recommendations

Climate Change in Education and Outreach Actions Items

Improve public awareness of risks due to sea level rise through outreach activities such as:

- Coordinate with the Natural Resources Outreach Coalition (NROC) to bring the NOAA Road map for coastal adaptation planning to the Town of Durham. The NOAA Road map is also a planning tool as well as a public engagement method.
  - Strafford Regional Planning Commission (SRPC) will coordinate with NROC staff and Durham officials to guide the Town of Durham through the NOAA Roadmap for coastal adaptation planning. SRPC staff will partner with NROC to plan a series of community workshops to engage Durham residents in seeking ways to reduce the impacts of climate change and sea level rise.
- Encourage homeowners to purchase flood insurance.
- Use outreach programs to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.
- Distribute flood protection safety pamphlets or brochures to the owners of property in high-risk areas.
- Educate citizens about safety during flood conditions, including the dangers of driving on flooded roads.
- Disclose the location of possible sea level rise areas to potential buyers.

Planning and Municipal Practice – Emergency Management and Hazard Mitigation Recommendations

To better understand and assess local vulnerability to sea level rise, consider actions such as:

- Use GIS to map hazard areas, at risk-structures, and associated hazards (flood and storm surge) to access high-risk areas.
- Develop an inventory of public buildings and infrastructure that may be particularly vulnerable to sea level rise.
- Locate utilities and critical facilities outside of areas susceptible to sea level rise to decrease the risk of service disruption.
- Retrofit critical facilities to be built 1 foot above the 500-year flood elevation or the predicted sea level rise level, whichever is higher.
- Retrofit structures to elevate them about potential sea level rise levels.
- Replace exterior building components with more hazard-resistant materials to withstand more intense storm events.

V. Conclusion

As stated throughout this chapter, climate change and projected sea level rise has the potential to considerably alter New Hampshire's shoreline. Effects are already being felt throughout the region and large coastal flooding events will continue, due largely in part to the overall increase of rainfall as well as the frequency of extreme precipitation events. According to the Piscataqua/Great Bay Report annual average temperatures for Durham can be expected to increase between 4°F and 9°F (greater increase in the summer) before the end of the century, depending on the future emissions of heat trapping gases. All of which will contribute to the continual rise of sea level.

The report also states that immediate and committed actions to reduce emissions are the most effective means to keep future climate changes at the projected lower emissions scenario. The more we can reduce our fossil fuel emissions, the more ecosystems, human communities, and economic sectors will be able to adapt to future changes we cannot avoid.

Moving forward, it will be important for Durham to identify public infrastructure and critical wildlife habitats that have the potential to be directly impacted by coastal storms and flooding. Local decision makers will need to develop and implement policies, such as those referenced in this chapter, in order to mitigate the impacts of climate change and projected sea level rise.

Appendix:

References and Resources

- New Hampshire Climate Change Policy Task Force. *The New Hampshire Climate Action Plan*. Rep. N.p.:, 2009. Print.

- Balbus, John, Kristie Ebi, Lauren Finzer, Catherine Malina, Amy Chadwick, Dennis McBride, Michelle Chuk, and Ed Maibach. *Are We Ready? Preparing for the Public Health Challenges of Climate Change*. Rep. N.p.: Environmental Defense Fund, 2008. Print.

- Baxter, Julie, and Karen Helbrecht. *Mitigation Ideas: Possible Mitigation Measures by Hazards Type*. Rep. N.p.: FEMA, 2013. Print.

- Wake, Cameron P., Katharine Hayhoe, Anne Stoner, Chris Watson, and Ellen Douglas. *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future*. Rep. Durham: Carbon Solutions, 2011. Print.

- Rockingham Planning Commission. *Adaptation Strategies to Protect Areas of Increased Risk From Coastal Flooding Due to Climate Change*. Rep. N.p.:, 2009. Print.

- http://nh.stormsmart.org/before/climate-preparedness/

- http://www.georgetownclimate.org/adaptation

- http://www.csc.noaa.gov/climate/