Multi-Hazard Mitigation Plan Update 2017

Town of Durham, NH

Expiration of Current Plan: September 27, 2022
Updated 2017
Submitted to the New Hampshire Homeland Security & Emergency Management
By the
Town of Durham, NH
with Strafford Regional Planning Commission

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The following organizations have contributed invaluable assistance and support for this project:

The Durham Multi-Hazard Mitigation Committee

New Hampshire Homeland Security Emergency Management (HSEM)

Town of Durham

The 2017 Town of Durham Multi-Hazard Mitigation Planning Committee

17 people have attended meetings and/or been instrumental in completing this plan:

Todd Selig	Town Administrator/EMD, Town of Durham
Kenny Rotner	Town Council, Town of Durham
Mike Lynch	Public Works Director, Town of Durham
Dave Kurz	Police Chief, Town of Durham
Corey Landry	Fire Chief, Town of Durham
Dave Emmanuel	Assistant Fire Chief, Town of Durham
Rachel Gasowski	Parks and Recreation, Town of Durham
Audrey Cline	Code Enforcement, Town of Durham
Luke Vincent	IT Director, Town of Durham
Mary Ellen Humphrey	Economic Development, Town of Durham
Michael Behrendt	Town Planner, Town of Durham
John Parry	US Forest Service
April Talon	Town Engineer, Town of Durham
Gail Jablonski	Business Manager, Town of Durham
Jim Rice	Assessor, Town of Durham
Sam Lingeman	CAD/DMS/GIS Administrator, UNH Campus Planning
Doug Bencks	Director, UNH Campus Planning

Plan Prepared and Authored By
James Burdin, Regional Economic Development Planner
Elizabeth Durfee, Senior Regional Planner
Strafford Regional Planning Commission
150 Wakefield Street, Suite 12
Rochester, NH 03867
603-994-3500
www.strafford.org

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Cover: 2016 King Tide Event, Jackson's Landing
Photo credit: Kyle Pimental, SRPC

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Executive Summary

This Plan was revised and updated to meet statutory requirements and to assist the Town of Durham in reducing and mitigating future losses from natural and man-made hazardous events. An initial edition of this Plan was developed and presented to FEMA in 2005. The plan was revised in 2012, and was updated in 2017 to reflect the most recent information obtained through the evolution of the hazard mitigation program at the State. This update was developed by Strafford Regional Planning Commission (SRPC) and participants from the Multi-Hazard Mitigation Planning Committee, which was made up by the Town Administrator/EMD, Public Works Director, Police Chief, Fire Chief, Assistant Fire Chief, Parks and Recreation Director, Code Enforcement Officer, IT Director, Economic Development Director, Town Planner, Town Engineer, Town Assessor, Business Manager, and representatives from the town council and US Forest Service. Valuable GIS support was also provided by UNH Campus Planning.

The Plan references historical events, as well as identifies specific vulnerabilities that are likely to impact the town. Overall vulnerability to hazards includes:

High Vulnerability	**Moderate Vulnerability**	**Low Vulnerability**
Inland Flooding (including dam breach)	Severe Thunderstorms & Lightning	Hurricanes & Tropical Storms
Severe Winter Weather	Drought	Tornado & Downburst
Public Health Threats	Wildfire	Landslide/Earthquakes
Extended Power Failure	Hazardous Material Threats	Extreme Heat
Cyber Threats	Coastal Flooding	
Large Crowd Events		

A description of each hazard and the extent, past events and impacts, potential future impacts to the community, and potential loss estimates associated with each hazard was included in the plan. As part of this analysis, the planning team reviewed past and existing mitigation strategies and made updates for improvement. Lastly, the planning team developed a series of new mitigation actions to be completed over the course of this plan's five-year cycle. Each mitigation action was prioritized using the STAPLEE Method and responsibilities for implementation were identified.

This plan provides an updated list of Critical Infrastructure and Key Resources (CI/KR) categorized as follows: Emergency Response Services (ERS), Non-Emergency Response Facilities (NERS), Critical Infrastructure (CI), and Water Resources (WR). All critical assets were inventoried and mapped.

The revision process included reviewing other Town Hazard Plans, technical manuals, federal and state laws, the State Hazard Mitigation Plan, research data, and other available mitigation documents from multiple sources. Combining elements from these sources, the Planning Team was able to produce this integrated multi-hazards plan and recognizes that such a plan must be considered a work in progress.

The Town of Durham received conditional approval on August 30, 2017. The plan was adopted by the Administration on September 11, 2017 after consultation with Town leadership. The Plan received formal approval from FEMA on September 27, 2017.

In addition to periodic reviews there are three specific situations which require a formal review of the plan. The plan will be reviewed:

- Annually to assess whether the existing and suggested mitigation strategies have been successful and remain current in light of any changes in federal state and local regulations and statutes. This review will address the Plan's effectiveness, accuracy and completeness in regard to the implementation strategy. The review will address any recommended improvements to the Plan, and address any weaknesses identified that the Plan did not adequately address.
- Every five years. The Plan will be revised and updated using the same criteria outlined above. At that time it is expected to be thoroughly reviewed and updated as necessary. The public will be allowed and encouraged to participate in that five year revision process.
- After any declared emergency event, the EMD shall review the plan using the same criteria outlined above.
- If the Town adopts any major modifications to its land use planning documents, the jurisdiction will conduct a Plan review and make changes as applicable.

Chapter 1: Multi-Hazard Mitigation Planning Process

Authority

Durham's Multi-Hazard Mitigation Plan was prepared pursuant to Section 322, Mitigation Planning, of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (the Act), herein enacted by Section 104 of the Disaster Mitigation Act of 2000 (DMA) (P.L. 106-390). This Act provides new and revitalized approaches to mitigation planning. Section 322 of DMA 2000 emphasizes the need for state, local and tribal entities to closely coordinate mitigation planning and implementation efforts. This revised multi-hazard plan will be referred to as the "Plan." Durham's Plan has been prepared by the Multi-Hazard Mitigation Committee (the Committee) with the assistance and professional services of Strafford Regional Planning Commission (SRPC) under contract with New Hampshire Homeland Security Emergency Management (HSEM) operating under the guidance of Section 206.405 of 44 CFR Chapter 1 (10-1-2010 Edition). This plan is funded, in part, by HSEM through grants from FEMA (Federal Emergency Management Agency). Funds from town dues and matching funds for Committee member's time are also part of the funding formula.

Purpose and History

The ultimate purpose of Disaster Mitigation Act of 2000 (DMA) is to:

> *Establish a national disaster hazard mitigation program –*
>
> *To reduce the loss of life and property, human suffering, economic disruption and disaster assistance costs resulting from natural disasters; and*
>
> *To provide a source of pre-disaster hazard mitigation funding that will assist States and local governments (including Indian tribes) in implementing effective hazard mitigation measures that are designed to ensure the continued functionality of critical services and facilities after a natural disaster.*

DMA 2000 amends the Robert T. Stafford Disaster Relief and Emergency Assistance Act by, among other things, adding a new section "322 – Mitigation Planning" which states:

> *As a condition of a receipt of an increased Federal share for hazard mitigation measures under subsection (e), a State, local, or tribal government shall develop and submit for approval to the President a mitigation plan that outlines processes for identifying the natural hazards, risks, and vulnerabilities of the area under the jurisdiction of the government.*

HSEM's goal is for all New Hampshire communities to complete a local multi-hazard plan as a means to reduce future losses from natural and man-made events before, during, or after they occur. HSEM has outlined a process whereby communities throughout the state may become eligible for grants and other assistance upon completion of this multi-hazard plan. The state's regional planning commissions are charged with providing assistance to selected communities to help develop local plans.

Durham's Multi-Hazard Mitigation Plan is a planning tool for reducing future losses from natural and man-made disasters as required by the Disaster Mitigation Act of 2000.

The DMA places new emphasis on local mitigation planning. It requires local a local jurisdiction to prepare and adopt a FEMA approved jurisdiction-wide Hazard Mitigation Plan as a condition for receiving Hazard Mitigation Assistance (HMA) project grants and other grants every five years. In addition to updating their plans every five years to continue program eligibility, local governments should review the plan yearly.

Scope of the Plan

This Plan addresses only one jurisdiction: the Town of Durham, NH. The Plan addresses 15 types of natural and man-made hazards that may affect the Town:

- Flooding (River & Dam Breach)
- Severe Winter Weather (Ice & Snow)
- Severe Thunderstorms & Lightning
- Hurricanes & Tropical Storms
- Tornado & Downburst
- Drought
- Landslide
- Earthquake
- Public Health Threats
- Wildfire
- Coastal Flooding (Sea Level Rise & Storm Surge)
- Hazardous Material Threats
- Extreme Heat
- Radon
- Extended Power Failure
- Cyber Threats
- Large Crowd Events

It describes each hazard and identifies past occurrences of hazard events and assesses probability of future hazard events in the Town. The Plan assesses the vulnerability of key infrastructure and critical facilities; existing residential buildings and other structures within Durham; and future development. The Plan also addresses the administrative, technical, and physical capacity of emergency response services and response coordination between federal, state, and local entities.

Multi-Hazard Mitigation Goals

The Town's multi-hazard goals are based on the State of New Hampshire Multi-Hazard Mitigation Plan (2013) goals and include:

- Ensure the protection of the general population, citizens and guests of Durham New Hampshire, before during and after a hazard.
- Protect existing properties and structures through mitigation activities.
- Provide resources to residents of Durham, when needed, to become more resilient to hazards that impact the town's critical support services, critical facilities, infrastructure, economy, environment, historical & cultural treasures and private property.

- Support the Presidential Policy Directive (PPD-8) through prevention, mitigation, preparedness, response, and recovery actions.
- Work regionally to identify, introduce, and implement cost effective hazard mitigation measures in order to accomplish the town's goals.
- Develop and implement programs to promote hazard mitigation to protect infrastructure throughout the town to reduce liability with respect to natural and human-caused hazards generally.
- Address the challenges posed by climate change as they pertain to increasing risks in the town's infrastructure and natural environment.

Multi-Hazard Mitigation Planning Process

Overview

The Plan was developed and updated with substantial local, state, and federal coordination. The completion of this new multi-hazard plan required significant planning preparation and represents the collaborative efforts of the Town of Durham, an ad-hoc local Multi-Hazard Mitigation Planning Committee, and SRPC. The Committee followed an established ten step multi-hazard mitigation planning process (see box, right).

The Committee met 5 times over a 4 month period to discuss the range of hazards included in this plan as well as brainstorm mitigation needs and strategies to address these hazards and their impacts on people, business, and infrastructure in the Town. All meetings were geared to accommodate brainstorming, open discussion, and an increased awareness of potential threats to the Town. This process results in significant cross talk regarding all types of natural and man-made hazards.

Ten Step Multi-Hazard Mitigation Planning Process

1. Establish and Orient a Hazard Mitigation Planning Committee
2. Identify Past and Potential Hazards
3. Identify of Hazards and Critical Facilities
4. Assess Vulnerability – Estimating Potential Losses
5. Analyze Development Trends
6. Identify Existing Mitigation Strategies and Proposed Improvements
7. Develop Specific Mitigation Measures
8. Prioritize Mitigation Measures
9. Prepare Mitigation Action Plan
10. Adopt and Implement the Plan

Public Involvement

Public involvement is an important part of the planning process. A local Multi-Hazard Mitigation Planning Committee (the Committee) was formed to guide and oversee the development of this Plan. Town Council; administrative staff; Conservation Commission members; Planning and Zoning Board of Adjustment Members; the Police, Fire, and Highway Departments; and local business owners, interested organizations, and residents of Durham were invited to participate on the Committee. Community officials were encouraged to contact as many people as they could to participate in the planning process. Members of the public and other stakeholders from neighboring communities were also informed of and encouraged to attend the Committee's meetings.

To build awareness of the Plan and opportunity to be involved, a public notice, stressing the public nature of the process, was posted on the Town's website and notices were hung at the Town Hall for a period of at least seven days one week in advance of each Committee meeting. The Committee met 5 times between February 21, 2017 and May 25, 2017. A public notice was also posted on Strafford Regional Planning Commission's website, and information about the Plan was included

in SRPC's news updates in order to ensure that adjacent communities were aware of Durham's committee meetings and had the opportunity to attend.

All feedback from participants of the planning committee was incorporated into the Plan.

Adoption and Integration

Once approved by the Planning Committee, the Plan will be forwarded to HSEM and FEMA for Conditional Approval. Upon review and conditional approval by HSEM and FEMA, the Administration will consider leadership and public comments and must promulgate a signed Resolution to Adopt the Plan.

Elements of the Plan will be incorporated into other planning processes and documents, such as the Town's Master Plan, Capital Improvement Plan, and Emergency Operations Plan. The Town will refer to this Multi-Hazard Mitigation Plan, as appropriate, in other documents.

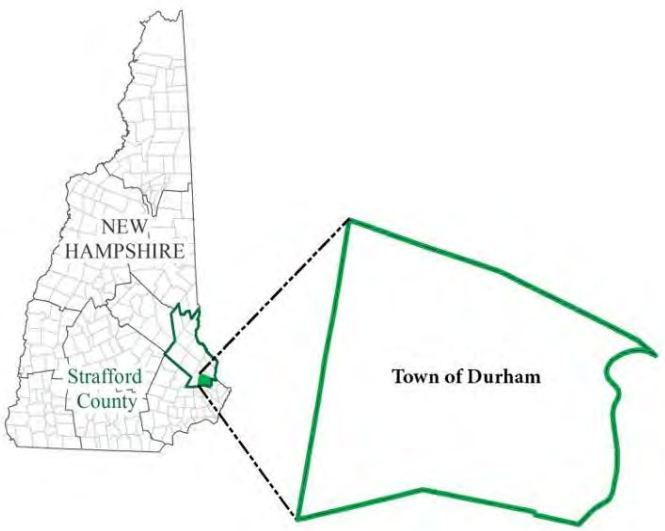
Figure 1.1 Committee Meeting Notice

University of New Hampshire

The Town of Durham is home to The University of New Hampshire's flagship campus. According to the 2015 Existing Land Use chapter of Durham's master plan, the university campus occupies approximately 1,928 acres within Durham, which is roughly 12% of the total land area of the town. The University is also the largest employer in the town, and is an important stakeholder and community partner for a variety of issues in Durham. However, as an entity of the State of New Hampshire, many aspects of campus planning and operations fall outside of the Town's jurisdiction. This plan prioritizes discussion of impacts, strategies, and actions over which the Town has sole or primary jurisdiction. UNH facilities are discussed where they are considered to be heavily related to Town facilities (for example, shared water and sewer infrastructure), and the Town recognizes UNH as an important partner for several possible mitigation actions and strategies. Finally, it is important to reiterate the focus of this plan on hazard mitigation and prevention and not on emergency operations. While collaboration and coordination in responding to ongoing disasters and emergency situations is highly encouraged, the details of any such joint response are better suited for an emergency operations plan and fall outside the scope of this document.

Chapter 2: Community Profile

The Town of Durham is located in southeastern NH within Strafford County. The towns bordering Durham include Madbury and Dover to the north; Newmarket to the south; and Lee to the west. The east side of Durham is adjacent to Little Bay. Durham contains 22.4 square miles of land area and 2.4 square miles of inland water in addition to large stretches of shoreline along Great Bay and Little Bay.



Map 2.1 Location of Durham

The town is home to regionally significant water features, including the Oyster River, which drains to Little Bay. The topography of Durham is gently rolling with elevations ranging from sea level along tidal areas to greater than 290 feet on Beech Hill, which is located on the Town's northern border. Great Bay, Little Bay, Oyster River and the Lamprey River are the Town's significant bodies of water.[1] Durham has significant wetlands, forested land, and conservation land that helps filter and control stormwater runoff during periods of high rainfall.

Durham is also home to the University of New Hampshire (UNH), which had a student enrollment of just over 15,000 degree-seeking and continuing education students in 2016.[2]

Historical Population Trends

In 1790, the first year the Census was taken, Durham's population was 1,247 residents. From 1960 to 2010, the town's population (including UNH students) increased from 5,504 to 14,638. The American Community Survey 5-Year population estimates indicate approximately 15,669 residents in 2015. Durham's full-time resident population was estimated to be between 5,500 and 6,200 individuals in 2010. Between 1960 and 2010, enrollment at UNH increased by about 10,000 people.

Projected Population Change

National population projections by the Census Bureau suggest that the United States will reach a population of approximately 380 million by 2040 (an 18% overall population growth). Although the Strafford Planning Region is not expected to grow on pace with the national rate, it is expected to grow by close to 10%, a significantly higher rate than projected for the state of New Hampshire (7.2%). Population projections completed by the New Hampshire Office of Strategic Initiatives and the state's Regional Planning Commissions, suggest that Durham's population will increase by approximately 17% percent to 17,134 people by 2040. This increase represents an average increase of 832 residents per decade.

[1] Town of Durham Master Plan. Existing Land Use Chapter. 2015.
[2] https://www.unh.edu/institutional-research/sites/unh.edu.institutional-research/files/media/fte_fall_2016_revised_0.pdf

Migration

Data suggest that fewer New Hampshire residents are leaving the State of New Hampshire. Since 2005, the peak year of outmigration between 2000 and 2010, there has been a 17% decrease in residents exiting the state. Unfortunately, New Hampshire is also experiencing a declining rate of in-migration, meaning that fewer individuals are coming into the state.

Aging

With a significant student population, Durham's age characteristics are unique. Nearly 67% of the total population in 2010 is between the ages of 15 and 24, with 29% of the total population between the ages of 15 and 19 and 38% between the ages of 20 and 24.[3]

Durham, like many communities in the region, experienced a significant increase in its 65 and older population between 2000 and 2010, albeit a smaller increase than many other communities. The percent of the population age 65 and older increased from 6.1% in 2000 to 6.9% in 2010.[4] This trend is occurring across both the state and much of the New England and is a product of aging Baby-Boom and Generation X populations.

In the whitepaper series *The Two New Hampshires: What does it mean?* Ross Gittell addresses the aging population, and how concentrations of older age cohorts vary across the state. In the report Gittell defines two New Hampshires, rural and metro. Rural NH includes Cheshire, Sullivan, Belknap, Carroll, Grafton, and Coos Counties, while Metro NH includes Rockingham, Hillsborough, Strafford and Merrimack Counties. As Gittell notes, Rural NH has a far older population (median age) than Metro NH, and if this was its own state it would be the second oldest in the nation. Even Metro NH, if considered by itself, would be older than Massachusetts, Connecticut, Rhode Island, and Vermont.

Population and Age

While data show the region growing at a faster rate than the state over the next 25 years, the slowed growth rate beginning in 1990 has, and will continue to have, an effect on the region. As the regional population ages, and in-migration continues to decrease, the percentage of school age children is declining. Out of the 161 districts in the state, 130 experienced a decline in enrollment between 2000 and 2010.

The aging population, combined with a decrease in population ages 18 to 55, may result in a labor force shortage in coming years. Additionally, a trend known as 'brain drain', the emigration of highly skilled or trained individuals to other states, could have potentially negative impacts on local, regional and state economic systems.

With the expected increase in demand for health care, assisted living facilities, and nursing home capacity, and the potential for a smaller labor force, a care-provider shortage may emerge. Local governments will likely need to create programs and strategies in order to provide adequate health and social services for increased numbers of aging seniors.

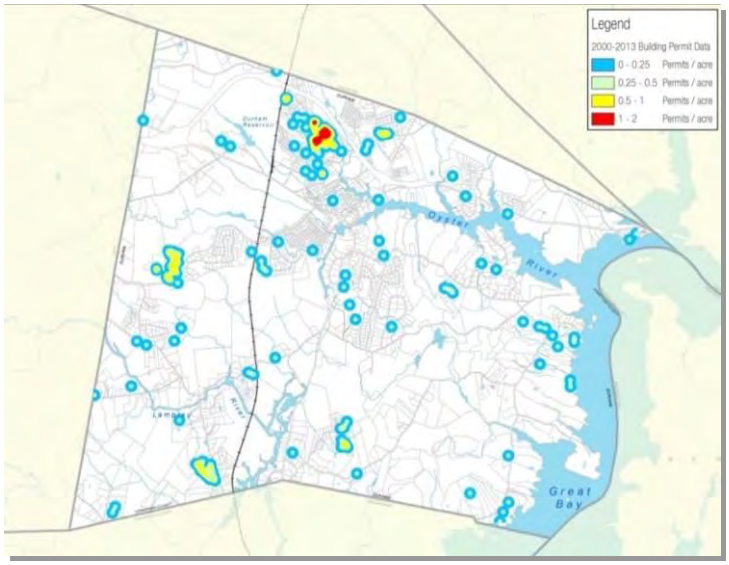
Table 2.1 Population in Durham 1990, 2000, 2010

	1990	2000	2010	% Change 1990-2000	% Change 2000-2010
Population	11,817	12,664	14,638	7.2%	15.6%

[3] Town of Durham Master Plan. Housing and Demographics Chapter. 2015.
[4] US Census 2000 and 2010

Past Development Trends

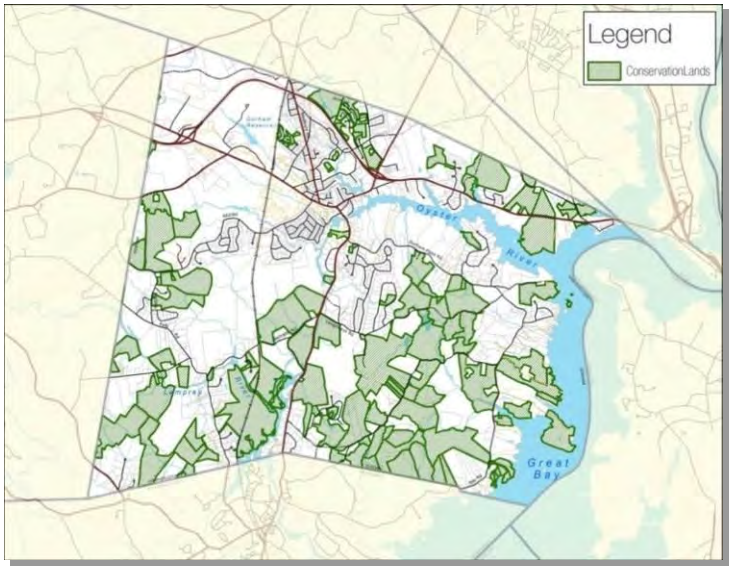
While the population of the Town continues to grow, the rate of growth has decreased significantly from the level of growth that occurred in 60s and 70s. Single-family residential growth has declined significantly since 1998-1999, shifting instead to a rise in multifamily units developed beginning in 2008. Residential land currently accounts for approximately 14% of the area of the town.[5] Figure 2.2 from Durham's Master Plan displays the concentration of residential development in recent years.



Mao 2.2 Map showing residential development patterns during 2000-2013 from the Town's Master Plan

Despite this population growth, Durham has significant open space areas with nearly 30% of the land in the town permanently conserved (See figure 2.3 from Durham's Master Plan).

Approximately 12% of the area of the town is occupied by the University of New Hampshire. UNH has been a nucleus for development for many decades, giving Durham the usual "college town" feel. The residential uses are predominantly single-family detached homes found throughout Durham, with some concentrations near UNH. The UNH campus development is mostly large, institutional masonry buildings (dormitories, academic halls, etc.), recreational and service buildings, and transportation infrastructure that support the UNH community. While some residents of Durham are UNH employees, many students, faculty, and staff live in surrounding communities. Consequently, UNH is a major commuting destination, though UNH does run a local bus system.

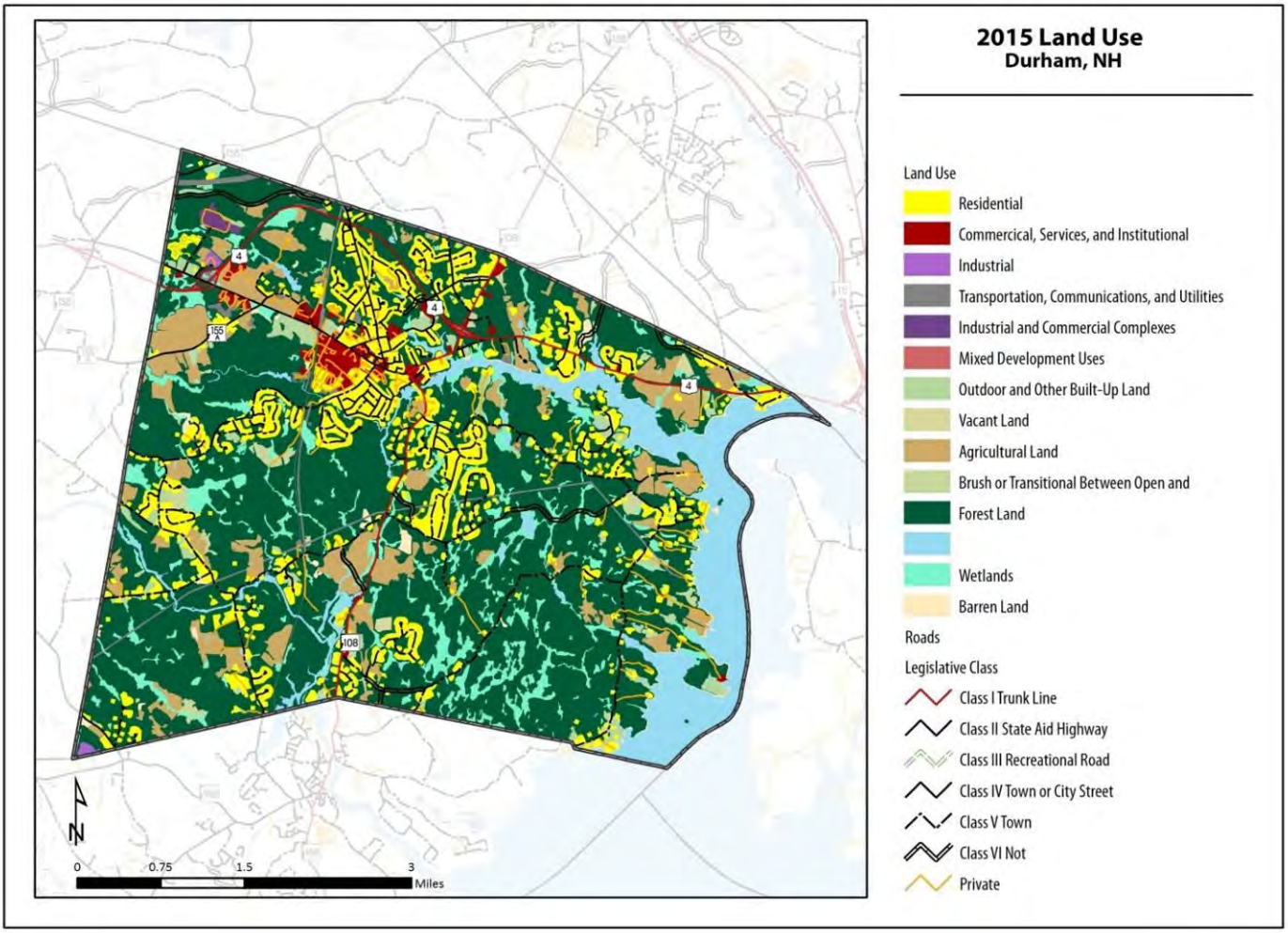


Map 2.3 Map showing conservation land as of 2015 from the Town's Master Plan

A significant portion of the working population does not work for UNH and commuting out of town to work is a necessity given the relatively small number of commercial/industrial land uses in Durham. The Town Hall, Police Station, Library, and primary and secondary schools are relatively dispersed. There is municipal water and sewer service in the greater UNH-downtown area.

The Planning Committee noted that there is some residential development in the floodplain near NH Route 4 and Cedar Point. While recent multi-unit residential development has not occurred in hazard prone areas, it has resulted in an increased residential density in a relatively small geographic area in the downtown. As a result, development may have increased vulnerability to hazards.

[5] Town of Durham Master Plan. Existing Land Use Chapter. 2015.



Map 2.4 2015 Land Use

Table 2.2 Change in land use from 2010 to 2015

Land Use	2010 (acres)	2015 (acres)	% of total area of the town	% change 2010-2015
Residential	2097.4	2187.3	13.2	4.3
Commercial, Services, Intuitional	211.0	210.9	1.3	-0.1
Industrial	17.0	21.5	0.1	26.1
Transportation, Communications	470.2	482.2	3.0	2.5
Industrial and Commercial Complexes	28.8	28.8	0.2	0.0
Mixed Development Uses	0.8	0.8	0.0	0.0
Outdoor and Other Build Up Land	315.5	315.0	2.0	-0.2
Vacant Land	6.1	23.2	0.0	280.2
Agricultural Land	1335.9	1331.9	8.4	-0.3
Brush or Transitional Between Open and Forested	193.9	188.9	1.2	-2.6
Forest Land	8418.1	8283.6	53.1	-1.6
Water	1542.0	1544.8	9.7	0.2
Wetlands	1102.2	1110.1	7.0	0.7
Barren or Disturbed Land	113.3	123.3	0.7	8.8
TOTAL	15852.3	15852.3	100.0	0.0

Future Development

The Town is currently initiating a Future Land Use chapter for its Master Plan. This chapter, which is anticipated to be completed by the end of 2017, will identify, among other things, areas that are targeted for future commercial development and areas where residential density may increase. A GIS-based build-out analysis that was prepared for the Existing Land Use Chapter of the Master Plan found that after accounting for existing development, conservation land, and development constraints, there are approximately 3,443 acres of land (25.4% of the total land area) that are suitable for development. Nearly 80% of remaining land suitable for development is located in the Residence Coastal and Rural Zoning Districts in the northeast, southeast, and southwest quadrants of the town. Future commercial development likely includes infill and redevelopment in existing commercial areas, as well as development in targeted areas along the town's main corridors: NH Route 4 and NH Route 108. Areas of the downtown near Pette Brook have experienced flooding in the past. This Plan will be used during the development of the Future Land Use chapter to help guide future development from especially vulnerable areas.

Housing

In the period between 1990 and 2010, Durham experienced an increase of 584 total housing units. Occupancy-type data show that in the same 20-year-period, total renter-occupied unit count increased by 20.4% while owner-occupied housing units increased by 26.3%. During this time period, the vacant housing units increased by 13.8% and occupied housing units increased by 23.7%.

As of 2010, Durham's occupied housing units are roughly 55% owner-occupied and 45% renter occupied. The town exhibits a 4.3% vacancy rate. With moderate population growth projected over the coming three decades, limited new housing unit development is expected.

Table 2.3 Housing units and tenure

	1990	2000	2010	% Change 1990-2010
Housing Units	2,508	2,923	3,092	23.3
Occupied Housing Units	2,392	2,882	2,960	23.7
Owner Occupied housing Units	1,356	1,628	1,713	26.3
Renter Occupied Housing Units	1,036	1,254	1,247	20.4
Vacant Housing Units	116	41	132	13.8

Building trend data indicates that the number of building permits issued increased significantly from 2008 – 2014. This is attributable to the increase in multi-family units during this time. Between 2006 and 2012, under 10 single family residential building permits were issued in each year, with as few as two issues in 2008 (see Figure 2.4). Since 2011, the number of permits issued for new commercial development and renovations to existing commercial development ranged from 21 to 33 per year. This data represents the best available data at the time of the preparation of the Plan.

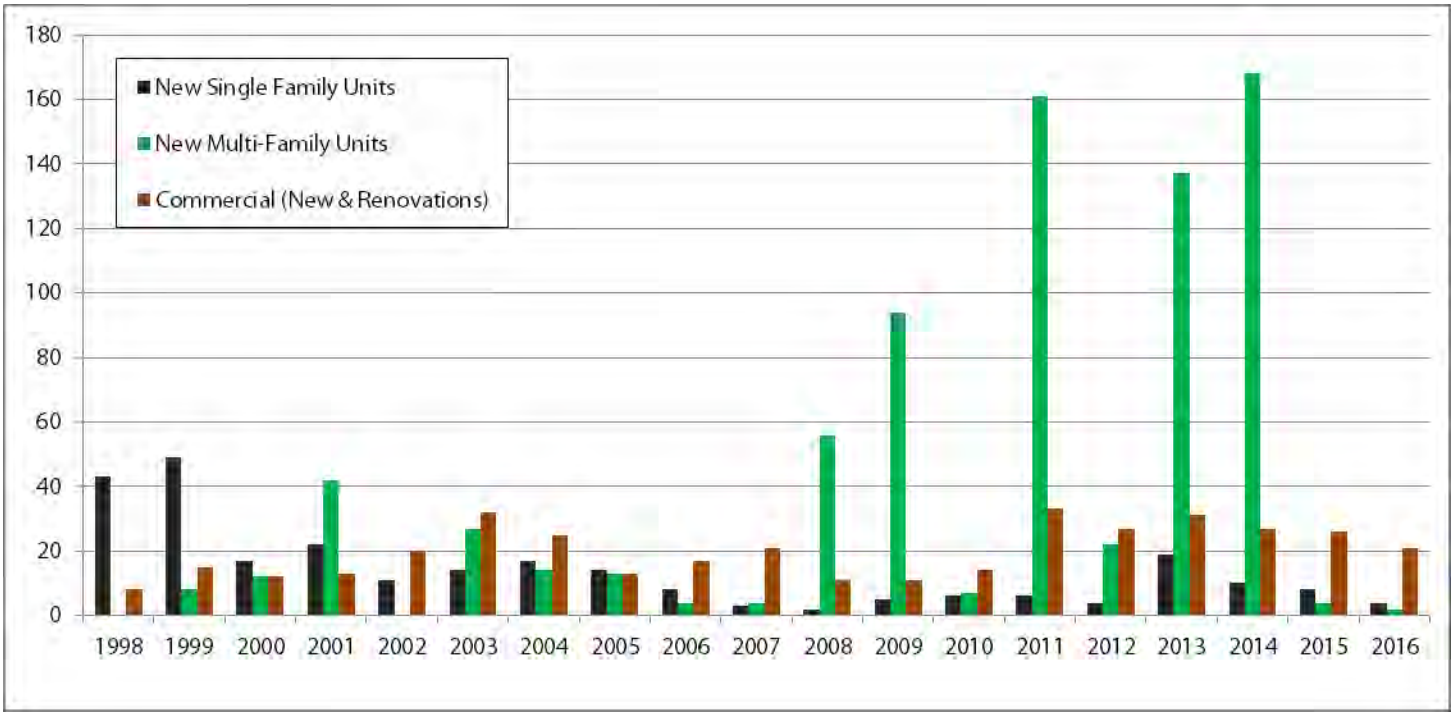


Figure 2.1 Building permits for new single family units, new multi-family units, and new commercial development and commercial renovations in Durham 1998-2016 (Source: Town of Durham)

Chapter 3: Asset Inventory

Critical Facilities and Key Resources

This chapter includes Critical Facilities and Key Resources (CF/KR) within the Town of Durham that were identified by the Committee during the update of this plan.

FEMA describes the term 'critical facilities' as all manmade structures or other improvements that, because of their function, size, service area, or uniqueness, have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired.[6] These facilities include all public and private facilities that a community considers essential for the delivery of vital services for the protection of the community, such as emergency operations centers, shelters, or utilities. [6]

"Critical facilities, and the functions they perform, are the most significant components of the system that protects the health, safety, and well-being of communities at risk."

-FEMA Critical Facility Design Considerations

Table 3.1 includes a list of Critical Facilities and Key Resources (CF/KR), including the type of facility or building. Map 3.1 displays the location of emergency Response facilities. Map 3.2 displays dams and bridges.

Table 3.1 Critical Facilities and Key Resources

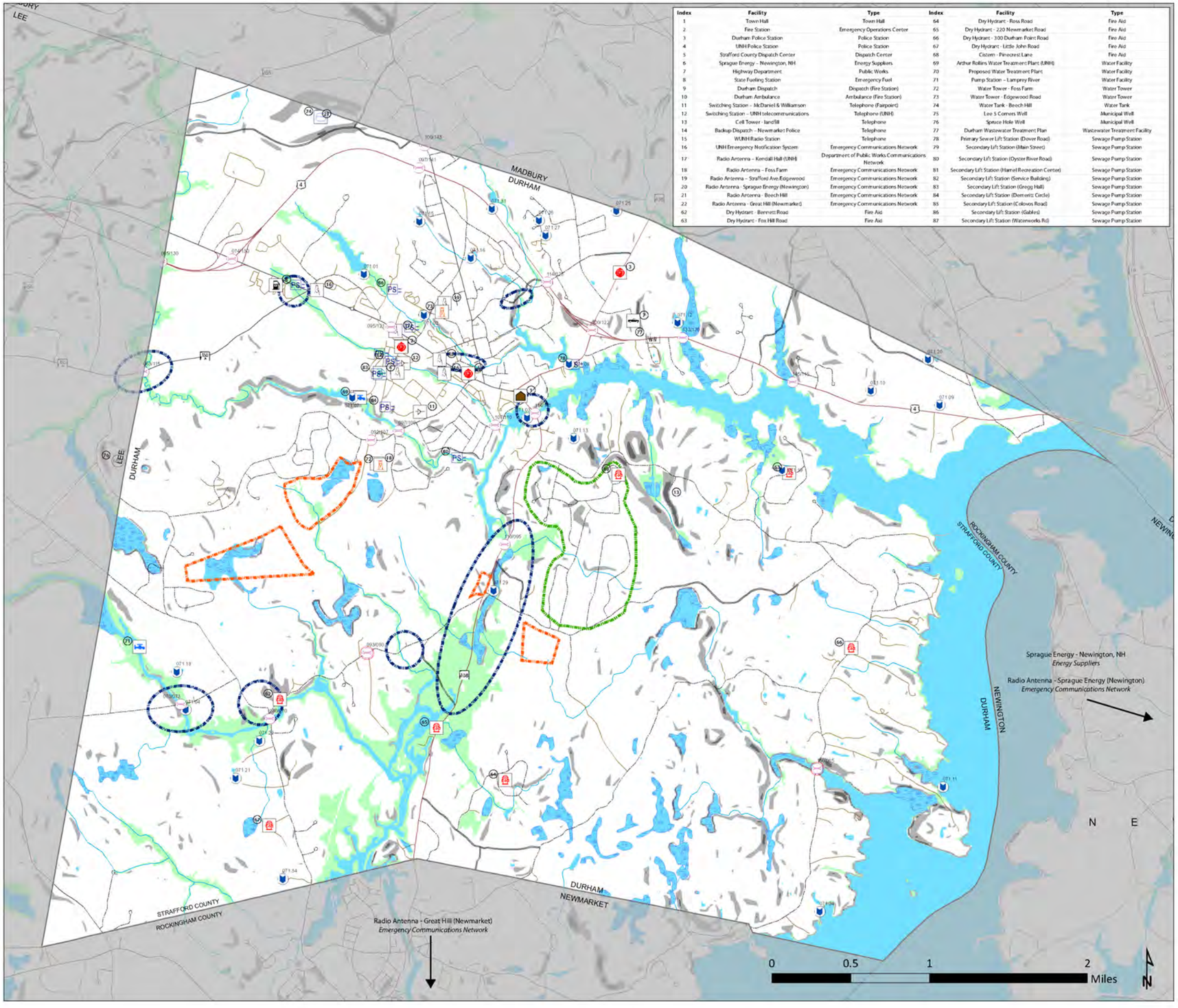
Emergency Response Facilities (ERF)	
Facility Name	*Type of Facility*
Town Hall	Town Hall
Fire Station	Emergency Operations Center
Durham Police Station	Police Station
UNH Police Station	Police Station
Strafford County Dispatch Center	Dispatch Center
Sprague Energy – Newington, NH	Energy Suppliers
Highway Department	Public Works
State Fueling Station	Emergency Fuel
Durham Dispatch	Dispatch (Fire Station)
Durham Ambulance	Ambulance (Fire Station)
Telephone and Radio/Broadcast Facilities	
Switching Station – McDaniel & Williamson	Telephone (Fairpoint)
Switching Station – UNH telecommunications	Telephone (UNH)
Cell Tower – landfill	Telephone
Backup Dispatch – Newmarket Police	Telephone
WUNH Radio Station	Telephone
UNH Emergency Notification System	Emergency Communications Network
Radio Antenna – Kendall Hall (UNH)	Department of Public Works Communications Network
Radio Antenna – Foss Farm	Emergency Communications Network
Radio Antenna – Strafford Ave/Edgewood	Emergency Communications Network
Radio Antenna – Sprague Energy (Newington)	Emergency Communications Network
Radio Antenna – Beech Hill	Emergency Communications Network
Radio Antenna – Great Hill (Newmarket)	Emergency Communications Network

[6] https://www.fema.gov/media-library-data/20130726-1557-20490-2839/fema543_chapter1.pdf

Non-Emergency Response Facilities (NERF)	
Facility Name	*Type of Facility*
UNH Generation Plant	Power Station/Substation
Substation (Mill Road)	Power Station/Substation
Packers Falls Solar Array	Solar Power Generation
Jackson's Landing Ice Rink	Hazardous Materials
Durham Transfer Station	Hazardous Materials
Whittemore Center – UNH	Hazardous Materials
UNH Hazardous Waste Accumulation Facility	Hazardous Materials
Durham Rail Station	Transportation/Rail Station
Facilities and Populations to Protect (FPP)	
Oyster River Middle/High School	School/Shelter
Whittemore Center	Shelter
Dimond Library	Day Shelter
Growing Places – Woodside	Daycare Facility
Spinney Lane – UNH Daycare	Daycare Facility
Thompson Hall	Historic
Chapel on Mill Road	Historic
Durham Historical Association	Historic
Goss Manufacturing	Commercial/Economic Area
Downtown Business District	Commercial/Economic Area
Nursing Homes/Elderly Housing & Special Needs	
Brookdale at Spruce Woods – Assisted Living – Worthen Rd	Nursing Home
Church Hill Apartments – Mill Pond Rd	Elderly Housing
Bagdad Wood – Madbury Rd	Elderly Housing
Harmony Homes	Elderly Housing/Assisted Living
Harmony Homes by the Bay	Assisted Living/Memory Care
Potential Resources (PR)	
Food/Water/Retail	
Three Chimneys Inn	Lodging
Holiday Inn	Lodging
Pines Guesthouse – Dover Road	Lodging
Highland House/Thompson Inn – Bennett Road	Lodging
Irving Gas Station	Services
Phillips 66 Gas Station	Services
LNG Filling Station – Gables Way	Services
Airport/Helipad	
Goss Manufacturing	Helipad
Recreational Facilities (Indoor and Outdoor)	
Oyster River Middle School	Indoor/Outdoor
Oyster River High School	Indoor/Outdoor
UNH Field House Complex	Indoor
Whittemore Center	Indoor
Jackson's Landing Ice Rink	Outdoor
Woodridge Fields	Outdoor
Outdoor Pool	Outdoor
Wagon Hill	Outdoor

Water Resources (WR)	
Facility Name	*Type of Facility*
Auxiliary Fire Aid	
Dry Hydrant – Bennett Road	Fire Aid
Dry Hydrant – Fox Hill Road	Fire Aid
Dry Hydrant – Ross Road	Fire Aid
Dry Hydrant – 220 Newmarket Road	Fire Aid
Dry Hydrant – 300 Durham Point Road	Fire Aid
Dry Hydrant – Little John Road	Fire Aid
Cistern - Pinecrest Lane	Fire Aid
Water-Related and Sewage Facilities	
Arthur Rollins Water Treatment Plant (UNH): to close in 2018-19	Water Facility
Proposed Water Treatment Plant (UNH): to open in 2018-19	Water Facility
Pump Station – Lamprey River	Water Facility
Water Tower – Foss Farm	Water Tower
Water Tower – Edgewood Road	Water Tower
Water Tank – Beech Hill	Water Tank
Lee 5 Corners Well	Municipal Well
Spruce Hole Well	Municipal Well
Durham Wastewater Treatment Plan	Wastewater Treatment Facility
Primary Sewer Lift Station (Dover Road)	Sewage Pump Station
Secondary Lift Station (Main Street)	Sewage Pump Station
Secondary Lift Station (Oyster River Road)	Sewage Pump Station
Secondary Lift Station (Hamel Recreation Center)	Sewage Pump Station
Secondary Lift Station (Service Building)	Sewage Pump Station
Secondary Lift Station (Gregg Hall)	Sewage Pump Station
Secondary Lift Station (DeMerritt Circle)	Sewage Pump Station
Secondary Lift Station (Colovos Road)	Sewage Pump Station
Secondary Lift Station (Gables)	Sewage Pump Station
Secondary Lift Station (Waterworks Road)	Sewage Pump Station

Index	Facility	Type	Index	Facility	Type
1	Town Hall	Town Hall	64	Dry Hydrant - Ross Road	Fire Aid
2	Fire Station	Emergency Operations Center	65	Dry Hydrant - 220 Newmarket Road	Fire Aid
3	Durham Police Station	Police Station	66	Dry Hydrant - 300 Durham Point Road	Fire Aid
4	UNH Police Station	Police Station	67	Dry Hydrant - Little John Road	Fire Aid
5	Strafford County Dispatch Center	Dispatch Center	68	Cistern - Pinecrest Lane	Fire Aid
6	Sprague Energy – Newington, NH	Energy Suppliers	69	Arthur Rollins Water Treatment Plant (UNH)	Water Facility
7	Highway Department	Public Works	70	Proposed Water Treatment Plant	Water Facility
8	State Fueling Station	Emergency Fuel	71	Pump Station – Lamprey River	Water Facility
9	Durham Dispatch	Dispatch (Fire Station)	72	Water Tower - Foss Farm	Water Tower
10	Durham Ambulance	Ambulance (Fire Station)	73	Water Tower - Edgewood Road	Water Tower
11	Switching Station – McDaniel & Williamson	Telephone (Fairpoint)	74	Water Tank - Beech Hill	Water Tank
12	Switching Station – UNH telecommunications	Telephone (UNH)	75	Lee 5 Corners Well	Municipal Well
13	Cell Tower - landfill	Telephone	76	Spruce Hole Well	Municipal Well
14	Backup Dispatch – Newmarket Police	Telephone	77	Durham Wastewater Treatment Plan	Wastewater Treatment Facility
15	WUNH Radio Station	Telephone	78	Primary Sewer Lift Station (Dover Road)	Sewage Pump Station
16	UNH Emergency Notification System	Emergency Communications Network	79	Secondary Lift Station (Main Street)	Sewage Pump Station
17	Radio Antenna – Kendall Hall (UNH)	Department of Public Works Communications Network	80	Secondary Lift Station (Oyster River Road)	Sewage Pump Station
18	Radio Antenna - Foss Farm	Emergency Communications Network	81	Secondary Lift Station (Hamel Recreation Center)	Sewage Pump Station
19	Radio Antenna – Strafford Ave./Edgewood	Emergency Communications Network	82	Secondary Lift Station (Service Building)	Sewage Pump Station
20	Radio Antenna - Sprague Energy (Newington)	Emergency Communications Network	83	Secondary Lift Station (Gregg Hall)	Sewage Pump Station
21	Radio Antenna - Beech Hill	Emergency Communications Network	84	Secondary Lift Station (Dementz Circle)	Sewage Pump Station
22	Radio Antenna - Great Hill (Newmarket)	Emergency Communications Network	85	Secondary Lift Station (Colovos Road)	Sewage Pump Station
62	Dry Hydrant - Bennett Road	Fire Aid	86	Secondary Lift Station (Gables)	Sewage Pump Station
63	Dry Hydrant - Fox Hill Road	Fire Aid	87	Secondary Lift Station (Waterworks Rd)	Sewage Pump Station



Critical Facilities / Key Resources

Emergency Response Facilities, Water Resources, & Past and Potential Hazards

Durham, NH

Legend

Water Resources
- Dry Hydrant/Cistern
- Municipal Well
- Sewage Pump Station
- Wastewater Treatment Facility
- Water Facility
- Water Tank
- Water Tower

Emergency Response
- Durham Fire Station/EOP (Shelter, Ambulance, Dispatch)
- Durham Police
- Highway Department
- Radio/Emergency Notification
- Fuel
- Switching Station
- Durham Town Hall
- University Police

Past & Potential Hazards
- Flooding
- Heavily Impacted by all Wind-Related Hazards
- Wildfire

Percent Slope
- 15.1-25%
- >25%

Roads

Legislative Class
- Class I Trunk Line Highway
- Class II State Aid Highway
- Class III Recreational Road
- Class IV Town or City Street
- Class V Town Road
- Class VI Not Maintained
- Private
- Redlist Bridges (NHDOT)
- Bridges (NHDOT)
- Dams

Water Features
- Perennial Stream/River
- Lakes, Ponds, Rivers
- 100 Year Floodplain
- Wetlands

Index	Facility	Facility Type	Index	Facility	Facility Type
23	UNH Generation Plant	Power Station/Substation	43	Bagdad Wood – Madbury Rd	Elderly Housing
24	Substation (Mill Road)	Power Station/Substation	44	Harmony Homes	Elderly Housing/Assisted Living
25	Packers Falls Solar Array	Solar Power Generation	45	Harmony Homes by the Bay	Assisted Living/Memory Care
26	Jackson's Landing Ice Rink	Hazardous Materials	46	Three Chimneys Inn	Lodging
27	Durham Transfer Station	Hazardous Materials	47	Holiday Inn	Lodging
28	Whittemore Center	Hazardous Materials	48	Pines Guesthouse – Dower Road	Lodging
29	UNH Hazardous Waste Accumulation Facility	Hazardous Materials	49	Highland House/Thompson Inn – Bennett Road	Lodging
30	Durham Rail Station	Transportation/Rail Station	50	Irving Gas Station	Services
31	Oyster River Middle/High School	School/Shelter	51	Phillips 66 Gas Station	Services
32	Whittemore Center	Shelter	52	LNG Filling Station – Gables Way	Services
33	Dimond Library	Day Shelter	53	Goss Manufacturing	Helipad
34	Growing Places – Woodside	Daycare Facility	54	Oyster River Middle School	Indoor/Outdoor Recreation
35	Spinney Lane – UNH Daycare	Daycare Facility	55	Oyster River High School	Indoor/Outdoor Recreation
36	Thompson Hall	Historic	56	UNH Field House Complex	Indoor Recreation
37	Chapel on Mill Road	Historic	57	Whittemore Center	Indoor Recreation
38	Durham Historical Association	Historic	58	Jackson's Landing Ice Rink	Outdoor Recreation
39	Goss Manufacturing	Commercial/Economic Area	59	Woodridge Fields	Outdoor Recreation
40	Downtown Business District	Commercial/Economic Area	60	Outdoor Pool	Outdoor Recreation
41	Brookdale at Spruce Woods	Nursing Home	61	Wagon Hill	Outdoor Recreation
42	Church Hill Apartments – Mill Pond Rd	Elderly Housing			

LEE
MADBURY
DURHAM
LEE
DURHAM
ROCKINGHAM COUNTY
STRAFFORD COUNTY
NEWINGTON
DURHAM
DURHAM
NEWMARKET
STRAFFORD COUNTY
ROCKINGHAM COUNTY
0 0.5 1 2 Miles
N
N E

Critical Facilities / Key Resources

Potential Resources, Facilities and Populations to Protect & Past and Potential Hazards

Durham, NH

Legend

Potential Resources
- Airport/Helipad
- Recreation Facilities (Indoor/Outdoor)
- Lodging
- Services

Non-Emergency Response
- Hazardous Materials
- Power Station/Substation
- Solar Power Generation
- Transportation/Rail Station

Facilities and Populations to Protect
- Assisted Living/Elderly Housing
- Commercial/Economic Area
- Shelter
- Daycare Facility
- Historic
- Commercial/Economic Area (Central Business)

Past & Potential Hazards
- Flooding
- Heavily Impacted by all Wind-Related Hazards
- Wildfire
- Wetlands

Roads

Legislative Class
- Class I Trunk Line Highway
- Class II State Aid Highway
- Class III Recreational Road
- Class IV Town or City Street
- Class V Town Road
- Class VI Not Maintained
- Private

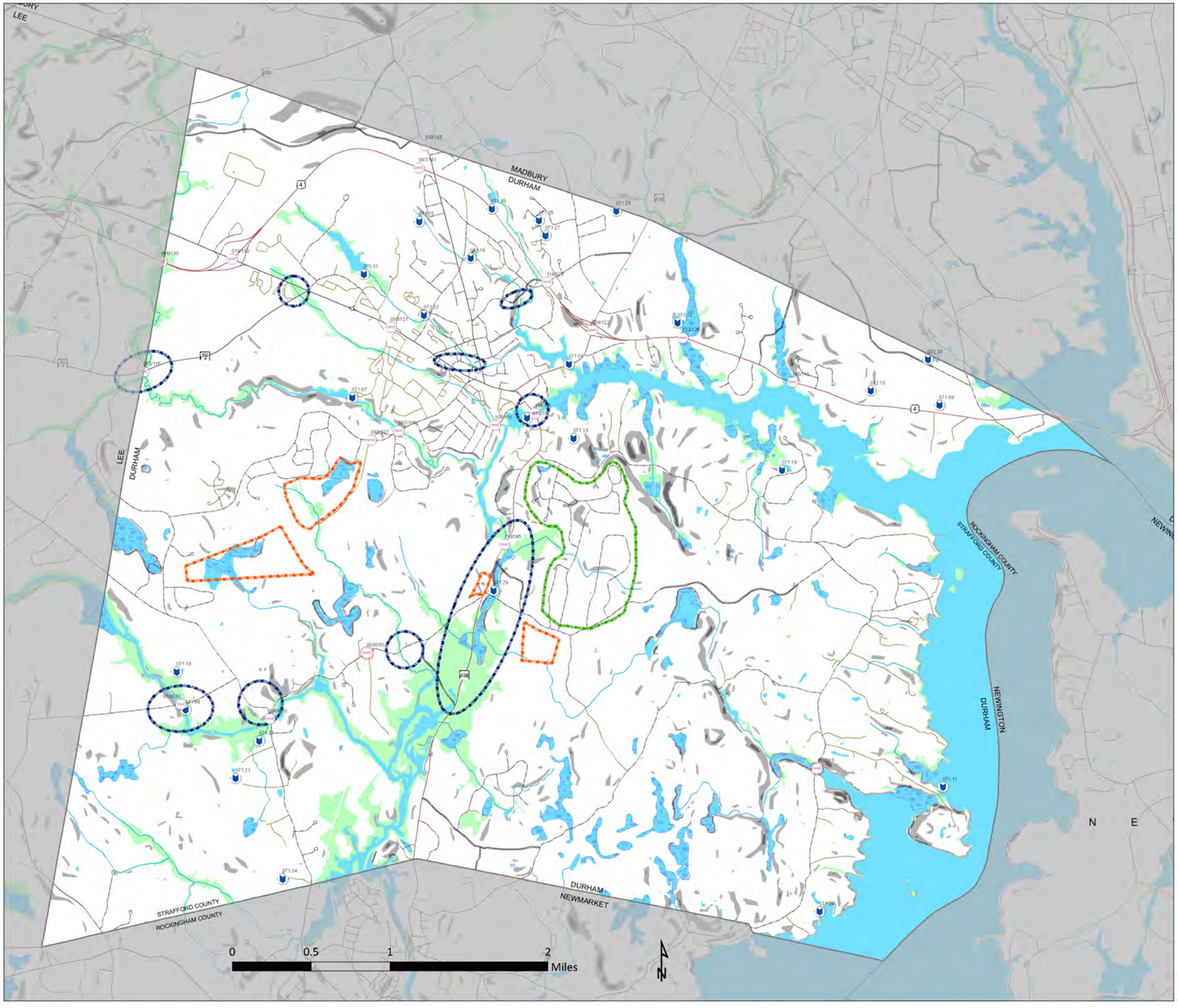
Percent Slope
- 15.1-25%
- >25%
- Lakes, Ponds, Rivers

Water Features
- Perennial Stream/River
- 100 Year Floodplain

Critical Facilities / Key Resources

Bridges, Dams &
Past and Potential Hazards

Durham, NH



Legend

- Dams
- Redlist Bridges (NHDOT)
- Bridges (NHDOT)

Past & Potential Hazards

- Flooding
- Heavily Impacted by all Wind-Related Hazards
- Wildfire

Percent Slope

- 15.1-25%
- >25%

Roads

Legislative Class

- Class I Trunk Line Highway
- Class II State Aid Highway
- Class III Recreational Road
- Class IV Town or City Street
- Class V Town Road
- Class VI Not Maintained
- Private

Water Features

- Perennial Stream/River
- Lakes, Ponds, Rivers
- 100 Year Floodplain
- Wetlands

Table 3.2 Bridges

Bridge ID	Location		Owner
097/141	US 4	1.5 mi from junction with Rt 108	NHDOT
107/110	Mill Pond Rd over College Brook	0.2 mi west of Rt108 junction	Municipality
063/115	NH 155A over Oyster River	0.03 mi from Lee town line	NHDOT
065/130	US 4 over Oyster River	0.02 mi from Lee town line	NHDOT
070/073	Wiswall Road over Lamprey River	0.6 mil from Lee town line	Municipality
074/130	US 4 over NH155A	0.5 mi from Lee town line	NHDOT
080/070	Packers Falls Road over Lamprey River	1.1 mi from Newmarket town line	Municipality
092/107	Mill Road	Town Road	Municipality
145/116	US 4 over Bunker Creek	1.8 mi west of Madbury town line	NHDOT
150/065	Durham Point Road over Crommet Creek	4.0 mi from Rt 108	Municipality*
095/121	Main Street, Pedestrian	1.6 mi from Lee town line	Municipality
097/109	Mill Road over Oyster River	TOWN RD	Municipality
100/143	Madbury Road	0.2 mi from junction with Rt 4	NHDOT
110/095	NH108 over Hamel Brook	2 mi north of Newmarket town line	NHDOT
093/080	Bennet Road	0.9 mi from Rt 108 junction	NHDOT**
114/111	NH108 over Oyster River	0.2 mi from junction with Rt 4	NHDOT
114/128	Bagdad Road over US 4	0.4 mi from Rt 108 junction	NHDOT
120/122	US 4 over NH 108	0.7 mi from Madbury town line	NHDOT
133/120	US 4 over Johnson Creek	2.5 mi northwest of Madbury town line	NHDOT

*Municipal Red List **State Red List

Table 3.3 Dams and Hazard Class

Hazard Class	Name	River or Stream	Owner	
H	Durham Reservoir Dam	Tributary Beards Creek	UNH	71.01
S	Oyster Reservoir Dam	Oyster River	UNH	71.07
S	Beards Creek	Beards Creek	NH DOT	71.07
S	Wiswall Dam	Lamprey River	Town	71.04
L	Mill Pond Dam	Oyster River	Town	71.03
NM	Wildlife Pond	Natural Swale	UNKNOWN	71.18
NM	Farm Pond	Natural Swale	Private	71.22
NM	Lonsinger Dam	Unnamed Stream	Private	71.29
NM	Farm Pond	Natural Swale	Private	71.09
NM	Farm Pond	Natural Swale	Private	71.1
NM	Recreation Pond Dam	Tributary Beards Creek	UNH	71.02
NM	Adams Point Wildlife Pond Dam	Natural Swale	NH Fish and Game	71.11
NM	Farm Pond	Johnson Creek	Private	71.12
NM	Fire Pond	Natural Swale	Private	71.13
NM	Ejarque Pond Dam	Natural Swale	Private	71.15
NM	Wildlife Pond	Little Hale Creek	Private	71.16
NM	Wildlife Pond	Natural Swale	Private	71.19
NM	Farm Pond Dam	Unnamed Stream	Private	71.2
NM	Farm Pond	Natural Swale	Private	71.22
NM	Farm Pond	Tributary Great Bay	Private	71.24
NM	Canney Farm Co Upper Dam	Tributary To Beards Creek	Private	71.25
NM	Canney Farm Co Middle Dam	Unnamed Stream	Private	71.26

NM	Canney Farm Co Lower Dam	Unnamed Stream	Private	71.29
NM	Hirst Dam	Tributary Beards Creek	Private	71.31
NM	Recreation Pond Dam	Unnamed Stream	Private	71.34

Table 3.4 Dams in Durham by Classification

Dam Classification	Classification Definition	Number of Dams in Durham	Inspection Interval (Years)
High	Dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life.	1	2
Significant	Dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in no probable loss of lives but major economic loss to structures or property.	3	4
Low	Dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in no possible loss of life and low economic loss to structures/property.	1	6
Non-Menace	Dam that is not a menace because it is in a location and of a size that failure of misoperation of the dam would not result in probable loss of life or loss to property.	20	6

Vulnerable Structures and Potential Loss

Critical Facilities/Key Resources and Other Assets

It is important to identify the critical facilities and other structures that are most likely to be damaged by hazards. Table 3.2 lists CF/KRs, bridges, and dams that are located within past and potential hazard areas. The majority of these structures are located within the 100-year floodplain or areas of past flooding, while one facility is located in an area that typically sees above-average negative impacts as a result of wind-related events.

Table 3.5

CF/KR and other Assets	Hazard	100% of Structure Value*
CF/KR		
Pump Station – Lamprey River	Flooding - Located in 100 yr Floodplain	$650,000
Lee 5 Corners Well		$2,500,000
Secondary Lift Station (Main Street)		$1,500,000
Dry Hydrant – Bennett Road		$500
Dry Hydrant – 220 Newmarket Road		$500
Secondary Lift Station (Colovos Rd)		**$300,000
WUNH Radio Station	Flooding – Located in Past Flooding Area	$300,000
Durham Historical Association		$376,200
Three Chimneys Inn		$1,927,800
Secondary Lift Station (Main Street)		$1,500,000
Dry Hydrant – Bennett Road		$500
Cistern – Pinecrest Lane	Area impacted by wind-related hazards	$100,000

Bridges* **		
Mill Pond Rd over College Brook (ID107/110)	Flooding – Located in 100 yr Floodplain	$460,000
NH 155A over Oyster River (ID 063/115)		$240,000
US 4 over Oyster River (ID 065/130)		$300,000
Wiswall Road over Lamprey River (ID 070/073)		$2,240,000
Packers Falls Road over Lamprey River (ID 080/070)		$1,340,000
US 4 over Bunker Creek (ID 145/116)		$360,000
Durham Point Road over Crommet Creek (ID 150/065)		$460,000
Mill Road over Oyster River (ID 097/109)		$340,000
NH 108 over Hamel Brook (ID 110/095)		$240,000
NH 108 over Oyster River (ID 114/111)		$620,000
US 4 over Johnson Creek (ID 133/120)		$446,000
Packers Falls Road over Lamprey River (ID 080/070)	Flooding – Located in Past Flooding Area	$1,340,000
NH 108 over Hamel Brook (ID 110/095)		$240,000
Dams		
Lonsinger Dam at unnamed stream (71.29)	Flooding – Located in Past Flooding Area	The Dam Bureau at NHDES has looked into assessing values for state-owned dams with marginal success. They considered bond ratings, market value, and construction costs. They also developed a formula that calculated the cubic feet of water impounded as a monetary value. Because dams serve different purposes (recreational, hydro-power), assessed values are hard to estimate and cannot be determined.
Total		$14,401,000

*Assessed values as of April 1, 2013. The Town's next update of property assessments is scheduled for April 1, 2018.
**Data provided by UNH Campus Planning. The current assessed value for the lift station is $900,000, but UNH plans to remove this lift station and replace it with gravity flow piping at a cost of $300,000. While there is currently no timeline for replacement, total loss of the lift station would accelerate that project rather than replacing the lift station at full assessed value.
***The approximate assessed value for the bridges was calculated by multiplying $1,000.00 per square foot of bridge. This estimate was provided by the Bridge Design Bureau at NHDOT and includes all cost (engineering, consulting and in-house design, construction, etc.) to build a new bridge. The square footage was calculated by multiplying the length of the bridge by 20 feet.

In Durham, nine CF/KR, 13 bridges, and one dam were identified during the risk assessment as being located in potentially hazardous areas. The potential total loss of CF/KR and municipal bridges in at-risk locations is estimated at $14,401,000.

Buildings and Utilities

It is difficult to ascertain the amount of damage that could be caused by a natural or man-made hazard because the damage will depend on the hazard's extent and severity, making each hazard event somewhat unique. The assumption used here

when calculating the damage to property is that a hazard may result in low (1% of structures damaged), medium (5% of structures damaged), or high (10% of structures damaged) economic loss depending on the nature of the hazard. Table 3.5 displays total assessed value and low, medium, and high economic loss.

Table 3.6

Local Assessed Valuation (2015)				
	Total Assessed Value (2015)	Economic Loss		
		Low 1% Damage	Medium 5% Damage	High 10% Damage
Buildings				
Residential	$452,391,100	$4,523,911	$22,619,555	$45,239,110
Manufactured Housing	$120,800	$1,208	$6,040	$12,080
Commercial Industrial	$171,519,490	$1,715,195	$8,575,975	$17,151,949
Total Buildings	**$624,031,390**	**$6,240,314**	**$31,201,570**	**$62,403,139**
Utilities				
Public Water*	$59,426,051*	$594,261*	$2,971,303*	$5,942,605*
Electric	$18,008,300	$180,083	$900,415	$1,800,830
Other	$8,029,100	$80,291	$401,455	$802,910
Total Utilities	**$85,463,451**	**$854,635**	**$4,273,173**	**$8,546,345**
Net Valuation Buildings and Utilities	**$709,494,841**	**$7,094,949**	**$35,474,743**	**$70,949,484**

Source: NH Department of Revenue Administration. 2016 Annual Report. Assessed value does not include value of land or local exemptions. (http://www.revenue.nh.gov/publications/reports/documents/dra2016annualreport.pdf)

*The Town of Durham and University of New Hampshire share a public water system, the value of which was not included in the Department of Revenue Administration annual report. The values used in this table were supplied by the Hazard Mitigation Committee.

The total local assessed value included in this analysis is $709,494,841, including $624,031,390 for buildings and $85,463,451 for utilities. Based on this assumption, the potential loss from any of the identified hazards under a low, medium, and high damage scenario of buildings and utilities would range from **$0 to $7,094,949 (low)** or **$7,094,949 to $35,474,743 (moderate)** or **$35,474,743 to $70,949,484 (high)** based on the 2015 Durham Town valuation.

In order to stay consistent, the Committee made the decision to use the results derived from the hazard vulnerability assessment tool (Table 5.1). There was consensus that the overall threat rankings (severity x probability) associated with each hazard were an equal indicator to the percentage of damage and were therefore used to determine the potential loss.

Human loss of life was not included in the potential loss estimates, but could be expected to occur, depending on the severity and type of the hazard.

Chapter 4: National Flood Insurance Program

Communities that participate in the NFIP have adopted and enforce community floodplain regulations. One of the community's requirements is to require and obtain certain elevation data for all new and substantially improved structures located in a special flood hazard area. Community permitting officials must review this elevation data to ensure floodplain development complies with the regulations.[7]

Durham National Flood Insurance Program (NFIP) Status & Compliance

Durham has been a member of the National Flood Insurance Program (NFIP) since October 1, 1975. The Town does have significant portions of land in the 100-year floodplain; along Bunker Creek, Johnson Creek, Beards Creek, Littlehole Creek, Crommet Creek, Woodman Brook, La Roche Brook, Folletts Brook, and parts of the Oyster River along the Durham and Lee border.

Durham's Flood Hazard Overlay District is Article XV of the Town's Zoning Ordinance, which was last updated February 20, 2017.[8] The Flood Hazard Overlay District applies to all lands designated as special flood hazard areas by FEMA in its Flood Insurance Study for the County of Strafford, N.H." dated September 30, 2015, together with the following associated Flood Insurance Rate Map panel numbers for Durham: 33017C0314E, 33017C0315E, 33017C0318E, 33017C0320E, 33017C0340E, 33017C0376E, 33017C0377E, 33017C0378E, 33017C0379E, 33017C0381E, 33017C0383E, 33017C0385E, 33017C0405E, dated September 30, 2015. The Ordinance requires, in general, that all proposed development in any special flood hazard area requires a building permit and that proposed development be designed to ensure that it is reasonably safe from flooding. The Code Enforcement Officer maintains certificates of flood proofing and the as-built elevation, in relation to mean sea level, of the lowest floor, including the basement, of all new or substantially improved structures and a record of if the structure has been flood proofed. No structures have been flood-proofed in the current Code Enforcement Officer's tenure; the town primarily ensures safety from flooding through the use of setbacks to prevent development in floodplains and flood hazard areas.

The Town has worked with elected officials and FEMA to correct existing compliance issues. Durham has continued communication with FEMA to discuss NFIP compliance issues and continues to monitor designated flood areas throughout the town. The Town continues to evaluate their flood hazard overlay district and will look to improve floodplain management in the community. The Town is scheduled to undergo and complete an update to the Special Flood Hazard Overlay District in the fall of 2017 to incorporate flood hazards associated with sea level rise impacts in climate change into the ordinance.

As reported in FEMA's Biennial Flood Report (last submitted on 05/28/2009), Durham is listed as only having 70 structures.[9] According to information from the FEMA Community Overview provided by NH OSI Assistant Planner and State Floodplain Program Assistant Coordinator Kellie Walsh (email dated 3/6/17), there are a total of 28 policies in force in Durham. Twenty-four policies are single family policies and four are non-residential. A total of 12 losses have been paid. Seven policies are located in A 01-30 & AE Zones, four are located in B,C & Z Zone (standard), and 17 are located in B,C & X Zone (preferred). Policies in the B, C &Z Zones are located outside of the Special Flood Hazard Area and 100-year floodplain. There are two repetitive loss structures, both of which were residential. Table 4.1 displays the types of policies by zone.

[7] https://www.nh.gov/oep/planning/programs/fmp/documents/fs-2-elevation-certificate.pdf
[8] https://www.ci.durham.nh.us/sites/default/files/fileattachments/planning_and_zoning/page/21491/article_xv.pdf
[9] FEMA Biennial Flood Report; from September 2010 email, Jennifer Gilbert, NH Office of Strategic Initiatives

Table 4.1 Durham Insurance Zone Policies (Source: FEMA Community Information System)

Zone	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
A01-30 & AE Zones	7	$9,404	$1,116,000	2	$127,717.38	$4,089.99
A Zones	0	$0	$0	3	$44,100.52	$2,300.00
B, C & X Zone – Standard	4	$3,105	$1,390,000	0	$0.00	$0.00
B, C & X Zone – Preferred	17	$5,956	$4,634,000	5	$36,697.25	$3,000.00
Total	**28**	**$18,465**	**$7,140,000**	**10**	**$208,514.00**	**$9,389.00**

As necessary, Durham continues to work with elected officials and FEMA to correct existing compliance issues. Durham's FEMA CAV (Community Assistance Visit) from August 23, 2012 identified minor problems with the Town's floodplain management regulations: *The floodplain development ordinance (Article XV Flood Hazard Overlay District) is generally compliant with NFIP requirements but there are several recommended additions and modifications. The subdivision and site plan regulations generally contain the language required by NFIP but need several minor corrections as well.* Recent flooding that had occurred prior to the CAV included flooding on NH Rt 108 south of Laurel Road (Oyster and Lamprey Rivers), along Newmarket Road (Lamprey River), and Packers Falls Road near Wiswall Road (Lamprey River). Several issues were included in the 2012 CAV:

- The Town's building permit does not include the question about whether the property is in a floodplain
- The Town does not have a repetitive loss of cumulative substantial damage provision in the zoning ordinance, so repetitive loss properties are not eligible for Increased Cost of Compliance coverage.
- There is one submit-for-rate structure. OSI staff discussed substantial improvement requirements and emphasized that the Town monitor the structure for any improvements.

The Community Action needed based on the CAV included amending the Subdivision and Site Plan Review Regulations and the Zoning Ordinance. These actions have not yet been completed. The town does continue to distribute NFIP brochures through the building department.

Chapter 5: Hazards & Mitigation Strategies

Overview

This section describes the location and extent of hazards that could impact the Town of Durham, presents past hazard events in the Town or elsewhere in New Hampshire, and discusses their rank order placement. The Multi-Hazard Mitigation Planning Committee investigated past and potential hazards using a variety of sources and techniques, including but not necessarily limited to interviewing Town historians and other citizens; researching historical records archived at the Town Library; scanning old newspapers; reading published Town histories; consulting various hazard experts; and extracting data from the NH Hazard Mitigation Plan and other state and federal databases. Past and potential hazards were mapped where spatial data was available.

Rating Probability, Severity, and Overall Risk of Future Disasters

The nature of each hazard type and the quality and availability of corresponding data made the evaluation of hazard potential difficult. The Multi-Hazard Planning Committee considered what data was at hand and used its collective experience to formulate statements of impact or potential. Each hazard type was rated using a hazard vulnerability assessment tool (refer to Table 2.3). This tool estimates the probability of occurrence, severity, and overall risk of an event using a projected number system answering questions, which answer High (3), Moderate (2), and Low (1). A zero (0) score meant that there is no likelihood the hazard would impact the Town in the next 25 years. The ranges established for the average to determine severity were:

- **High** = >3
- **Moderate** = 2
- **Low** = 1 or below

The overall risk is a numeric indication developed by multiplying the total numbers of the probability and the severity.

Probability of Occurrence

Probability is based on a limited objective appraisal of a hazard's probability using information provided by relevant sources, observations and trends. The Planning Committee discussed and rated probability of each hazard.

- **High:** There is a very strong likelihood (67-100% chance) that Durham will experience a hazardous event within the next 25 years. Score = 3
- **Moderate:** There is moderate likelihood (34-66% chance) that Durham will experience a hazardous event within the next 25 years. Score = 2
- **Low:** There is little likelihood (0-33% chance) that Durham will experience a hazardous event within the next 25 years. Score = 1

Severity

Severity is an estimate generally based on a hazard's impact human, property and business. The Planning Committee discussed the severity of each hazard. The severity was calculated by the average of human, property and business.

- **High:** The total population, property, commerce, infrastructure and services of the Town are uniformly exposed to the effects of a hazard of potentially great magnitude. In a worst case scenario there could be a disaster of major to catastrophic proportions. Score = 3
- **Moderate:** The total population, property, commerce, infrastructure and services of the Town are exposed to the effects of a hazard of moderate influence; or the total population, property, commerce, infrastructure and services of the community is exposed to the effects of a hazard, but not all to the same degree; or an important segment of population, property, commerce, infrastructure or service is exposed to the effects of a hazard. In a worst case scenario there could be a disaster of moderate to major, though not catastrophic, proportions. Score = 2
- **Low:** A limited area or segment of population, property, commerce, infrastructure or service is exposed to the effects of a hazard. In a worst case scenario there could be a disaster of minor to moderate proportions. Score = 1

Overall Risk

The risk number is one, which can help the Town weigh the hazards against one another to determine which hazard is most detrimental. This is calculated by multiplying the ***Probability of Occurrence*** score by the average of the ***Severity*** score (human, property, and business impacts).

- **High:** There is a great risk of this hazard in Durham. Score = 4 or greater
- **Moderate:** There is moderate risk of this hazard in Durham. Score = 2-3
- **Low:** There is little risk of this hazard in Durham. Score = 1 or less

Hazard Ratings in Durham, NH

The Committee determined that the overall risk associated with the identified hazards is distributed as follows:

- 6 hazards rated as having a **High** overall risk in Durham:
    - Inland Flooding (riverine flooding & dam breach)
    - Severe Winter Weather
    - Public Health Threats
    - Extended power failure
    - Cyber Threats
    - Large Crowd Events

- 5 hazards rated as having a **Moderate** overall risk in Durham:
    - Drought
    - Severe Thunderstorms & Lightning
    - Wildfire
    - Hazardous Material
    - Coastal Flooding (storm surge & sea level rise)

- 4 hazards rated as having a **Low** overall risk in Durham:
    - Hurricanes & Tropical Storms
    - Tornado & Downburst
    - Landslide/Earthquake
    - Extreme heat

Table 5.1 is the Town's vulnerability assessment tool, which provides more information on the multi-hazard threat analysis that was completed during a brainstorming session with the Planning Committee.

Table 5.2 documents all presidentially declared disasters that have impacted the Town of Durham from 1990 through the preparation of this plan in 2017, including documentation of the local impacts of each event.

Table 5.3 documents all declarations of a state of emergency that have impacted the Town of Durham from 1990 through the preparation of this plan in 2017, including documentation of the local impacts of each event.

Hazard Vulnerability Table

Table 5.1: Hazard Vulnerability Assessment Tool - Town of Durham

Hazard Event	Human Impact	Property Impact	Business Impact	Severity	Probability	Overall Threat
Impact Rankings: 0 – N/a 1-Low 2-Moderate 3-High	*Probability of death or injury*	*Physical losses and damages*	*Interruption of service*	*Average of human, property, and business impacts*	*Likelihood this will occur within 25 years*	*(Severity x probability) (Rounded to the nearest whole number)* *Low = 0-1* *Moderate = 2-3* *High = 4<*
Inland Flooding (River & Dam Breach)	1	2	1	1.33	3	4
Severe Winter Weather (Ice & Snow)	1	1	2	1.33	3	4
Severe Thunderstorms & Lightning	1	1	1	1	2	2
Hurricanes & Tropical Storms	1	1	1	1	1	1
Tornado & Downburst	1	1	1	1	1	1
Drought	1	1	1	1	2	1
Landslide & Earthquake	1	1	1	1	1	1
Public Health Threats	2	1	1	1.33	3	4
Hazardous Material Threats	3	2	2	2.33	1	2
Extreme Heat	1	1	1	1	1	1
Extended Power Failure	1	1	2	1.33	3	4
Wildfire	1	1	1	1	2	2
Coastal Flooding (Storm Surge & Sea Level Rise)	1	1	1	1	2	2
Cyber Security	1	3	3	2.33	3	7
Large Crowd Events	3	3	3	3	3	9

Declared Disasters and Emergency Declarations

Table 5.2: Presidentially Declared Disasters (DR) 1990- July 2017 impacting the Town of Durham

Date Declared	Event	Date of Event	Source	Program	Amount (Statewide)	Remarks
September 9, 1991	Hurricane Bob	August 18-20, 1991	FEMA 917-DR	PA	$2,293,449	Extended power outage.
October 29, 1996	Severe Storms & Flooding	Oct 20-23, 1996	FEMA 1144-DR	PA	$2,341,273	Heavy rains.
January 15, 1998	Ice Storm	January 7-35, 1998	FEMA 1199-DR	PA/IA	$12,446,202	Major tree damage, electric power interrupted for many days. Schools were closed.
May 25, 2006	Severe Storm & Flooding	May 12-23, 2006	FEMA 1643-DR	PA/IA	$17,691,586	Roads were flooded and damaged which resulted in many closures. The two roads that most affected daily travel of residents were Bennett Road and Longmarsh Road; these residents were either stranded or utilized detours. There were 120 residents stranded in the Bennett Rd Cold Spring Road area, this included of 52 grade school children who may or may not have access to school on these days. Both Bennett and Longmarsh Road stayed closed to travel longer than all other roads affected in Durham.
April 27, 2007	Severe Storm & Flooding	April 15-23, 2007	FEMA 1695-DR	PA/IA	$26,826,780	During this event, which lasted approximately 6 days, many roads in Durham were closed or damaged by flooding. The roads that most affected residents and travel were Bennett Road and Longmarsh Road. These closures affect travel times for residents and due to various detours may increase the number of people traveling on these roads to around 17,000. We are assuming using previous (2006) data that approximately 120 residents were stranded in the Bennett Road in the Cold Springs area
August 11, 2008	Severe Storms, Tornado, & Flooding	July 24, 2008	FEMA 1782-DR	PA	$3,673,097	Very little impact. A few trees down.

January 2, 2009	Severe Winter Storm	December 11-23, 2008	FEMA 1812-DR	DFA/PA	$14,898,663	Durham received over 3/4 inch of ice, multiple hours of rainfall/freezing rain and snow during the December ice storm. Durham had to close fourteen roads, some multiple times, for several days due to falling tree limbs and downed utility wires, which created public safety issues during this disaster.
March 29, 2010	Severe Winter Storm	February 23-March 3, 2010	FEMA 1892-DR	PA	$6,841,093	Flooding started on March 14, 2010 and continued for a number of days. The Hamel Brook rose substantially resulting in the flooding and closure of Route 108, parts of Bennett Road and Longmarsh Road. Power outages in some areas. Property damage. Schools were closed for a few days.
September 3, 2011	Tropical Storm Irene	August 26 – Sept 6, 2011	FEMA 4026-DR	PA	$17,684,244	The primary impact in NH from the storm was damage to roads and bridges. Local impacts included tree damage, moderate flooding in low-lying areas, and minor infrastructure damage. No major damage.
March 19, 2013	Severe Snow and Blizzard	February 9-11, 2013	FEMA 4105-DR	PA	$6,153,471	Governor requested snow assistance. The President's declaration made snow assistance available for a period of 48 hours for Strafford County and 7 other counties. Statewide Public Assistance included $5,824,040.89 for Categories A and B work and $298,796.60 for Categories C-G work. Per capita impact in Strafford County was $4.14. Town received 48-hour assistance that was used for cleanup, snow removal, and minor infrastructure repairs.
March 25, 2015	Severe Snow & Snowstorm	January 26-29, 2015	FEMA 4209-DR	PA	$4,799,048	The primary impact was emergency protective measures. The per capita impact in Strafford County was $4.16. Town received 48-hour assistance that was used for cleanup, snow removal, and minor infrastructure repairs.
11 declarations totaling approximately $115,648,906						
Program Key: **PA**: Public Assistance, **IA**: Individual Assistance, **DFA**: Direct Federal Assistance						

Table 5.3: Emergency Declaration (EM) 1990-March July 2017 impacting the Town of Durham

Date Declared	Event	Date of Event	Source	Program	Amount (Statewide)	Remarks
March 16, 1993	Heavy Snow	March 13-17, 1993	FEMA 3101-EM	PA	$832,396	Snow removal.
March 28, 2001	Snow Emergency	March 5-7, 2001	FEMA 3166-EM	PA	$3,433,252	
March 11, 2003	Snow Emergency	February 17-18, 2003	FEMA 3177-EM	PA	$2,288,671	
March 30, 2005	Snow Emergency	January 22-23, 2005	FEMA 3207-EM	PA	$3,611,491	Snow removal. School closures. Public Assistance for 48 hours. Minor Impact.
December 13, 2008	Severe Winter Storm	December 11-23, 2008	FEMA 3297-EM	DFA/PA	$900,000	Snow removal. School closures. Public Assistance for 48 hours. Minor Impact.
November 1, 2011	Severe Winter Storm	October 29-30, 2011	FEMA 3344-EM	PA	Data not available	Statewide Category B Public Assistance. Town experienced widespread power outages but minimal lasting impacts.
October 30, 2012	Hurricane Sandy	October 26-31, 2012	FEMA 3360-EM	PA	$643,660	Minor local impact. Strong Storm surge and heavy rains across New England, NYC and New Jersey caused significant damage resulting in an emergency declaration EM-3360 for Direct Federal Assistance and Category B (Emergency Protective Measures). Town experienced minimal local impacts related to heavy rains.
7 emergency declarations totaling approximately $11,709,470 **Program Key: PA: Public Assistance, DFA: Direct Federal Assistance**						

Table 5.4 Hazard Overview

Hazard Type	Flooding
Location/Extent	Town-wide; Especially areas within the 100 year floodplain; other areas identified by committee
Vulnerability	
Severity	1.33
Probability	3
Overall Threat	4
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

Riverine flooding is the most common natural disaster to impact New Hampshire. Riverine flooding occurs when surface water runoff introduced into streams and rivers exceeds the capacity of the natural or constructed channels to accommodate the flow. As a result, water overflows the river banks and spills out into adjacent low lying areas.[10] Floods are most likely to occur in the spring due to the increase in rainfall and the melting of snow; however, floods can occur at any time of the year because of heavy rains, hurricane, or a Nor'easter.

New Hampshire's climate ranges from moderate coastal to severe continental, with annual precipitation ranging from about 35 inches in the Connecticut and Merrimack River valleys, to about 90 inches on top of Mount Washington. Localized street flooding occasionally results from severe thundershowers, or over larger areas, from more general rain such as tropical cyclones and coastal "nor'easters." More general and disastrous floods are rare, but some occur in the spring from large rainfall quantities combined with warm, humid winds that rapidly release water from the snowpack.

Causes of flooding that could potentially affect Durham include:

- 100-year rainstorm.
- Severe tropical storm (hurricane or tropical storm) that can bring torrential rainfall in excess of that from a 500-year storm.
- Rapid snow pack melt in spring can be a significant potential flooding source, given the northern, relatively cold location and climate of Durham and has occurred multiple times in the past.
- River ice jams, which could occur although there are no records of ice jams in Durham recorded in the USACE Ice Jam Database as of May 2017.
- Erosion and mudslide in steep slope areas or riverbanks resulting from heavy rainfall that can alter topology
- Dam breach or failure.

The "100-year flood" Term:

The "100-year flood" is a term often used to describe a flood that has a 1% chance of occurring in any year. But the phrase is misleading, and often causes people to believe these floods happen every 100 years on average. The truth is, these floods can happen quite close together, or not for long stretches of time, but the risk of such a flood remains constant from year to year. The 100-year-flood term was originated to delineate areas on a map to determine what properties are subject to the National Flood Insurance Program. Properties within the 100-year-floodplain, as defined by the Federal Emergency Management Agency, have special requirements and mortgage holders will require owners to carry flood insurance on these properties.

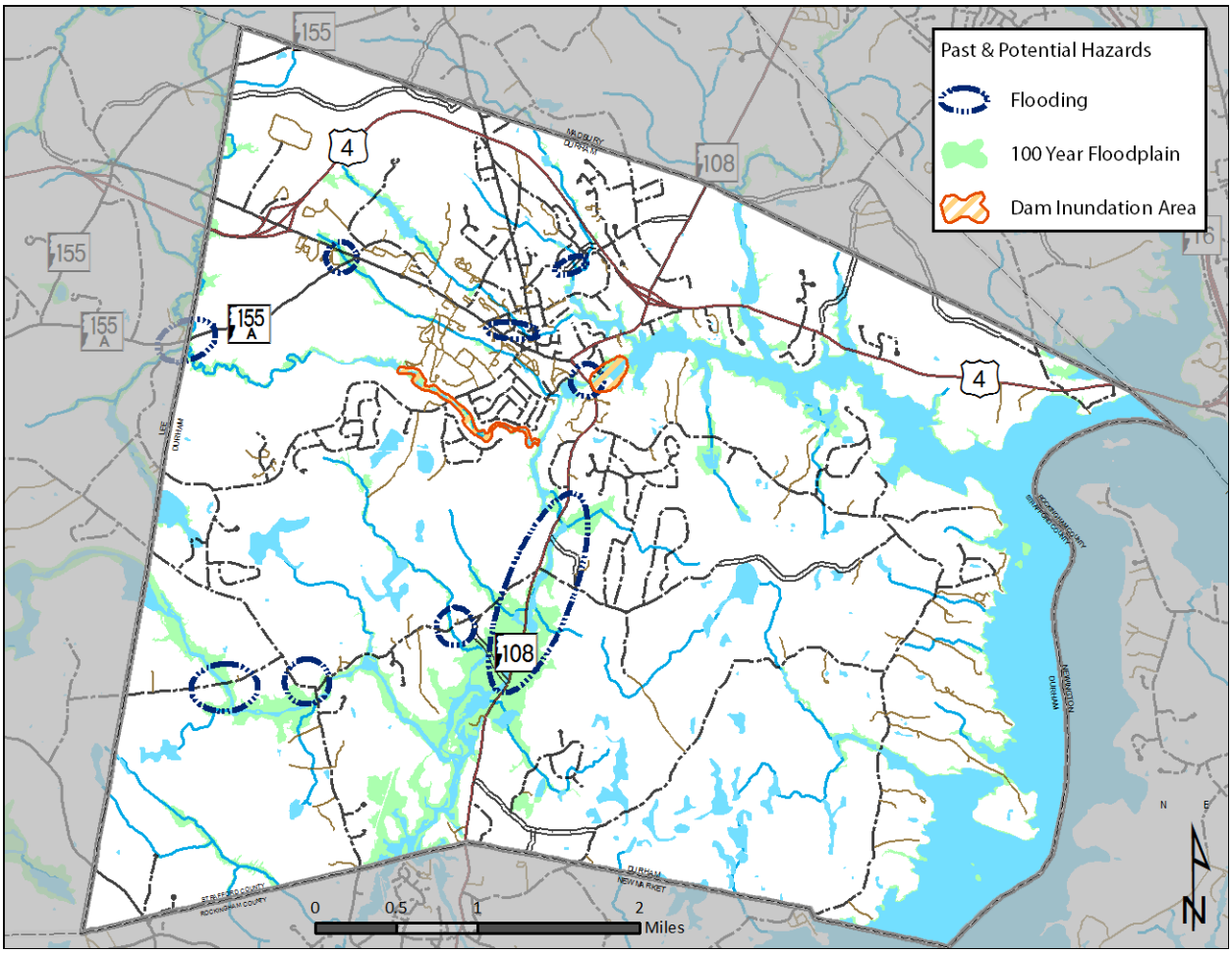
[Source: The Nurture Nature Center: Focus on Floods]

[10] FEMA Training Chapter 2 Types of Floods and Floodplains (https://training.fema.gov/hiedu/docs/fmc/chapter%202%20-%20types%20of%20floods%20and%20floodplains.pdf)

Extent of the Hazard

Based on extent of the floodplain, Durham has significant flooding potential along the Lamprey River and its tributaries in the southeast of town and along the Oyster River and its tributaries in the northwest of town above the Mill Pond Dam. Chronic road flooding occurs in one location along State Rte. 108 in south central Durham where the road runs closely by the Lamprey River. A significant amount of coastal floodplain also occurs in Durham along its Great Bay/Oyster River Estuary shoreline. Overall, Durham has approximately 7.2% (1,021.8 ac) of its land area in 100-yr. floodplain. In general, although 100-yr. floodplain is reasonably extensive, Durham has seen relatively little development in floodplain areas. One exception is in the case of the coastal floodplain. Many high-value private residences have been built in this shoreline area and could be susceptible to coastal flooding. The Durham shore is also susceptible to storm surge from hurricanes, which technically have roughly the same probability of occurrence as the 100-yr. storm (see map 5.1).

Map 5.1 Past & Potential Inland Flood Hazard Areas



Although flooding of the full extent of this floodplain by definition would require a 100-year storm, smaller storms with a higher annual probability of occurrence could still flood significant portions of that floodplain. Some structures that could be impacted by a 100-year storm could also be affected by smaller, more frequent flooding. It is likely that the 100-year floodplain will expand in area when flood maps are updated due to better mapping technology and current precipitation data.

Dams

The potential for catastrophic flooding from dam breach or failure exists in Durham. The Oyster Reservoir Dam (# 071.07), the Mill Pond Dam (# 071.03), the Wiswall Dam (#071.04), the Durham Reservoir Dam (# 071.01), and the Beard's Creek Dam (# 071.08) are all Class B, Significant Hazard Dams. The dam inundation areas for the Oyster Reservoir and Mill Pond Dams have been delineated and digitized (breach during 100-yr. storm). In both cases, the inundation area is not extensive. Inundation information for the other three dams were not available. On visual inspection of digital orthophotography, several high-value structures on the University of New Hampshire (UNH) campus, for example the Whittemore Center and the Alumni Center, could be substantially impacted by a breach of the Durham Reservoir Dam, but nothing specific can be said for sure without inundation data. All five dams, however, have never breached, have been continually inspected, and are in excellent condition. The probability of this particular flooding hazard occurring is quite small. UNH representatives have previously expressed an interest in evaluations of both the Durham Reservoir and Oyster Reservoirs Dams toward possible downgrading of their Class B hazard rating.

Table 5.5 Dams in Durham by Classification

Dam Classification	Classification Definition	Number of Dams in Durham	Inspection Interval (Years)
High	Dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life.	1	2
Significant	Dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in no probable loss of lives but major economic loss to structures or property.	3	4
Low	Dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in no possible loss of life and low economic loss to structures/property.	1	6
Non-Menace	Dam that is not a menace because it is in a location and of a size that failure of misoperation of the dam would not result in probable loss of life or loss to property.	20	6

Past Events and Impacts

The most notable recent flood events were the "Mother's Day" floods of May 2006 and spring floods in April 2007. In both cases, severe rain and flooding damaged roads and caused road closures. Bennett Road and Longmarsh Road saw significant damage and were the two roads closed for the longest in both storms. Approximately 120 people were stranded due to the closure of Bennett Road in 2006. While no official figure exists for people stranded in the 2007 storm, the similarity of damage and road closures implies that a similar number of people were affected. A bridge on Wiswall Road partially collapsed during the May 2006 floods.

Potential Future Impacts on Community

Both Longmarsh Road and Bennett Road intersect Newmarket Road/Route 108 in a low lying area known locally as "the flats". While the floods of 2006-2007 are the largest scale flooding to impact the area in recent years, flooding in this area is common in heavy rains due to low elevation and proximity to the Lamprey River, and a large-scale storm event would likely cause road closures that would last for multiple days. The floods of 2006 and 2007 were estimated to be 100-year events, suggesting that there is approximately a 1% chance that equally disruptive flooding will occur in a given year.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to inland flooding is $35,474,743 to $70,949,484.

Table 5.6 Hazard Overview

Hazard Type	Severe Winter Weather
Location/Extent	Town-wide
Vulnerability	
Severity	1.33
Probability	3
Overall Threat	4
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

Winter snow and ice events are common in New Hampshire. The National Climatic Data Center (NCDC) Storm Events database reports 37 heavy snow events, 2 blizzards, 1 ice storm, and 6 winter storms (nor'easters) among large winter weather events impacting Strafford County from January, 1 2008 to December 31, 2016.[11] Heavy snow typically brings significant snow removal costs along with delays in transportation schedules. Wet snow can result in major infrastructure damage from heavy snow loads and has been the cause of human harm during long periods of shoveling, including back injuries and in some cases heart attacks to older individuals. The most severe damage, though, often comes from ice storms and winter nor'easters.

- The State's Multi-Hazard Mitigation Plan Update 2013 identifies four types of winter storms:
- *Heavy snowstorms:* A storm that deposits four or more inches of snow (or 10 cm) in a twelve-hour period
- *Blizzards:* A violent snowstorm with winds blowing at a minimum speed of 35 miles (56 kilometers) per hour and visibility of less than one-quarter mile (400 meters) for three hours
- *Nor'easter:* A large weather system traveling from south to north, passing along the coast. As the storm's intensity increases, the resulting counterclockwise winds which impact the coast and inland areas in a Northeasterly direction. Winds from a Nor'easter can meet or exceed hurricane force winds.
- *Ice Storms:* An event that occurs when a mass of warm, moist air collides with a mass of cold, arctic air. The less dense warm air will rise and the moisture may precipitate out in the form of rain. When this rain falls through the colder, denser air and comes in contact with cold surfaces, ice will form and may continue to form until the ice is as thick as several inches.

Extent of the Hazard

Snow and ice storms are a town-wide hazard.

Sperry-Piltz Ice Accumulation Index

The Sperry–Piltz Ice Accumulation Index, or SPIA Index, is a forward-looking, ice accumulation and ice damage prediction index that uses an algorithm of researched parameters that, when combined with National Weather Service forecast data, predicts the projected footprint, total ice accumulation, and resulting potential damage from approaching ice storms. It is a tool to be used for risk management and/or winter weather preparedness.

[11] NOAA Storm Event Database (https://www.ncdc.noaa.gov/stormevents/)

Figure 5.1 Sperry-Piltz Ice Accumulation Index

The Sperry-Piltz Ice Accumulation Index, or "SPIA Index" – Copyright, February, 2009

ICE DAMAGE INDEX	* AVERAGE NWS ICE AMOUNT (in inches) *Revised-October, 2011	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
0	< 0.25	< 15	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	0.10 – 0.25	15 - 25	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
	0.25 – 0.50	< 15	
2	0.10 – 0.25	25 - 35	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
	0.25 – 0.50	15 - 25	
	0.50 – 0.75	< 15	
3	0.10 – 0.25	> = 35	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
	0.25 – 0.50	25 - 35	
	0.50 – 0.75	15 - 25	
	0.75 – 1.00	< 15	
4	0.25 – 0.50	> = 35	Prolonged & widespread utility interruptions with extensive damage to main distribution feeder lines & some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
	0.50 – 0.75	25 - 35	
	0.75 – 1.00	15 - 25	
	1.00 – 1.50	< 15	
5	0.50 – 0.75	> = 35	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.
	0.75 – 1.00	> = 25	
	1.00 – 1.50	> = 15	
	> 1.50	Any	

(Categories of damage are based upon combinations of precipitation totals, temperatures and wind speeds/directions.)

Past Events and Impacts

Three events of those listed in the NCDC database are of particular note for their severity:

The Ice Storm of 2008 (December 11th – 12th) was a major winter storm that brought a mixture of snow, sleet, and freezing rain. The greatest impact in the state was in southern and central New Hampshire where a significant ice storm occurred. Following the ice storm, recovery and restoration efforts were negatively impacted by additional winter weather events that passed through the state. The freezing rain and sleet ranged from 1 to 3 inches, ice accretion to trees and wires in these areas generally ranged from about a half inch to about an inch. The weight of the ice caused branches to snap, and trees to either snap or uproot, and brought down power lines and poles across the region. About 400 thousand utility customers lost power during the event, with some customers without power for two weeks. Property damage across northern, central and southeastern NH was estimated at over $5 million. Durham experienced widespread power outages as a result of the storm, but had minimal lasting impacts.

The Blizzard of 2013 – NEMO (February 8th-9th) was an area of low pressure developed rapidly off the Carolina coast late on the 7th and early on the 8th. The storm moved very slowly northeast during the 8th and 9th as it continued to intensify. By the morning of the 10th, the storm was located just to the east of Nova Scotia. The storm brought heavy snow, high winds, and blizzard conditions to the southeastern part of the state. Snowfall amounts were generally 18 inches or more in the southeast where blizzard conditions caused considerable blowing and drifting snow. In western and northern sections, snowfall amounts were in the 4 to 18 inch range. Southeastern New Hampshire had blizzard conditions for about 3 to 10 hours.

According to the NOAA Northeast Snowfall Impact Scale (NESIS), which ranks storms that have large areas of 10 inch snowfall accumulations or greater based on a function of the area affected, the amount of snow, and the number of

people living in the path of the storm, Nemo was ranked as a 'major' event (http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis).

The NCDC Regional Snowfall Index for the stations near Durham reported between 18 and 24 inches of snow (Rochester and Nottingham) and 12 to 18 inches (between Epsom and Northwood) from February 8-February 10, 2013. According to the NH Union Leader, wind gusts of over 30-miles-per hour were expected to occur with the storm; however, the NH Electric Co-op reported only minor power outages.[12] Local impacts primarily consisted of downed tree limbs that caused damage to power lines and other infrastructure. Durham received 48-hour assistance that was used for cleanup, snow removal, and minor infrastructure repairs.

The Blizzard of 2015 – JUNO (January 26th – 28th) was area of low pressure developed off the Delmarva peninsula on Monday, January 26th, and intensified rapidly as it moved slowly northward through the 27th. Snow spread northward across the region Monday night and became heavy on Tuesday, the 27th. Winds became strong during the day Tuesday leading to blizzard conditions at times along and inland from the coast. The snow persisted into Tuesday night in many areas with blowing and drifting snow. Snowfall amounts ranged from 10 to more than 30 inches across much of the southeastern part of the state.

Juno was ranked on the NESIS as a 'major' event passed on the area affected, the amount of snow, and the number of people living in the path of the storm. Local impacts primarily consisted of downed tree limbs that caused damage to power lines and other infrastructure. Durham received 48-hour assistance that was used for cleanup, snow removal, and minor infrastructure repairs.

Other, less recent events were also damaging. The nor'easter of December 7, 1996 was especially damaging to power systems and is described in the NCDC database as "the most extensive and costliest weather related power outage in the state's history," at least until 1996 when that database entry was made. The 1998 ice storm probably surpassed this storm in power systems impact. This storm is thought to have been of the same magnitude as the one that occurred in the region in 1929, indicating a return period of approximately 70 years (CRREL 1998).

Extended power failure often occurs in conjunction with severe winter weather and has serious implications for lighting and visibility, heating, water supply, and communication during these events.

Potential Future Impacts on Community

Durham will continue to receive impacts from severe, regional winter weather events. Due to its heavily forested nature, the Town is most highly exposed in terms of damage to forest resources and the secondary impacts of those damages. Downed trees and extra plowing are likely the main concern associated with this hazard.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to severe winter weather is $35,474,743 to $70,949,484.

[12] New Hampshire Union Leader. February 9, 2013. http://www.unionleader.com/apps/pbcs.dll/article?AID=/20130209/NEWS1101/130209041/0/OPINION02

Table 5.7 Hazard Overview

Hazard Type	Extreme Heat
Location/Extent	Town-wide
Vulnerability	
Severity	1
Probability	1
Overall Threat	1
Potential Loss	$0 to $7,094,949 (low)

Description of the Hazard

Extreme temperatures can be describes as heat waves. A *heat wave* is a prolonged period of excessively hot and sometimes also humid weather relative to normal climate patterns of a certain region. Heat kills by pushing the human body beyond its limits. In extreme heat and high humidity, evaporation is slowed and the body must work extra hard to maintain a normal temperature. Most heat disorders occur because the victim has been overexposed to heat or has over-exercised for his or her age and physical condition. Older adults, young children, and those who are sick or overweight are more likely to succumb to extreme heat. Conditions that can induce heat-related illnesses include stagnant atmospheric conditions and poor air quality. Consequently, people living in urban areas may be at greater risk from the effects of a prolonged heat wave than those living in rural areas. Also, asphalt and concrete store heat longer and gradually release heat at night, which can produce higher nighttime temperatures known as the "urban heat island effect."[13]

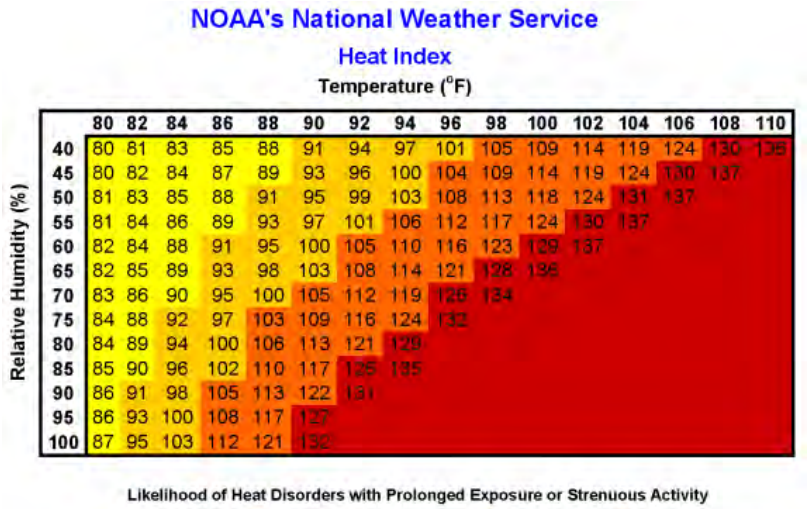


Figure 5.2 National Weather Service Heat Index Scale

Extent of the Hazard

Extreme heat events can be described as periods with high temperatures of 90°F or above. The graph above displays the likelihood of heat disorders with prolonged exposure or strenuous activity.

Extreme heat is a town-wide hazard.

Past Impacts and Events

According to a 2014 study of climate change by Climate Solutions New England, Climate Change in Southern New Hampshire, from 1970 to 1999, southern New Hampshire experienced an average of seven days per year above 90°F each year. This is projected to increase to 22 days per year under a low emissions scenario to nearly 50 days per year under a high emissions scenario. Between 1980 and 2009, an average of one day per year reached 95°F in southern New Hampshire. By the end of the century, the number of days per year over 95°F is expected to increase as much as six to 22

[13] International Federation of Red Cross and Red Crescent Societies. Climatological hazards: extreme temperatures. http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/definition-of-hazard/extreme-temperatures/

days per year. Additionally, the average daytime maximum temperature on the hottest day is expected to increase to as much as 98°F to 102°F (depending on the emissions scenario), compared to the historical average of 93°F.[14] Between 1960 and 2012, there was an average of 8.3 days per year (or 0.8 days/decade) greater than 90°F recorded in Durham. During this time the hottest day of the year averaged 95.0°F.[15] The Town of Durham does not have a record of severe local impacts of extreme heat.

Potential Future Impacts on Community

Annual average temperatures may increase on average by 3-5°F by 2050 and 4-8°F by 2100.[16]

Estimated Loss Potential

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to extreme heat is $0 to $7,094,949.

Extended Power Outages

Table 5.8 Hazard Overview

Hazard Type	Extended Power Outages
Location/Extent	Town-wide
Vulnerability	
Severity	1.33
Probability	3
Overall Threat	4
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

When discussing extended power failure in this plan, it is referring to power failure that can last for a period of days or weeks. Many things can cause power failure: downed power lines (due to storm, wind, accident, etc.); failure of public utilities to operate or failure of the national grid.

Extent of the Hazard

Extended power failure can negatively impact lighting, heating, water supply, and emergency services. In Durham, extended power failure is particularly hazardous for remote areas. Elderly populations and other populations to protect listed in Table 3.1 could also be particularly vulnerable if the extended power outage occurred in conjunction with extreme heat or severe winter weather.

Past Events and Impacts

Historically, power outages have coincided with storm and wind events due to impacts upon power lines. While power outages lasting multiple days in some areas have occurred, no significant impacts beyond repair of damaged lines have been reported

.

[14] Wake, C. et al. "Climate Change in Southern New Hampshire; Past, Present, and Future." Climate Solutions of New England. 2014
[15] Wake, C. et al. "Climate Change in Southern New Hampshire; Past, Present, and Future." Climate Solutions of New England. 2014
[16] Wake, C. et al. "Climate Change in Southern New Hampshire; Past, Present, and Future." Climate Solutions of New England. 2014

Potential Future Impacts on Community

The likelihood of future power outage events can be difficult to predict, though the historic record in Durham and elsewhere indicates that they will be highly correlated with high wind events such as thunderstorms and severe winter weather.

Estimated Loss Potential

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to extended power outages is $35,474,743 to $70,949,484.

Severe Thunderstorms & Lightning

Table 5.9 Hazard Overview

Hazard Type	Severe Thunderstorms & Lightning
Location/Extent	Town-wide
Vulnerability	
Severity	1
Probability	2
Overall Threat	2
Potential Loss	$7,094,949 to $35,474,743 (moderate)

Description of the Hazard

As defined by NOAA, a thunderstorm is a rain shower during which thunder is heard. Because thunder comes from lightning, all thunderstorms have lightning. A thunderstorm is the result of convection, which is the upward atmospheric motion that transports whatever is in the air (such as moisture) with it. A thunderstorm is classified as *severe* if it has hail one inch or greater, winds gusting in excess of 50 knots (57.5 mph), or a tornado. Thunderstorm-related hazards that could impact Durham include: high winds and downburst, lightning, hail, and, torrential rainfall. Thunderstorms and severe thunderstorms are a town-wide hazard. They are most likely to occur in spring and summer.

Extent of the Hazard

Lightning heats air to a temperature of 50,000 degrees Fahrenheit and causes the air to expand and contract rapidly, which causes thunder. A lightning strike occurs very quickly but can occur multiple times during a storm.

Figure 5.3: Lightning Activity Scale

Lightning Activity Level (LAL)	Conditions
LAL1	No thunderstorms activity
LAL2	Isolated thunderstorms
LAL3	Widely scattered thunderstorms
LAL4	Scattered thunderstorms
LAL5	Numerous thunderstorms
LAL6	Widely scattered, scattered, or numerous DRY thunderstorms

Past Events and Impacts

Thunderstorms are common in New Hampshire but can be considered generally less severe than in other areas of the country, such as the Great Plains states. Severe thunderstorms do occur in New Hampshire, though. The NCDC database lists 41 reported events (over 22 different days) of severe thunderstorm winds in Strafford County from January 1, 2008 to December 31, 2016 (the most current data available at the time this chapter was drafted in May 2017). During that time period there were two reported events in Durham in June 2008 and August 2014.

Lightning can cause significant, sometimes severe, damage. Lightning strikes can cause direct damage to structures and serious injury or death to people and animals. Extensive damage also commonly results from secondary effects of lightning, such as electrical power surges, wildfire, and shockwave. According to lightning fatality data collected by the National Oceanic and Atmospheric Administration (NOAA), lightning kills an average of 49 people each year in the United States. There were 349 fatalities in the United States from 2005 to 2015.

There were no reported deaths in New Hampshire associated with lightning. The NCDC database lists two reports of lightning events in Strafford County from January 1, 2008 to December 31, 2016 (the most current data available at the time this chapter was drafted in May 2017). Neither event occurred in the Town of Durham. While reports of significant lightning events have not occurred frequently in the past in Strafford County, lighting and thunder can occur throughout the jurisdiction.

Finally, hail is a fairly common part of thunderstorms in New Hampshire, but damaging hail is apparently not. The damage that can result from hail is mostly to cars and windows. The NCDC Storm Events database lists 23 reported hailstorms in Strafford County from January 1, 2008 to December 31, 2016 (the most current data available at the time this chapter was drafted in May 2017). Two of these events took place in Durham –on July 18, 2008 and August 1, 2012. The July 2008 events produced 0.75 inch hail but resulted in no direct or indirect injuries or death and no significant damage to property or crops. The June 2009 storm produced 1 inch hail. No injuries or significant damages were attributed to this event.

While the annual recurrence probability of thunderstorms in general is effectively 100%, the likelihood of severe thunderstorms is low. Durham will continue to experience thunderstorms and should expect to sustain significant damage periodically.

Potential Future Impacts on Community

It is highly likely that the Town will continue to experience thunderstorms and lightning, however the severity of those impacts is anticipated to be low to moderate depending on factors include the location of lightning strikes, wind, or other factors such as flash flooding or downbursts that may accompany a thunderstorm.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to severe thunderstorms and lightning is $7,094,949 to $35,474,743.

Hurricanes & Tropical Storms

Table 5.10 Hazard Overview

Hazard Type	Hurricanes & Tropical Storms
Location/Extent	Town-wide
Vulnerability	
Severity	1
Probability	1
Overall Threat	1
Potential Loss	$0 to $7,094,949 (low)

Description of the Hazard

A hurricane is the term used for tropical cyclones that occur in the Northern Hemisphere east of the International Dateline to the Greenwich Meridian. Tropical cyclones originate over tropical or subtropical waters and are characterized by organized

deep convection and a closed surface wind circulation about a well-defined center. These events are called typhoons if they occur west of the International Dateline. Hurricane season in the Atlantic runs from June 1 to November 30.

According to the State Hazard Mitigation Plan (2013) tropical cyclones with maximum sustained winds of less than 39 mph are called tropical depressions. Once the tropical cyclone reaches winds of at least 39 mph, they are typically called a tropical storm and assigned a name. If the winds reach 74 mph or greater, they are upgraded and called a hurricane.

Extent of the Hazard

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating system based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures.

Hurricanes may impact all areas of the Town.

Scale Number (Category)	Sustained Winds (MPH)	Damage	Storm Surge
1	74-95	**Minimal:** Unanchored mobile homes, vegetation and signs.	4-5 feet
2	96-110	**Moderate:** All mobile homes, roofs, small crafts, flooding.	6-8 feet
3	111-130	**Extensive:** Small buildings, low-lying roads cut off.	9-12 feet
4	131-155	**Extreme:** Roofs destroyed, trees down, roads cut off, mobile homes destroyed. Beach homes flooded.	13-18 feet
5	More than 155	**Catastrophic:** Most buildings destroyed. Vegetation destroyed. Major roads cut off. Homes flooded.	Greater than 18 feet

Figure 5.4 Saffir-Simpson Hurricane Wind Scale

Past Impacts and Events

The NCDC Storm Events database lists 1 tropical storm event in Strafford County from January 1, 2008 to December 31, 2016 (the most current data available at the time this chapter was drafted in October 2016) that occurred on August 28, 2011 (Tropical Storm Irene).

> **Tropical Storm Irene** (August 28, 2011) - brought a prolonged period of strong and gusty winds and heavy rain to the state. The high winds snapped or uprooted numerous trees throughout the state causing more than 160,000 customers to lose electrical and/or communication services. The heavy rains caused rivers and streams throughout the state to flood causing damage to bridges, roads, and property. The strongest winds across the state began Sunday morning in southern areas and spread northward during the day. Winds continued to be gusty overnight as the storm moved away from the area. Observed maximum wind gusts included 63 mph at Portsmouth, 52 mph at Concord, and 51 mph at Manchester. On the top of Mt. Washington, winds gusted to 104 mph as the storm approached and 120 mph as it moved away. The combination of wet soil and the prolonged period of strong and gusty winds brought down numerous trees throughout the state. One person was killed and three people were injured across the state due to falling trees or branches. Rainfall amounts across the state ranged from 1.5 to 3 inches across southeastern New Hampshire. Local impacts included wind, downed trees, and moderate flooding in low-lying areas. Downed tree limbs and flooding caused minor infrastructure damage.

Quite a few other hurricanes have impacted the Town — including Donna, Gloria, and Bob — bringing high winds but causing relatively little damage.

The NOAA National Climatic Data Center's Storm Events database (NCDC 2015) does not list any Hurricanes as directly affecting Strafford County from January 1, 2008 to December 31, 2016, however, Strafford County did experience impacts from Hurricane Sandy. Hurricane Sandy was the last hurricane to hit the region during the period of October 26 to November 8, 2012. Durham experienced minimal impacts associated with rain and wind. Presidential Declaration FEMA-4095 requested funds for debris removal and emergency protective measures. Strafford County was not included in the

public assistance or direct federal assistance declaration. Strafford County did received Emergency Declaration funds for Emergency Protective Measures.

Potential Future Impacts on Community

Durham is vulnerable to hurricane hazards including wind, tornadoes, heavy rainfall, and inland flooding. Portions of Durham located near the Great and Little Bays and along tidal portions of the Oyster River may also be susceptible to storm surge. Recurrence potential of hurricane and tropical storm hazards in Durham is moderate. As many as 10 significant Hurricanes have impacted Durham and the surrounding region and it is likely that that the region will be impacted by a significant storm of tropical origin within the foreseeable future

Based on historical data and statistical predictors, the Atlantic Basin averages approximately 12 total named storms per year. Six of those storms will become hurricanes with three becoming a category three or higher. With variability in sea-level pressure and sea-surface temperatures in the Atlantic Ocean, it is difficult to predict with certainty the number of storms in any given year. It is even more difficult to determine which of those storms will make landfall. While Durham is located inland from the New Hampshire coast, which may diminish wind speeds from their coastal strength, Durham is also located along significant stretches of tidal water that could be impacted. Any significant impact on the town would be dependent on the exact track of these concentrated storms.

Hurricanes and tropical storms will continue to affect Durham and recurrence potential of hurricane and tropical storm hazards is, therefore, moderate. It is likely that the region will be impacted by a significant storm of tropical origin within the foreseeable future.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to severe hurricanes and tropical storms is $0 to $7,094,949.

Tornado & Downburst

Table 5.11 Hazard Overview

Hazard Type	Tornado & Downburst
Location/Extent	Town-wide
Vulnerability	
Severity	1
Probability	1
Overall Threat	1
Potential Loss	$0 to $7,094,949 (low)

Description of the Hazard

A ***tornado*** is a violent windstorm characterized by a twisting, funnel shaped cloud with winds in excess of 200 mph, often accompanied by violent lightning, peripheral high winds, severe hail, and severe rain. Tornadoes develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. The atmospheric conditions required for the formation of a tornado include great thermal instability, high humidity, and the convergence of warm, moist air at low levels with cooler, drier air aloft. Most tornadoes remain suspended in the atmosphere, but if they touch down they become a force of destruction.

Tornadoes produce the most violent winds on earth, at speeds of 280 mph or more. In addition, tornadoes can travel at a forward speed of up to 70 mph. Violent winds and debris slamming into buildings cause the most structural damage. A tornado is usually accompanied by thunder, lightning, heavy rain, and a loud "freight train" noise. In comparison to a hurricane, a tornado covers a much smaller area but can be more violent and destructive.

A ***downburst*** is a severe localized wind blasting down from a thunderstorm. These "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris. Downbursts fall into two categories: microburst, which covers an area less than 2.5 miles in diameter and macroburst, which covers an area at least 2.5 miles in diameter.

Extent of the Hazard

The Fujita Scale is the standard scale for rating the severity of a tornado as measured by the damage it causes. The scale measures wind speeds of 65 to greater than 200 miles per hour. The damage path of a tornado can be in excess of one mile wide and 50 miles long, whereas a downburst is typically less than 2.5 miles. Downbursts can have wind speeds of 150 miles per hour.

Tornados and downbursts may impact all areas of Town.

Enhanced Fujita Scale	
EF–0	65–85 mph winds
EF–1	86–110 mph
EF–2	111–135 mph
EF–3	136–165 mph
EF–4	166–200 mph
EF–5	>200 mph

Figure 5.5 Enhanced Fujita Scale

Past Impacts and Events

Between 1991 and 2010, the average annual number of tornadoes in New Hampshire was one.[17] Though the frequency of tornado events in New Hampshire is not great, the state has experienced large tornados throughout its history. An early example is the tornado that stuck the state in September 1821. This tornado was reported to have tracked from the Connecticut River, near Cornish, and terminating near Boscawen. When the skies cleared, 6 people were dead, hundreds injured and thousands homeless.

In 1998 an F2 tornado in Antrim, N.H. blew down a 45-foot by 12-foot section of the Great Brook Middle School. Witnesses reported seeing a funnel cloud, and the weather service, after an inspection, confirmed it was a tornado. According to the June 2, 1998 edition of the Eagle Tribune, John Jensenius from the National Weather Service in Gray, Maine estimated that the twister cut a path half a mile long, up to 100 yards wide, and was on the ground for several minutes.

In July 2008, an F2 tornado and high winds created a path of destruction through five New Hampshire counties that destroyed homes, displaced families, downed trees and forest lands and closed major state roadways. The impact to residents was extensive, with over 100 homes rendered uninhabitable. Phone and electric service was cut off to over 12,500 customers. One fatality is attributed to a building collapse, and local hospitals reported numerous physical injuries associated with this severe storm.[18]

Since the July 2008 tornado (through June 30, the most current data available at the time this chapter was drafted in October 2016), The NCDC Storm Events database reports that eight tornados have hit New Hampshire, however none have hit Strafford County. The most recent event occurred in July 2015 in Warner.

Downburst activity is very prevalent throughout the State. However, the majority downburst activity is mostly unrecognized unless a large amount of damage has occurred. Several of the more significant and recent events are highlighted below:

- Central, NH – July 6, 1999 –Two roofs blown off structures, downed trees, widespread power outages, and damaged utility poles and wires; two fatalities.

[17] NOAA. U.S. Tornado Climatology (https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology)
[18] New Hampshire Department of Safety. State of NH Natural Hazard Mitigation Plan 2013. Homeland Security and Emergency Management.

- Stratham, NH – August 18, 1991 –$2,498,974 worth of damages; five fatalities.
- Moultonborough, NH – July 26, 1994 –Downed trees, utility poles and wires. Approximately 1,800 homes without power and 50-60 homes damages.
- Bow, NH – September, 6, 2011 –City Auto in Bow had 15 campers damaged and estimated $200,000 in damage.

While tornados are not common, they would cause significant impacts in the town, especially to older mobile homes that are not tied down properly. The probability of reoccurrence of a downburst may be higher. A tornado or downburst can impact the entire jurisdiction and may cause greater damage in the community center.

Tornadoes are rare in New Hampshire. The NCDC Storm Events database (NCDC 2004) lists only five tornadoes that have impacted Strafford County since 1950. One was an F1 event (73-112 mph) and the other four were F2 events (113-157 mph). These tornadoes also occurred one in each decade from the 1950's through the 1990's. The average annual probability of recurrence, therefore, is 10% (5/50 x 100). The probability would be slightly higher if local reports of tornadoes were considered; however, this 10% probability is for all of Strafford County, not just Durham. The actual probability for Durham should be much lower, considering the great dependence of impact upon the actual track of any tornado.

Potential Future Impacts on Community

It is possible that a tornado could strike Durham in the future and inflict significant damage to property, forest resources, and potentially cause injury to people. Microbursts are more likely to occur. Microbursts could cause downed trees that damage structures and property.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to tornados and downbursts is $0 to $7,094,949.

Drought

Table 5.12 Hazard Overview

Hazard Type	Drought
Location/Extent	Town-wide
Vulnerability	
Severity	1
Probability	2
Overall Threat	2
Potential Loss	$7,094,949 to $35,474,743 (moderate)

Description of the Hazard

A drought is defined as a long period of abnormally low precipitation, especially one that adversely affects growing or living conditions. The impacts of droughts are indicated through measurements of soil moisture, groundwater levels, and stream flow. The effect of drought on these indicators is variable during any particular event. For example, frequent minor rainstorms can replenish the soil moisture without raising groundwater levels or increasing streamflow. Low streamflow also correlates with low ground-water levels because ground water discharge to streams and rivers maintains streamflow during extended dry periods. Low streamflow and low ground-water levels commonly cause diminished water supply.

Extent of the Hazard

The National Drought Monitor classifies the duration and severity of the drought using precipitation, stream flow, and soil moisture data coupled with information provided on a weekly basis from local officials. There are five magnitudes of drought outlined in the New Hampshire State Drought Management Plan: Exceptional, Extreme, Severe, Moderate, and Abnormally Dry.

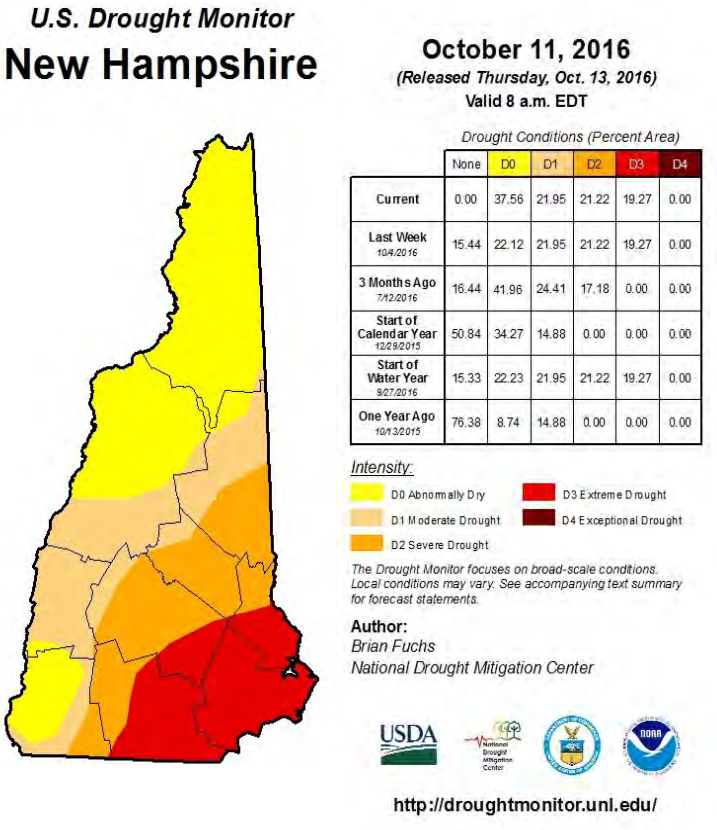
Drought is a regional hazard and can impact the entire jurisdiction. Agricultural land and residents who use dug, shallower wells may be more vulnerable to the effects of drought.

Past Impacts and Events

While the impacts of drought are typically not as damaging and disruptive as floods or storm events, the impacts of long term drought or near drought conditions can impact crops and the water supply.

Periods of drought have occurred historically in New Hampshire. Six droughts of significant extent and duration were evident in the 20th century as noted below in Table 2.5. The most severe drought recorded in New Hampshire occurred from 1960 to 1969. This drought encompassed most of the northeastern United States (1956-1966). The drought of 1929-1936 was the second worst and coincided with severe drought conditions in large areas of the central and eastern United States. The drought of 2001-2002 was the third worst on record.[19]

Figure 5.6 Peak Drought Conditions in NH, 2016



In more recent years, drought has again become a problem in New Hampshire. In 1999, a drought warning was issued by the Governor's Office. In March 2002, all counties in New Hampshire with the exception of Coos County were declared in Drought Emergency. This was the first time that low-water conditions had progressed beyond the Level Two, Drought Warning Stage. With extreme variation in environmental conditions due to global warming possibly on the rise, drought probability may grow in the future. Currently, drought possibility seems moderate. The large amount of water resources and relatively sparse population in New Hampshire have tended to minimize the impacts of drought events in the region, but this regional protection may be endangered in the future with increases in drought frequency or severity.

Normal precipitation for the state averages 40 inches per year. During the summer of 2015, most of central and southern New Hampshire experienced its most recent drought, the first since 2001 – 2002 (was the 3rd worst on record, exceeded only by the national droughts of 1956-1966 and 1941-1942). While many communities experienced record snowfall totals this past winter (2014-2015), the lack of rainfall and higher-than-average temperatures resulted in river and groundwater levels to be lower than average. This resulted in the implementation of local water conservation plans throughout the region.[20]

[19] NHDES. Drought Management Program. Publications. *NH Drought Historical Events*. Viewed on 8/10/15. http://des.nh.gov/organization/divisions/water/dam/drought/documents/historical.pdf

[20] See: http://des.nh.gov/organization/divisions/water/dwgb/water_conservation/documents/waterban.pdf.

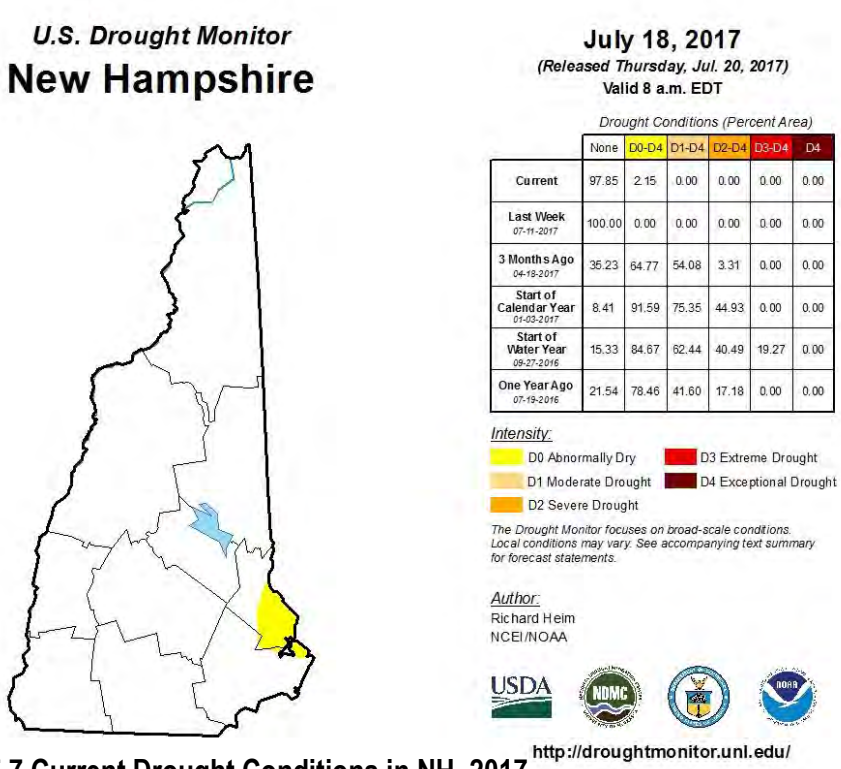


Figure 5.7 Current Drought Conditions in NH, 2017

Drought conditions continued and intensified into 2016 in New Hampshire and in Southeast New Hampshire in particular. As of October 11, 2016, nearly 20% of the state was categorized as being in extreme drought. One hundred and sixty community water systems reported implementing a water restriction or ban, and 13 towns reported implementing voluntary or mandatory outdoor use bans in the state during the peak drought conditions. Conditions in New Hampshire largely returned to normal in the first half of 2017, with just over 2% of the state still experiencing abnormally dry conditions. This area covers the southern part of Strafford County, including the Town of Durham, illustrating the extent to which local drought conditions can vary both geographically and over time.

The Town of Durham has not reported any instances of dry wells as a result of drought. Water conservation protocols were enacted in response to the drought of 2016. However, Durham has few agricultural or other intensive water users, so the overall local impacts of this drought were limited.

Table 5.13 New Hampshire Drought History & Conditions

Dates	Area Affected	Magnitude	Remarks
1929 – 1936	Statewide	-	Regional; recurrence interval 10 to > 25 years
1939 – 1944	Statewide	Severe Moderate	Severe in southeast NH and moderate elsewhere in the State. Recurrence interval 10 to > 25 years.
1947 – 1950	Statewide	Moderate	Recurrence interval 10 to >25 years
1960 – 1969	Statewide	Extreme	Longest recorded continuous spell of less than normal precipitation. Encompassed most of the northeast US. Recurrence interval >25 years.
2001 – 2002	Statewide	Severe	Recurrence interval 10 to >25 years
2015	Central & Southern NH	Moderate	Recurrence interval cannot yet be determined

Potential Future Impacts on Community

The National Drought Mitigation Center website (NDMC 2004) emphasizes that reliable drought prediction for regions above 30°N latitude is effectively impossible.

With extreme variation in environmental conditions due to climate change possibly on the rise, drought probability may grow in the future. Currently, drought possibility seems moderate. The large amount of water resources and relatively sparse population in New Hampshire have tended to minimize the impacts of drought events in the region, but this regional protection may be endangered in the future with increases in drought frequency or severity.

Historically, droughts in New Hampshire have had limited effect because of the plentiful water resources and sparse population. Since 1960, the population has more than doubled, which has increased demand for the State's water resources. Further droughts may have considerable effect on the State's densely populated areas along the seacoast and in the south-central area.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to drought is $7,094,949 to $35,474,743.

Earthquakes & Landslide

Table 5.14 Hazard Overview

Hazard Type	Earthquakes & Landslide
Location/Extent	Town-wide, Steep slopes and river banks
Vulnerability	
Severity	1
Probability	1
Overall Threat	1
Potential Loss	$0 to $7,094,949 (low)

Description of the Hazard

The USGS defines an earthquake as a term used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth. Earthquakes can cause buildings and bridges to collapse, disrupt gas, electric and phone lines, and often cause landslides, flash floods, fires, avalanches, and tsunamis. Larger earthquakes usually begin with slight tremors but rapidly take the form of one or more violent shocks, and are followed by vibrations of gradually diminishing force called aftershocks.[21] Earthquakes in the Northeast are not associated with specific know faults.

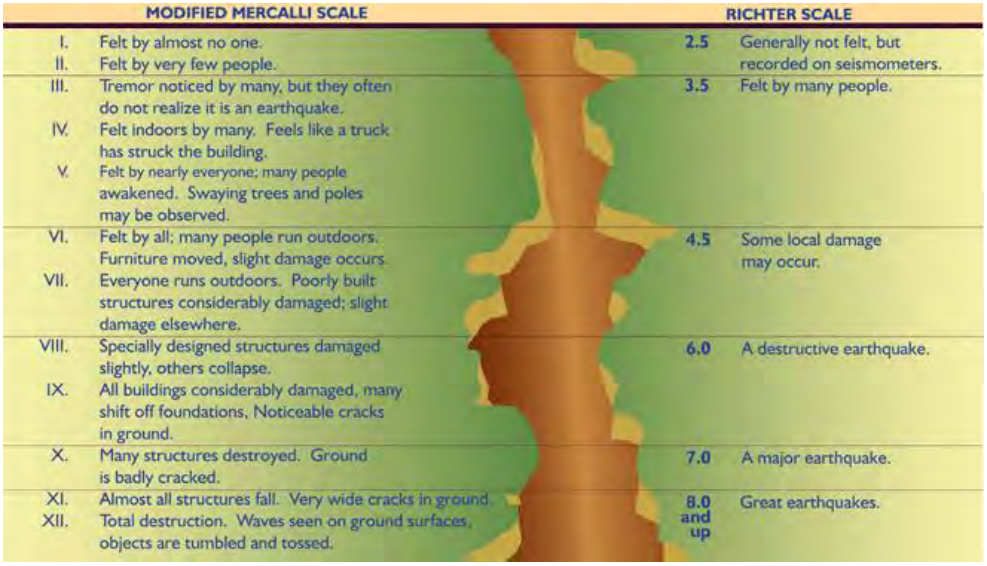
Due to the geology of the region, the area impacted by an earthquake in the Northeast can be up to 40 times greater than the same magnitude event occurring on the West coast. Earthquakes can occur at any time without warning.

An earthquake can impact all areas of the jurisdiction. People at greatest risk from earthquakes are those who live in unreinforced masonry buildings build on filled land or unstable soil.[22]

[21] The Northeast States Emergency Consortium Earthquake Hazards. http://nesec.org/earthquakes-hazards/. Viewed on 8/10/15
[22] http://nesec.org/earthquakes-hazards/

Extent of the Hazard

Figure 5.8 Measuring the magnitude and intensity of earthquakes



The magnitude and intensity of an earthquake is measured by the Richter scale and the Modified Mercalli Intensity (MMI) scale, respectively. The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes.[23]

The Modified Mercalli Intensity (MMI) scale was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects actually experienced at a given place and therefore has a more meaningful measure of severity.[23]

Past Impacts and Events

Due to the state's location in an area of moderate seismic activity earthquakes are a common event in New Hampshire, but significantly damaging earthquakes are not. The Northeast States Emergency Consortium (NESEC, 2016) website presents a history of earthquake in the Northeast and documents that New Hampshire is an area of high earthquake probability. Three hundred and sixty earthquakes occurred in New Hampshire from 1638 to 2007. Approximately 40-50 earthquakes are detected in the Northeast annually.[22] However, New Hampshire has only experienced nine earthquakes of significant magnitude (Richter Magnitude 4.0 or greater) in that time period. Durham has experienced no major earthquakes in recent years. Earthquakes are on average an annual occurrence but significant quakes have an annual probability of occurrence (based on the 1638 to 2007 period) of about 2.4%.

Table 5.15 Notable Historic Earthquakes in NH 1638-2007 (Magnitude 4.0 or Greater)

Location	Date	*Intensity MMI Scale*	Magnitude *Richter Scale*
Central New Hampshire	June 11, 1638	-	6.5
Portsmouth	November 10, 1810	V	4.0
Near Hampton	July 23, 1823	IV	4.1
Ossipee	October 9, 1925	VI	4.0
Ossipee	December 20, 1940	VII	5.5
Ossipee	December 24, 1940	VII	5.5
West of Laconia	January 19, 1982	-	4.7
Northeast of Berlin	October 20, 1988	-	4.0
Southeast of Berlin	April 6, 1989	-	4.1

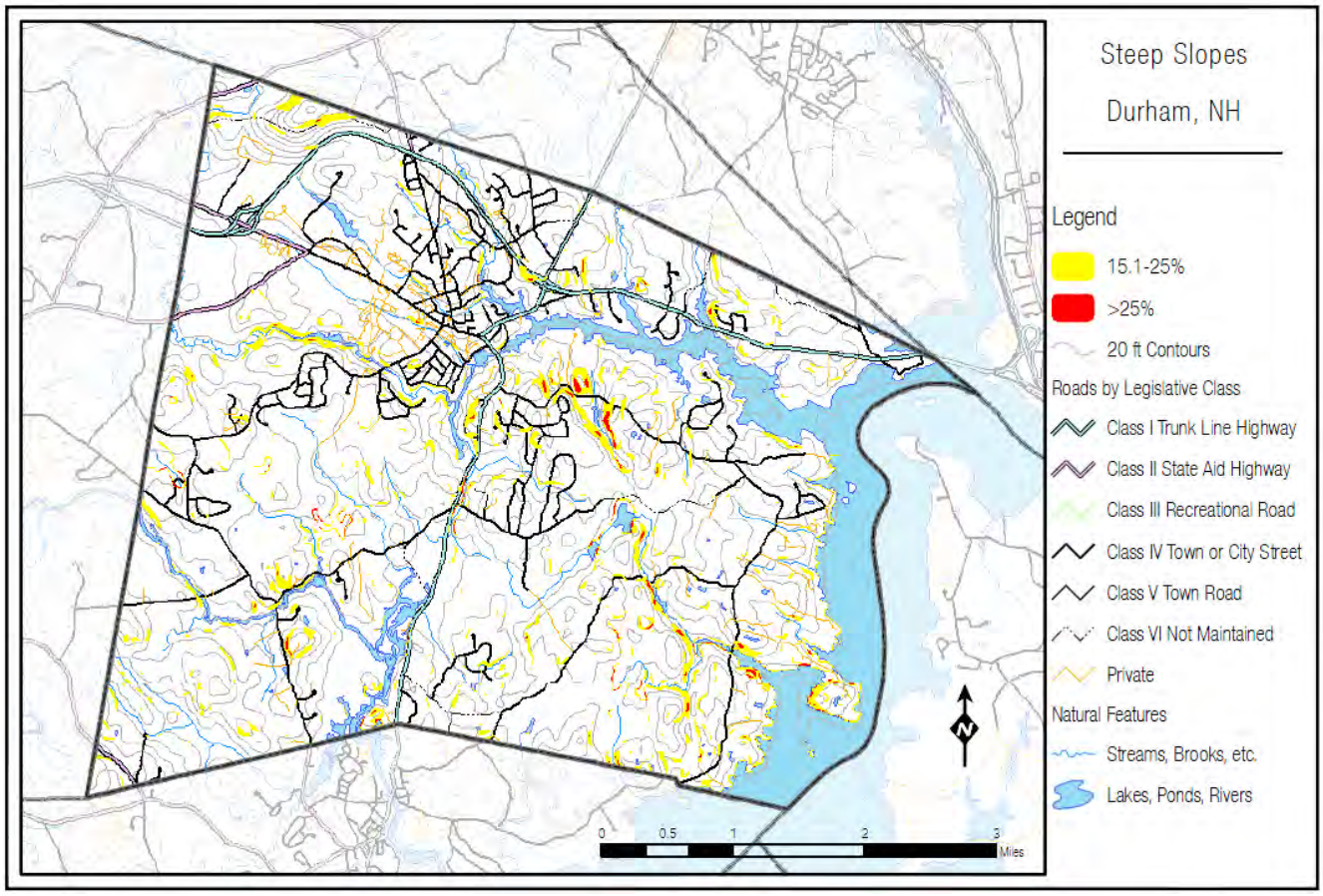
[23] USGS. Earthquake Hazard Program. http://earthquake.usgs.gov/learn/glossary/?term=Richter%20scale., http://pubs.usgs.gov/gip/earthq4/severitygip.html.

Earthquakes could readily cause landslides, as could ground saturation from extended heavy precipitation events. Given seismic or precipitation events that could initiate landslide, landslide hazard is likely in steep slope areas. However, these areas are extremely limited in scale. No local impacts of earthquakes or landslides have been reported for Durham.

Potential Future Impacts on Community

Landslides could occur in Durham in areas with steep slopes, where soils and loose bedrock formations would tend to slough off and move en masse downhill under gravity. Earthquakes could readily cause landslides, as could ground saturation from extended heavy precipitation events. Given seismic or precipitation events that could initiate landslide, landslide hazard is likely quite high in steep slope areas. There are approximately 48.27 acres of steep slopes greater than 25% in Durham. Areas of steep slopes are most prevalent south of the Oyster River, particularly along Durham Point Road (see Map 5.2)

Map 5.2 Areas of Steep Slope



The USGS (1997) classifies landslide incidence regionally as very low (less than 1.5% of land area involved). The local probability in Durham will depend on specific soil/rock types and upon the probability of initiating events. Potential impacts could include property damage, road closures, and increased erosion if forests were damaged.

Estimated Loss

Based the 2015 valuation and the hazard ranking, the estimated potential loss due to earthquakes and landslides is $0 to $7,094,949.

Table 5.16 Hazard Overview

Hazard Type	Public Health Threats
Location/Extent	Town-wide, school population and families may be more susceptible to certain epidemics
Vulnerability	
Severity	1.33
Probability	3
Overall Threat	4
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

Epidemic

As defined by the CDC, and epidemic is "the occurrence of more cases of disease than expected in a given area or among a specific group of people over a particular period of time."[24] In addition to being categorized by the type of transmission (point-source or propagated), epidemics may occur as outbreaks or pandemics. As defined in the State Hazard Mitigation Plan, an outbreak is a sudden increase of disease that is a type of epidemic focused to a specific area or group of individuals. A pandemic is an epidemic that spreads worldwide, or throughout a large geographic area.

Epidemics may be caused by infectious diseases, which can be transmitted through food, water, the environment or person-to-person or animal-to-person (zoonoses), and noninfectious diseases, such as a chemical exposure that causes increased rates of illness. Infectious disease that may cause an epidemic can be broadly categorized into the following groups[25]:

- Foodborne (Salmonellosis, Ecoli)
- Water and Foodborne (Cholera, Giardiasis)
- Vaccine Preventable (Measles, Mumps)
- Sexually Transmitted (HIV, Syphilis)
- Person-to-Person (TB, Aseptic meningitis)
- Arthropodborne (Lyme, West Nile Virus)
- Zoonotic (Rabies, Psittacosis)
- Opportunistic fungal and fungal infections (Candidiasis).

An epidemic may also result from a bioterrorist event in which an infectious agent is released into a susceptible population, often through an enhanced mode of transmission, such as aerosolization (inhalation of small infectious disease particles).[26]

Tick-Borne Diseases

Lyme disease, which is spread to humans by the bite of an infected tick, is a growing threat in New Hampshire. New Hampshire has one of the highest rates of Lyme disease in the U.S. Other tick-borne illnesses that could impact New Hampshire include Babesiosis, Anaplasmosis, and Rocky Mountain Spotted Fever.

Radon

Radon is a radioactive gas which is naturally occurring as a result of the typical decay of uranium commonly found in soil and rock (especially granite). Radon has carcinogenic properties and is a common problem in many states; New Hampshire

[24] Slate; http://www.slate.com/id/2092969/
[25] New Hampshire Department of Safety. State of NH Natural Hazard Mitigation Plan 2013. Homeland Security and Emergency Management.
[26] Ibid.

has some isolated areas that are among the highest levels of radon in the United States according to the US Environmental Protection Agency (EPA). Whether or not a particular type of granite emanates radon is dependent on the geochemistry of that particular granite, some types are a problem and some are not. In other parts of the country, radon is associated with certain black shales, sandstones, and even limestones. The EPA has estimated that radon in indoor air is responsible for about 13,600 lung cancer deaths in this country each year (EPA document, EPA 811-R-94-001, 1994).[27]

Arsenic

Arsenic is a semi-metal element that is odorless and tasteless. Arsenic is a hazard because it can enter drinking water supplies, either from natural deposits in the earth or from agricultural and industrial practices.[28]

Wells drilled into New Hampshire's bedrock fractures have about a 1 in 5 probability of containing naturally occurring arsenic above 10 parts per billion. In addition, wells within short distances (~50 feet) can present very different water quality because of our highly fractured bedrock. Arsenic in water has no color or odor, even when present at elevated levels. Therefore, the only way to determine the arsenic level in your well water is by testing.

Extent of the Hazard

Public health threats are events or disasters that can affect an entire community.

Past Impacts and Events

Epidemic

The University of New Hampshire campus is a large population center that could be vulnerable to the rapid spread of disease. Additionally, the large number of students, faculty, and staff travelling to the campus from across the region on a regular basis and visiting speakers traveling from across the country and around the world could be a source of contaminants from outside the region. Because of these factors, an epidemic or pandemic could present a possible threat to Durham. With the occurrence of worldwide pandemics such as SARS, H1N1 and Avian Flu, Durham could be susceptible to an epidemic and subsequent quarantine. While all individuals are potentially vulnerable to the hazard of an epidemic, epidemics often occur among a specific age group or a group of individuals with similar risk factors and exposure.[27]

Tick-Borne Diseases

The number of New Hampshire residents diagnosed with Lyme disease has increased over the past 10 years, with significant increases occurring since 2005.[29] In 2009, the rate of cases of Lyme disease reported in New Hampshire residents was 108 cases per 100,000 persons, which is significantly higher than the Healthy People 2010 science-based 10-year national objective for improving the health of all Americans objective of 9.7 cases per 100,000 persons.[30] From 2009 to 2013, reported cases of Lyme disease in New Hampshire increased by approximately 20% from 1416 cases per year to 1691 cases per year.[31] Rockingham, Strafford, and Hillsborough counties had the highest rates of disease in 2008-2009. In 2012, there were 172 reported cases of Lyme disease in Strafford County.[29]

Radon

Exposure is a significant hazard in New Hampshire. According to a NH Bureau of Environmental & Occupational Health (BEOH) study looking at >15,000 indoor radon test results in single-family dwellings, households in northern, eastern, and

[27] New Hampshire Department of Safety. State of NH Natural Hazard Mitigation Plan 2013. Homeland Security and Emergency Management.
[28] EPA. Arsenic in Drinking Water. (http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm)
[29] 2011 New Hampshire State Health Profile; Improving Health, Preventing Disease, Reducing Costs for All. NH Division of Public Health Services Department of Health and Human Services. http://www.dhhs.nh.gov/dphs/documents/2011statehealthprofile.pdf
[30] HealthyPeople.gov. About Healthy People. Accessed April 2014. Available at: http://healthypeople.gov/2020/about/default.aspx
[31] NHDHHS. State of New Hampshire Tickborne Disease Prevention Plan. March 31, 2015. http://www.dhhs.state.nh.us/dphs/cdcs/lyme/documents/tbdpreventionplan.pdf)

southeastern regions of New Hampshire especially tend to have nominally high concentrations of radon in air or water (BEOH 2004); however, values in excess of the US Environmental Protection Agency's 4.0 picocurie per liter (pCi/L) action guideline have been found in nearly every community in New Hampshire. Values exceeding 100 pCi/L have been recorded in at least eight of New Hampshire's ten counties. The highest indoor radon reading in New Hampshire known to NHDES is greater than 1200 pCi/L; higher values probably exist. The probability of significant radon exposure is apparently quite high. In the BEOH study, 44.0% of tests in Strafford County exceeded the 4.0 pCi/L action level and 13.0% even exceeded 12.0 pCi/L.

In Durham, between 30 and 39.9% of homes tested by homeowners from 1987 to 2008 tested at or above the radon action level of 4.0 pCi/L. The probability of significant radon exposure is fairly high.[32]

Arsenic

From 1975 until 2001, the federal maximum contaminant limit (MCL) for arsenic in water supplied by public water systems was 50 parts per billion, because the health effects of exposure to lower concentrations was not recognized. Based on an exhaustive review of the new information about arsenic's health effects, in January 2001 EPA established a goal of zero arsenic in drinking water. At the same time, EPA adopted an enforceable MCL of 10 parts per billion (ppb) based on balancing treatment costs and public health benefits. Studies have shown that chronic or repeated ingestion of water with arsenic over a person's lifetime is associated with increased risk of cancer (of the skin, bladder, lung, kidney, nasal passages, liver or prostate) and non-cancerous effects (diabetes, cardiovascular, immunological and neurological disorders). The same studies found that dermal absorption (skin exposure) of arsenic is not a significant exposure path; therefore, washing and bathing do not pose a known risk to human health.[33]

Potential Future Impacts on Community

Exposure to radon and arsenic will continue to be a concern in Durham and throughout the state. It is likely that exposure to Lyme's disease will increase in the future due to warmer temperatures. The spread of epidemics is also plausible.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to public health threats is $35,474,743 to $70,949,484.

Wildfire

Table 5.17 Hazard Overview

Hazard Type	Wildfire
Location/Extent	Town-wide; remote, forested areas may be more vulnerable
Vulnerability	
Severity	1
Probability	2
Overall Threat	2
Potential Loss	$7,094,949 to $35,474,743 (moderate)

[32]NHDES http://des.nh.gov/organization/divisions/air/pehb/ehs/radon/documents/radon_by_town.pdf
[33] New Hampshire Environmental Services. Drinking Water and Groundwater Bureau. Arsenic in Drinking Water Fact Sheet.

Description of the Hazard

Wildfire is defined as an uncontrolled and rapidly spreading fire. A forest fire is an uncontrolled fire in a woody area. Forest fires occur during drought and when woody debris on the forest floor is readily available to fuel the fire. Grass fires are uncontrolled fires in grassland areas. Although Durham is a developed college town, it has managed to conserve large tracts of land that contribute to a predominantly forested landscape. Exposure to natural factors such as lightning that can cause wildfires is consequently high and can occur throughout the jurisdiction.

Extent of the Hazard

The National Wildfire Coordinating Group (NWCG) categorizes the size of a wildfire in six classes depending on acres burned, ranging from less than ¼ acre to greater than 5,000 acres (see box below). The US Forest Service's surface fire behavior fire characteristics chart illustrates primary fire behavior values including the spread rate and the intensity of the fire, which can be used to compare predicted and observed fire behavior and to describe potential fire behavior.[34]

Past Impacts and Events

Wildfires in New Hampshire historically have tended to run in 50-yr cycles, which can be observed starting from the 1800s. This 50-year cycle is partially based upon human activities and, therefore, may not prove to be accurate into the future.[35] The peak in wildfires in the late 1940's and early 1950's is thought to be related to the increased fuel load from trees downed in the 1938 hurricane. Here, 60 years later, New Hampshire officials are again concerned about the high fuel load created by the 1998 and 2008 ice storms that hit New Hampshire.

The NCDC Storm Events database lists 0 reported wildfires in Strafford County from January 1, 2008 to December 31, 2016 (the most current data available at the time this chapter was drafted in May 2017). The 2017 Hazard Committee identified a large fire that occurred in 2010 in the vicinity of Falls Way. The fire covered more than 10 acres, predominantly burning grass with some forest and tree damage. The fire was deemed "suspicious in origin", indicating that it could have been started by human activity.

Potential Future Impacts on Community

The probability of occurrence of wildfires in the future is difficult to predict due to the dependence of wildfire on the occurrence of the causal hazards and the variability of numerous factors that affect the severity of a wildland fire. As indicated above, loading of dead brush and other fuels in forested areas can be cyclical, indicating that the risk of wildfire can grow over time if potential sources of fuel are not regularly removed.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to wildfire is $7,094,949 to $35,474,743.

[34] How to Generate and Interpret Fire Characteristics Charts for Surface and Crown Fire Behavior. (https://www.fs.fed.us/rm/pubs/rmrs_gtr253.pdf)
[35] New Hampshire Department of Safety. State of NH Natural Hazard Mitigation Plan 2013. Homeland Security and Emergency Management.

Coastal Flooding (Sea Level Rise & Storm Surge)

Table 5.18 Hazard Overview

Hazard Type	Hazardous Material
Location/Extent	Great Bay, Little Bay; upriver impacts most likely along the Oyster River
Vulnerability	
Severity	1
Probability	2
Overall Threat	2
Potential Loss	$7,094,949 to $35,474,743 (moderate)

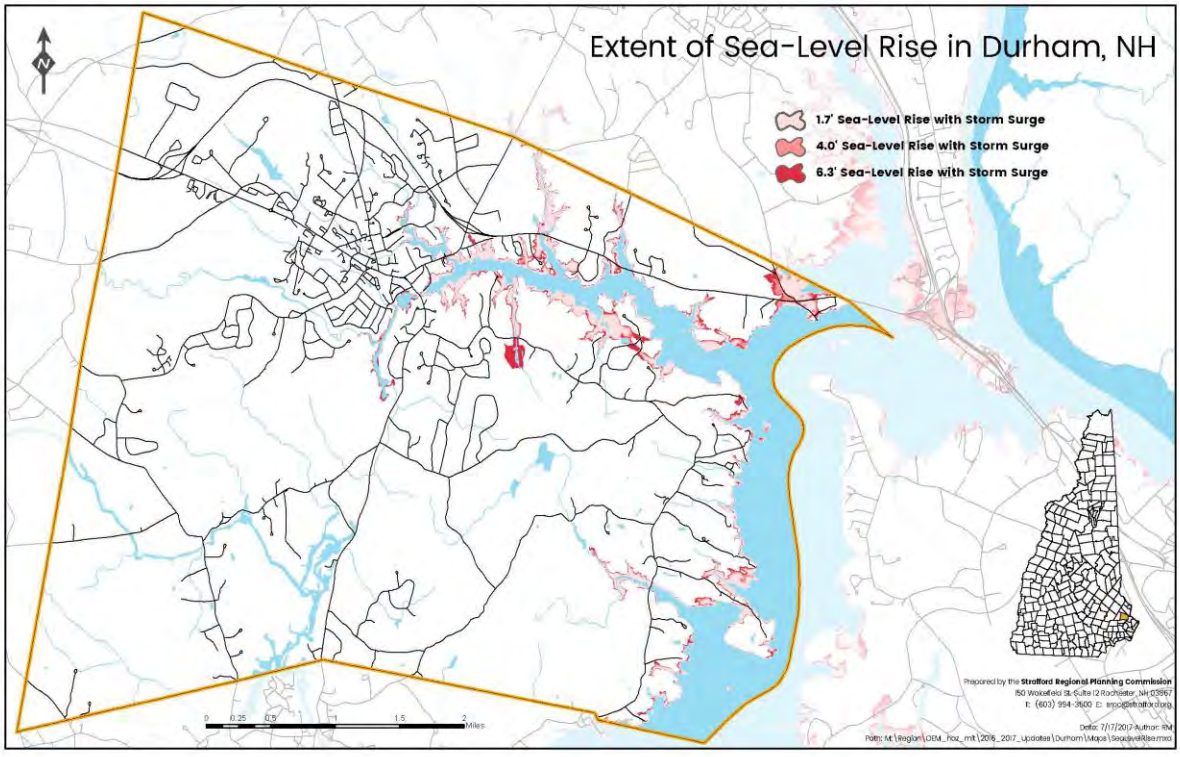
Description of the Hazard

Global climate change is expected to have a broad range of impacts ranging from anticipated sea level rise to changing weather patterns and increasing numbers of extreme weather events. Coastal municipalities in particular need to prepare for these changes that would have serious implications for their communities, including storm surge, coastal erosion, and coastal flooding due to sea level rise. These changes pose a threat to coastal populations due to potential negative impacts upon existing buildings, infrastructure, and natural resources. In order to better understand these threats, the Town of Durham adopted a *Climate Adaptation Chapter* in 2013 and completed a *Vulnerability Assessment* in 2017 to explore projected impacts from sea-level rise and coastal storm surge flooding and develop possible strategies for mitigating this flooding. Those documents have been adopted as Appendices A and B to this plan, respectively.

Extent of the Hazard

The 2017 Vulnerability Assessment analyzed areas likely to be impacted by sea-level rise projections of 1.7, 4.0, and 6.3 feet by the year 2100, with additional projections provided for storm surge from a 100-year storm event. These areas are located along the coast of the Great Bay and Little Bay and in the tidal portions of the Oyster River. The tidal portions of the Lamprey River are located outside of Durham, meaning it is unlikely to be impacted by sea-level rise within Durham.

Map 5.3 Sea-Level Rise Scenarios



Past Impacts and Events

Durham has not yet experienced significant impacts relating to sea-level rise, but prefers to consider possible negative impacts proactively as a result of their proximity to tidal waters.

Potential Future Impacts on Community

As shown in Table 5.19 below, approximately 385 acres of land in Durham are impacted by at least one future sea-level rise scenario once storm surge is taken into account. Roughly 55 percent of this land currently falls within the FEMA 100-year floodplain. While much of Durham's infrastructure and critical facilities appear to be outside the areas that are most susceptible to sea-level rise, several community assets, including evacuation routes on Routes 4 and 108 are at risk. These vulnerabilities should be reviewed periodically and considered during long-term planning efforts. For additional information regarding potential future impacts, see Appendix B.

Table 5.19 Area Impacted by Future Sea-Level Rise Scenarios

	Town of Durham Sea-Level Rise (SLR) Scenarios					
Scenario	1.7ft SLR	4.0ft SLR	6.3ft SLR	1.7ft SLR + storm surge*	4.0ft SLR + storm surge*	6.3ft SLR + storm surge*
Area Impacted (acres)	43.85	116.82	216.27	162.00	264.09	385.81
*Storm surge calculated for a 100-year/1% storm event						

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to coastal flooding is $7,094,949 to $35,474,743.

Hazardous Materials

Table 5.20 Hazard Overview

Hazard Type	Hazardous Material
Location/Extent	Town-wide; NH Route 4 and Route 108 likely more vulnerable
Vulnerability	
Severity	2.33
Probability	1
Overall Threat	2
Potential Loss	$7,094,949 to $35,474,743 (moderate)

Description of the Hazard

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, property, and the environment. Many products containing hazardous chemicals are used and stored in homes

routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Hazardous materials continue to evolve as new chemical formulas are created.

Extent of the Hazard

Incidents involving hazardous materials could potentially occur at any residence or business or along any road; however, it is more likely that a large-scale incident would occur in the form of a spill along the Pan Am Railways tracks, NH Route 4, or NH Route 108. The extent of such an incident can be difficult to predict and would depend upon the type and volume of materials involved.

Past Impacts and Events

No historic incidents relating to hazardous materials were identified. Durham prefers to consider possible impacts proactively due to the presence of several facilities containing potentially hazardous materials, and vehicle and rail transportation corridors.

Potential Future Impacts on Community

The 2012 update to this plan identified Route 4 as an east/west corridor that often has trucks carrying bio-diesel fuel and other harmful chemicals through Durham. A major concern is the Lee traffic circle at Route 4 west. Any spill there would directly affect the drinking water supply for Durham downstream. Route 108 is also a high-traffic corridor that runs close to downtown Durham and crosses the Oyster and Lamprey Rivers in addition to numerous smaller streams in Durham. Any spill affecting these bodies of water could have downstream impacts on the Piscataqua River and Great Bay. The 2012 plan also expressed concern for hazardous compounds that are produced within the labs on UNH's campus.

Estimated Loss

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to hazardous materials is $7,094,949 to $35,474,743.

Large Crowd Events

Table 5.21 Hazard Overview

Hazard Type	Large Crowd Events
Location/Extent	Town-wide; downtown/UNH likely more vulnerable
Vulnerability	
Severity	3
Probability	3
Overall Threat	9
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

For the purposes of this plan, large crowd events refer to any large gathering of people that has the potential to require higher-than-usual levels of preparedness and/or response from emergency services. As a university town, Durham regularly experiences large crowds related to sporting events, graduation, visiting speakers, or other events that require closing or redirecting streets, directing traffic, and increased emergency and/or medical services to ensure the safety of participants.

Additionally, large concentrations of residents close to downtown and the university increase the likelihood of property damage during celebratory events and holidays, particularly when widespread consumption of alcohol has occurred.

Extent of the Hazard

Large crowd events are typically either scheduled in advance, as is the case with official town or university events, or tend to coincide with particular holidays, sporting events, or other high-profile occurrences. This correlation makes crowd events easier to predict than most hazards.

Past Events and Impacts

The Town of Durham's civic involvement and UNH's academic calendar include a variety of annual crowd events, such as UNH graduation, the Memorial Day parade, and the town's Durham Day celebrations. As the state's flagship public university, UNH also regularly attracts public speakers that draw large crowds and require higher than usual levels of security. This impact was magnified in the 2015-2016 presidential election cycle due to New Hampshire's status as a swing state, particularly close to the primary and general elections. These events have historically been peaceful, and impacts are largely limited to the time and cost associated with providing heightened security and inconveniences to residents from increased traffic, road closures, and other direct results from the presence of large numbers of people. In many cases, negative impacts to the community as a result of these events are offset by increased business and civic engagement opportunities surrounding these events.

However, some crowd events have historically required more intensive security responses or have correlated with increased property damage and/or arrests. Recurring events such as UNH Homecoming and Cinco de Mayo celebrations typically see higher rates of arrest and emergency calls for alcohol-related incidents. Celebrations related to Boston sporting events have also historically been sources of disruption and property damage.

- Cinco de Mayo: Celebrations on May 5, 2017 resulted in 32 arrests by town and UNH police for vandalism or alcohol-related charges.[36] While alternative programming has been successful at mitigating levels of intoxication in the past, rain forced an outdoor cookout to be relocated and resulted in low attendance. Town and UNH police shared the costs of mobilizing 60-80 officers for the event, spending approximately $12,000 each on increased security.[37]

- UNH Homecoming: 116 arrests were reported over homecoming weekend in the fall of 2016, though police indicated that most were for minor infractions, many of them alcohol-related.[38] This was an increase over the 83 arrests in 2015, while the average number of arrests since 2005 has been around 96.[39]

- Super Bowl 2017: An estimated 3,000 people gathered in Durham to celebrate a Super Bowl victory by the New England Patriots, resulting in 15 arrests for criminal mischief related to the destruction of three parked vehicles.[40] Similar celebrations after the Patriots' victory in 2015 were more peaceful, and no arrests were made.[41]

- World Series 2013: Five people were arrested after a crowd gathered to celebrate the Boston Red Sox' 2013 World Series victory.[42] Police used pepper spray to disperse the crowd after vehicles were damaged and members of the crowd shot off fireworks and threw bottles at police.[43]

[36] http://www.unionleader.com/Cinco-de-Mayo-parties-lead-to-32-arrests-in-Durham
[37] http://www.seacoastonline.com/news/20170505/drinking-unh-students-celebrate-cinco-de-mayo
[38] http://www.fosters.com/news/20161004/more-than-100-arrested-during-unh-homecoming
[39] http://www.fosters.com/article/20151005/NEWS/151009621
[40] http://www.unionleader.com/crime/Police-charge-15-people-with-criminal-mischief-in-UNH-post-Super-Bowl-celebration-02222017
[41] http://nhpr.org/post/no-arrests-thousands-unh-students-celebrate-patriots-super-bowl-victory#stream/0

- Halloween: While Halloween festivities at UNH tend to be peaceful and generally do not result in elevated levels of arrests, the planning committee indicated that emergency medical services typically see an increase in calls, mostly related to alcohol poisoning.

Potential Future Impacts on Community

Civic, athletic, and academic crowd events are likely to continue into the foreseeable future, and in most cases both UNH and the Town of Durham are active partners. While both entities seek to mitigate the negative impacts of such events, such as blocking or rerouting traffic, neither has indicated a desire to lessen the overall number of such events.

The planning committee also anticipates that more dangerous celebratory events are likely to continue in the future, and even indicated that such events have the potential to be far more dangerous or destructive than recent events have been. A working group with representatives of UNH and the Town of Durham has been created to identify specific strategies for addressing these events. These strategies were not yet available when this plan was updated in 2017, but may be kept as an addendum to this plan or incorporated in future updates. While there is often a fine line between mitigation and emergency preparedness, the planning committee felt strongly that in this case a strong preparedness strategy is important to mitigating the extent or severity of threats to human health, property, and economic activity, and the working group will consider all relevant strategies for addressing this hazard.

Estimated Loss Potential

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to large crowd events is $35,474,743 to $70,949,484.

Cyber Threats

Table 5.22 Hazard Overview

Hazard Type	Cyber Threats
Location/Extent	Town-wide
Vulnerability	
Severity	2.33
Probability	3
Overall Threat	7
Potential Loss	$35,474,743 to $70,949,484 (high)

Description of the Hazard

The field of cyber security is primarily concerned with protecting against damage and disruption to or theft of hardware, software, or information. Due to the variety of services they provide, local government organizations collect, store, and work with large amounts of personal data and other sensitive information. While the security of this information has always been important, increasing use of digital networks to store and transmit that information makes the security of those networks a

[42] http://www.fosters.com/article/20130502/GJNEWS_01/130509749
[43] http://www.seacoastonline.com/article/20131031/NEWS/131039951

priority. Furthermore, local governments provide critical services such as police, fire, utilities, and other services, and disruption to these services could be devastating for residents. Types of cyber threat include:[44]

- Malware: Malicious software that can damage computer systems, including monitoring system activity, transferring information, or even taking control of computers or accounts. This includes a wide variety of viruses, Trojans, ransomware, and other programs that are usually installed by clicking on infected links, files, or email attachments.
- Phishing: These attacks come in the form of emails, often disguised as a trusted or legitimate source, that attempt to extract personal data.
- Denial of Service: This is a large-scale attack designed to disrupt network service by overloading the system with connection requests. These attacks are more likely to impact large, high-profile organizations, but such attacks can occasionally have residual impacts on other organizations in the same network.
- Man in the Middle: By imitating an end user (e.g. an online bank), an attacker can extract information from a user. The attacker can then input that information to the end user to access additional information, including sensitive data such as personal or account information.
- Drive-by Downloads: Malware installed on a legitimate website causes a system to download a program simply by visiting that website. This program then downloads malware or other files directly to the user's system.
- Malvertising: This attack type downloads malware or other files to your computer when you click on an infected advertisement.
- Rogue Software: Attackers use pop-up windows to mimic legitimate anti-virus or other security software in order to trick users into clicking on links to download malware or other files.
- Sponsored Attacks: These threats, which could be perpetrated by state or non-state actors, include specific attacks to damage or disrupt infrastructure such as utilities or wastewater facilities.

Extent of the Hazard

Cyber threats are a town-wide hazard that have the potential to impact any location if critical services are disrupted, or any resident, business, contractor, or employee whose information is stored in town records in the event of a data breach. The severity of any impact depends upon the type of incident – targeted phishing attacks may be focused upon a single employee or account, while malware attacks could impact an entire department or gain access to an entire database of personal information.

Past Events and Impacts

A global ransomware attack began on May 12, 2017 that impacted more than 100,000 organizations in 150 countries.[45] Ransomware is a type of malware that encrypts a user's files, making them inaccessible, and demands a ransom to return access. While ransomware has existed for years, it is becoming more prevalent. An IBM study of the impacts of ransomware found that nearly 40% of all spam emails contain a ransomware attachment, up from 0.6% in 2015.[46] The FBI

[44] Sullivan, Megan. 8 Types of Cyber Attacks Your Business Needs to Avoid (http://quickbooks.intuit.com/r/technology-and-security/8-types-of-cyber-attacks-your-business-needs-to-avoid/)
[45] http://www.npr.org/sections/thetwo-way/2017/05/14/528355526/repercussions-continue-from-global-ransomware-attack
[46] IBM X-Force. *Ransomware: How consumers and businesses value their data*. 2016

estimates that over $1 billion in ransoms were paid by businesses and consumers in 2016 compared to $24 million in 2015.[47]

The Durham Police Department was the victim of a ransomware attack in June 2014. The attack originated from a phishing attack that linked to a Dropbox account containing malware. The malware locked access to files in a shared directory, effectively preventing the department from filing or accessing reports, sending and receiving emails, or researching the record management system. In this case, damage was limited by the fact that the officer who opened the file did not have local administrative rights to make changes to the computer or system. The Durham IT department was able to restore service by isolating and identifying infected computers and drives before reimaging computers and replacing system files with external backups. These preventative measures of limiting administrative rights and backing up data regularly to external servers meant that the biggest impact was the network downtime necessary to restore the computers and servers, and recovery was relatively quick. In total, it took the Town three days to restore full service (police servers were unavailable for two days) at a cost of $3,500.

Potential Future Impacts on Community

A town of Durham's size is most likely to be at risk from malware, phishing, and other methods of acquiring personal information. These threats may be targeted, as in the case of phishing emails sent to employee accounts, or threats that individuals encounter during their regular computer usage. Cyber threats are also constantly evolving in order to find new weaknesses in anti-virus software and other network defenses. As noted above, ransomware has become an increasingly prevalent form of malware in recent years, and is likely to continue to be a threat in years to come.

Estimated Loss Potential

Based on the 2015 valuation and the hazard ranking, the estimated potential loss due to cyber threats is $35,474,743 to $70,949,484.

Hazards Not Included in this Plan

The State of New Hampshire identifies avalanches as a hazard in the State Multi-Hazard Mitigation Plan Update of 2013. Avalanches are not included in this Plan for the Town of Durham. Avalanches were not identified by the present or past Planning Committee as a local hazard due to the fact that there are no significant mountains or topographical features where avalanches would be likely to occur. The Town will re-evaluate the need to include additional hazards to this Plan during subsequent updates of the Plan.

[47] http://www.nbcnews.com/tech/security/ransomware-now-billion-dollar-year-crime-growing-n704646

Chapter 6: Action Plan

Existing Programs and Policies

Table 6.1 displays existing, ongoing mitigation programs and policies in Durham. This matrix was updated by the Planning Committee during the preparation of this report. The matrix includes the type of existing protection (Column 1), a description of the existing protection (Column 2), the type of hazard (Column 3), the type of activity (Column 4), the area of town impacted (Column 5), enforcement (Column 6), effectiveness of the strategy (Column 7), and a status update in 2017 (Column 8).

Table 6.1 Ongoing Programs and Policies

Existing Program/Activity	Description	Type of Hazard	Type of Activity	Area of Town Covered	Enforcement	Effectiveness	2017 Update
Building Code / Permits	Requires builder to obtain all permits prior to action.	Multi-Hazard	Prevention	Town-wide	Building Official and Code Enforcement Officer.	Good	The Town will continue to obtain permits prior to action. All development will continue in accordance with the building codes adopted by the Town. Electronic means of processing permits and the ability to use GIS software would facilitate the process of issuing permits.
Elevation Certificates	A land surveyor would have to provide the Town with an elevation certificate.	Flooding	Prevention	Potential Flood Areas	Code Enforcement	Good	New FIRM maps are available for Strafford County. The program continues to be administered and maintained by the code enforcement officer to ensure that elevation certificates are properly filed, certified, and implemented. GIS would be a helpful tool. The Town will review its Special Flood Hazard Overlay district and flood regulations in summer of 2017.
Emergency Operations Plan	Emergency response procedures	Multi-Hazard	Emergency Preparedness	Town-wide	Emergency Mgt. Officer, Fire Chief	Excellent	Chapters of the EOP are updated annually. A series of table-top exercises are regularly tested.
Storm Drain Maintenance	Open/closed channel/culvert year round maintenance.	Flooding	Town Planning	Town-wide, culverts not mandated.	Public Works	Excellent	Public Works typically has 2-3 maintenance, replacement, or improvement projects at any given time. Problem areas are identified and tied to the 16-year road program. Public Works coordinates with UNH, the State, and Strafford County as necessary.
Road Design Standards	Above State minimum regulations.	Multi-Hazard	Prevention	Town-wide	Planning Board or Public Works; Durham Town Council for existing roads.	Excellent	Town meets state standards. Durham Town Council is involved with amendments to standards, funding, and accepting new roads. Town Council updates standards regularly. Recent amendments have been made to ensure bike and pedestrian safety.
EAP for all Town Dams, Inspection by State	Emergency Action Plan for all Dams	Multi-Hazard, flooding	Prevention	Town-wide	State	Excellent	All dams have an EAP. Copy is provided to the State. Town addresses any issues. Dispatch calls down a test.
Tree Maintenance	Eversource, NHCOOP, DPW	Multi-Hazard	Prevention	Town-wide	PSNH, DPW, after event, Verizon	Good	Will continue as needed. Utilities play a big role in removing and pruning hazardous trees. DPW responds to concerns and takes appropriate action.

Existing Program/Activity	Description	Type of Hazard	Type of Activity	Area of Town Covered	Enforcement	Effectiveness	2017 Update
Evacuation and Notification	Radio station notification, DCAT, Email	Multi-Hazard	Emergency Preparedness	Town-wide	Emergency Mgt. Director	Excellent	Will continue to pursue new actions for public safety. Roam Secure in 2008 allows UNH Police to send text messages to students, faculty, and staff during an emergency. Durham's website. Multi-alert system with a siren at two locations: MUB & the Horse Farm. Parents and students can subscribe to notification system. Town could utilize alerts through the state system or other options if deemed necessary. Town has flashing road signs.
Emergency Back-up Power	Generators with limited back-up power	Multi-Hazard	Emergency Preparedness	Selected buildings in Town	Emergency Management Director, department heads.	Excellent	Generators with limited back-up power at police, fire, all DPW facilities, high school. 2017 Town budget includes a generator for Town Hall. Monthly tests conducted of municipally owned generators automatically or manually. Many residents have generators. UNH, Town Hall can be used as warming and charging stations.
Shoreland Protection Act	Referenced in ordinances	Multi-Hazard	Prevention	Town-wide	Planning Board, all town boards/departments	Excellent	Will continue to be monitored for changes from the State and update local regulations as needed.
BMPs	Forestry	Multi-Hazard, Flooding, Wildfire	Town Planning	Town-wide	DPW, Building Inspector, CEO	Excellent	Will continue to implement best management practices.
	Wetlands	Flooding	Town Planning	Town-wide	Fire Dept, DPW, Business Manager	Excellent	Will continue to implement best management practices.
	Stormwater	Flooding	Town Planning	Town-wide	DPW, Planning, Business Manager	Excellent	Will continue to implement best management practices.
	Agriculture	Multi-Hazard, Erosion, Public health	Town Planning	Town-wide	Agriculture Commission, Business Manager, Planning	Excellent	Will continue to implement best management practices.
Hazardous Materials Response Team	Mutual response system with mutual area within southern New Hampshire	Hazardous Materials	Emergency Preparedness	Town-wide	Fire Dept. and Emergency Mgt.	Excellent	Continue to work with response team within southern New Hampshire. Continue to pursue training for response team as needed.
Mutual Aid	Mutual Aid System with Police.	Multi-Hazard	Emergency Preparedness	Most of Strafford County	Police Departments	Excellent	System is in place and will continue to operate. Mutual Aid System is in place and will be monitored as needed.

Existing Program/Activity	Description	Type of Hazard	Type of Activity	Area of Town Covered	Enforcement	Effectiveness	2017 Update
Mutual Aid	Mutual Aid System with Fire.	Multi-Hazard	Emergency Preparedness	Strafford, part of Rockingham Counties, Seacoast area, MA, ME	Fire Departments	Excellent	Mutual Aid System is in place and will be monitored as needed.
Mutual Aid	Unofficial program. Town responds and receives support as needed.	Multi-Hazard	Emergency Preparedness	State-wide	Highway Departments	Excellent	Police on digital, fire and DPW on analog. Radios will be replaced as vehicles are replaced.
Floodplain Management Ordinance	Land Use Ordinance	Flooding	Town Planning	Town-wide	All town boards, CEO	Excellent	Will continue to adopt and revise ordinance as needed. Completed. Updates in the most recent zoning ordinance (2015).
Local Shoreland	Land Use Ordinance	Flooding	Town Planning	Town-wide	All town boards, CEO	Excellent	Will continue to adopt and revise ordinance as needed
Wetland	Land Use Ordinance, more stringent standards than state	Flooding	Town Planning	Town-wide	All town boards, CEO	Excellent	Will continue to adopt and revise ordinance as needed

Effectiveness:
Excellent – The existing program works as intended and is exceeding its goals
Good – The existing program works as intended and meets its goals
Average – The existing program does not work as intended and/or does not meet its goals
Poor – This existing program is failing to do what it is intended to do and is negatively impacting the community

2017 Update:
Recommendations for improvement

Table 6.2 displays mitigation strategies identified during the development of Durham's Multi-Hazard Mitigation Plan in 2007 and 2012. The Committee provided a status update for each mitigation strategy during the preparation of the current Plan. The Planning Committee members then ranked past mitigation actions from prior plan as high, medium, and low priority.

Table 6.2 Accomplishments since Prior Plan(s) Approval

Rank	Strategy	2017 Update
H	Install back-up generator in Town Hall	Ongoing. In 2017 budget for new Town Hall
H	Upgrade drainage system	Ongoing. 2017 funding for Longmarsh and Hamel Brook
N/A	Upgrade the radio station that is used for information during emergency and educate community on what station to tune into during emergency.	Removed from Plan. Local radio station would do an announcement, not the Town.
L	Update Contractor/Operator List once per year.	Ongoing. Updated with snow program in November
H	Improve Wiswall Dam.	Ongoing. Bridge done, spillway not, dam has had repairs. In CIP, funded, working through best strategies.
L	Obtain NFIP brochures from FEMA and have them available at the Town Offices for new developers and current homeowners.	Ongoing.
H	Maintain transportation infrastructure by identifying potential areas of concern recognized in this plan.	Ongoing. Longmarsh to be completed. Safety and bike lanes and traffic issues addressed on an ongoing basis.
L	Continue to provide outreach assistance to elderly and special needs populations by organizing staff and coordinating within Town departments.	Ongoing. Town has a fairly good understanding of what is going on. Town does not have a list of elderly. Meals on Wheels will check / call with Police Department. In the past, officers have gone out to homes. Friday updates have encouraged residents to check on their neighbors.
H	Design and construct new culverts and nearby outfalls on Coe Drive at Littlehale Brook crossing on Oyster River Road near Garden Lane, on Dame Road at Crommets Creek crossing, on Longmarsh Road at Longmarsh crossing. These projects are assumed to include some degree of stream bank restoration and possible off-site erosion control measures.	Coe Drive completed. Oyster River Road completed. Dame Road/Crommets Creek completed. Longmarsh pending in 2017.
N/A	The Old Concord Road Wastewater pump station was constructed in 1984 and is currently in need of substantial renovations and upgrades.	Completed
H	Installation of three 60" culverts to relieve flooding conditions along LaRoche Brook on Bennett Road, as well as the installation of two 60" concrete culverts downstream of Bennett Road on the LaRoche Farm. In addition this project will raise the grade of 175 feet of Bennett Road by 18 inches.	Deferred. Three 60" culverts on LaRoche in FEMA queue, application has been submitted. This is all one project.

M	The 8" College Brook Interceptor runs along College Brook from Rudman Pump Station to the Memorial Union Building and is in a very environmentally sensitive area. It is 1,645 feet of old clay pipe with cracks and tree root problems and needs to be repaired.	Deferred. Has not been repaired. Shared with UNH. On books as a project. Issue sis size, smaller pipe. UNH is looking at putting a park deck to double the capacity of parking and would have to repair the culvert at that time.
N/A	Repairs to Crommets Creek Bridge, which will improve the safety of this structure and increase the load limit. Currently this bridge is on the NH DOT Red List of deficient bridges in NH.	Completed to the extent that the Town intends to complete. The bridge has been shored up and has a new deck and the same width. Needs a guard rail to be removed from the list but is a very small bridge and will not be widened to have a guard rail.
N/A	This project will install either a 36-foot long bridge or five 60" concrete culverts on Longmarsh Road. This project will also raise the grade along 200 feet of Longmarsh Road by 14".	This strategy is already identified above in this table.
N/A	Interior and exterior painting of the 3,000,000-gallon Foss Farm water storage tank and the interior and exterior of the 650,000 gallon Beech Hill water storage tank.	Completed
N/A	Replacement of Wastewater diesel generator. Runs the Wastewater Treatment	Completed in 2017
H	This 18-inch diameter wastewater force main pipe carries all of the Town's wastewater (up to 2.4 million gallons per day) under pressure from the Dover Road Wastewater Pump Station to Durham's Wastewater Treatment Plant. This pipe was constructed of asbestos cement in the mid-1960s and is approaching the end of its useful life. It is anticipated that the pipe will be replaced along a similar alignment using modern methods and materials that are longer lasting.	Ongoing. To be completed in 2018. Preliminary engineering occurring at the time of the preparation of this Plan.

Status Update:

Completed Action – This program continues to be an implemented mitigation action item since the last updated plan was developed

Deferred Action – At the time of developing this plan, more time is required for completion

Removed Action – This existing program is no longer a priority to the Town

Ongoing Action – This program will occur throughout the life of the plan

Gaps in Existing Measures

During a review of existing mitigation strategies, the Committee identified the following gaps and needs:

Feasibility & Prioritization

A technique known as a STAPLEE evaluation, which was developed by FEMA, was used to evaluate new mitigation strategies based on a set of criteria (see below). The STAPLEE method is commonly used by public administration officials and planners.

S	**Social:**	Is the proposed strategy socially acceptable to the community? Is there an equity issue involved that would result in one segment of the community being treated unfairly?
T	**Technical:**	Will the proposed strategy work? Will it create more problems than it solves?
A	**Administrative:**	Can the community implement the strategy? Is there someone to coordinate and lead the effort?
P	**Political:**	Is the strategy politically acceptable? Is there public support both to implement and to maintain the project?
L	**Legal:**	Is the community authorized to implement the proposed strategy? Is there a clear legal basis or precedent for this activity?
E	**Economic:**	What are the costs and benefits of this strategy? Does the cost seem reasonable for the size of the problem and the likely benefits?
E	**Environmental:**	How will the strategy impact the environment? Will it need environmental regulatory approvals?

The Committee evaluated each mitigation strategy using the STAPLEE and ranked each of the criteria as poor, average, or good. These rankings were assigned the following scores: *Poor=1; Average=2; Good=3.*

The following questions were used to guide further prioritization and action:

- Does the action reduce damage?
- Does the action contribute to community objectives?
- Does the action meet existing regulations?
- Does the action protect historic structures?
- Can the action be implemented quickly?

The prioritization exercise helped the committee evaluate the new hazard mitigation strategies that they had brainstormed throughout the multi-hazard mitigation planning process. While all actions would help improve the Town's multi-hazard and responsiveness capability, funding availability will be a driving factor in determining what and when new mitigation strategies are implemented.

Table 6.3 displays new and ongoing mitigation strategies identified by the Planning Committee.

Table 6.3 Future Mitigation Actions & STAPLEE								
New Mitigation Project	S	T	A	P	L	E	E	Total
Culvert upgrade to a bridge at Long Marsh Road to address flooding concerns. Current culverts get overwhelmed. Will provide second access point for Bennett Road residents	3	3	3	3	3	3	3	21
Wagon hill farm erosion control project. Restoring and maintaining natural shoreline to protect against erosion	3	2	3	3	3	3	3	20
Bagdad Road dam removal to remove flood event. Adding large culvert/bridge to allow water flow	2	3	3	2	3	3	3	19
Friday updates - educate public about	3	2	3	3	3	3	3	20

threats (disease et al)			Friday updates already in use; all departments have ability to contribute					
Make public aware of cleaning up loose brush to lessen risk of fire. Code enforcement making public aware as issues come up.	3	2	2	3	3	3	3	19
Town of Durham/UNH working group to discuss ways to decrease frequency and intensity of large-scale student celebretory events. Working group may identify additional strategies or actions with associated cost analysis in the future.	3	2	3	3	3	3	3	20
Communications system improvements for coordinating advanced notice and response to all threats and hazards (to include police, fire, EMS, public works)	3	3	3	2	3	3	3	20
Cyber security awareness training (could include general training sessions or active assessments of staff awareness)	3	2	3	2	3	2	3	18
Provide antivirus, firewall, information	3	3	3	3	3	3	3	21

backup, and other support services to improve cyber security								
Reviewing overall security systems and approaches with specific focus on impacts and need for cyber security to be included in all policies	3	2	2	3	3	3	3	19
Using tick-killing fungus in public parks as an alternative to pesticides	3	2	2	2	3	2	3	17
		Technology is in early stages and may need more work before it is practical in Durham					More environmentally appropriate approach to tick problems than pesticides	
Developing town policies for identifying qualified vendors of software as a service to limit exposure to cyber threats.	3	2	3	3	2	2	3	18
Install back-up generator in Town Hall	3	3	3	3	3	3	2	20

Upgrade drainage system	3	3	3	3	3	3	3	21
Update Contractor/Operator List once per year	3	3	2	3	3	3	3	20
Improve Wiswell Dam	3	3	2	3	3	3	3	20
Obtain NFIP brochures from FEMA and have them available at the Town Offices for new developers and current homeowners	3	3	3	3	3	3	3	21
Maintain transportation infrastructure by identifying potential areas of concern recognized in theis plan.	3	3	3	3	3	2	3	20
						Budgetary Constraints		
Continue to provide outreach assistance to elderly and special needs populations by organizing staff and coordinating within Town departments	3	3	3	3	3	3	3	21

Design and construct new culverts and nearby outfalls on Coe Drive at Littlehale Brook crossing on Oyster River Road near Garden Lane, on Dame Road at Crommets Creek crossing, on Longmarsh Road at Longmarsh crossing. These projects are assumed to include some degree of stream bank restoration and possible off-site erosion control measures.	3	3	3	3	3	3	3	21
Installation of three 60" culverts to relieve flooding conditions along LaRoche Brook on Bennett Road, as well as the installation of two 60" concrete culverts downstream of Bennett Road on the LaRoche Farm. In addition this project will raise the grade of 175 feet of Bennett Road by 18 inches.	3	3	3	3	3	3	3	21
The 8" College Brook Interceptor runs along College Brook from Rudman Pump Station to the Memorial Union Building and is in a very environmentally sensitive area. It is 1,645 feet of old clay pipe with cracks and tree root problems and needs to be repaired.	3	3	3	3	3	3	3	21

This 18-inch diameter wastewater force main pipe carries all of the Town's wastewater (up to 2.4 million gallons per day) under pressure from the Dover Road Wastewater Pump Station to Durham's Wastewater Treatment Plant. This pipe was constructed of asbestos cement in the mid-1960s and is approaching the end of its useful life. It is anticipated that the pipe will be replaced along a similar alignment using modern methods and materials that are longer lasting.	3	3	3	3	3	3	3	21

New Mitigation Strategies

Table 6.4 New Mitigation Strategies

New Mitigation Project	Type of Hazard	Affected Location	Type of Activity	Responsibility	Funding	Cost Effectiveness	Timeframe
							**Ongoing/Continuous*
						Low = < $5,000	*6 months - 1 year*
						Medium = $5,000 - $10,000	*1 - 2 years*
						High = > $10,000	*2 - 5 years*
Culvert upgrade to a bridge at Long Marsh Road to address flooding concerns. Current culverts get overwhelmed. Will provide second access point for Bennett Road residents	Flooding	Long Marsh Road, with implications for Bennett Road and 108	Culvert upgrade	Public Works	FEMA	High = > $10,000	1-2 years
Wagon hill farm erosion control project. Restoring and maintaining natural shoreline to protect against erosion	Flooding	Wagon Hill	Shoreline restoration	Public Works	NOAA and DES Coastal grants in place. Town to seek additional grants and contribute town funds if necessary.	High = > $10,000	1-2 years

Bagdad Road dam removal to remove flood event. Adding large culvert/bridge to allow water flow	Flooding	Bagdad Road	Dam removal	Public Works	Town applying for grants and may use town funds to match grants as needed	High = > $10,000	1-2 years
Friday updates - educate public about threats (disease et al)	All	everywhere	Public Awareness	All departments should contribute as necessary	Existing budget	Low = < $5,000	ongoing/continuous
Make public aware of cleaning up loose brush to lessen risk of fire. Code enforcement making public aware as issues come up.	Fire	everywhere	Public Awareness	Code Enforcement	Existing budget	Low = < $5,000	ongoing/continuous
Town of Durham/UNH working group to discuss ways to decrease frequency and intensity of large-scale student celebretory events. Working group may identify additional strategies or actions with associated cost analysis in the future.	Large crowd events	Town-wide with focus on downtown/UNH	Public Awareness	Public Safety	Existing budget	Low = < $5,000	1-2 years

Communications system improvements for coordinating advanced notice and response to all threats and hazards (to include police, fire, EMS, public works)	All	Town-wide	Communications	Fire Chief	Existing budget unless outside funding sources are identified	High = > $10,000	3-4 years
Cyber security awareness training (could include general training sessions or active assessments of staff awareness)	Cyber threats	Town-wide	Awareness/ cyber security	IT Administrator	Funding sources to be identified	Medium = $5,000 - $10,000	3-4 years
Provide antivirus, firewall, information backup, and other support services to improve cyber security	Cyber threats	Town-wide	Cyber security	IT Administrator	Existing Budget	Low = < $5,000	ongoing/continuous
Reviewing overall security systems and approaches with specific focus on impacts and need for cyber security to be included in all policies	Cyber threats	Town-wide	Cyber security	IT Administrator	Existing Budget	Low = < $5,000	ongoing/continuous

Using tick-killing fungus in public parks as an alternative to pesticides	Tick-borne diseases	Town-wide	Pest Control	Public Health	TBD	High = > $10,000	ongoing/continuous
Developing town policies for identifying qualified vendors of software as a service to limit exposure to cyber threats.	Cyber threats	Town-wide	Cyber security	IT Administrator	Existing Budget	Low = < $5,000	ongoing/continuous

Implementation Schedule for Prioritized Strategies

After reviewing the finalized STAPLEE numerical ratings, the Team prepared to develop the Implementation Plan (Table 21). To do this, the Team developed an implementation plan that outlined the following:

- ∴ Type of hazard
- ∴ Affected location
- ∴ Type of Activity
- ∴ Responsibility
- ∴ Funding
- ∴ Cost Effectiveness; and
- ∴ Timeframe

The following questions were asked in order to develop an implementation schedule for the identified priority mitigation strategies.

WHO? Who will lead the implementation efforts? Who will put together funding requests and applications?

WHEN? When will these actions be implemented, and in what order?

HOW? How will the community fund these projects? How will the community implement these projects? What resources will be needed to implement these projects?

In addition to the prioritized mitigation projects, Table 21, Implementation Plan, includes the responsible party (WHO), how the project will be supported (HOW), and what the timeframe is for implementation of the project (WHEN).

Chapter 7: Monitoring, Evaluating, and Updating the Plan

Introduction

A good mitigation plan must allow for updates where and when necessary, particularly since communities may suffer budget cuts or experience personnel turnover during both the planning and implementation states. A good plan will incorporate periodic monitoring and evaluation mechanisms to allow for review of successes and failures or even just simple updates.

Multi-Hazard Plan Monitoring, Evaluation, and Updates

To track programs and update the mitigation strategies identified through this process, the Town will review the Plan annually and after a hazard event. Additionally, the Plan will undergo a formal review and update at least every five years and obtain FEMA approval for this update or any other major changes done in the Plan at any time. The Emergency Management Director is responsible for initiating the review and will consult with members of the Multi-Hazard Mitigation Planning Committee identified in this plan. The public will be encouraged to participate in any updates and will be given the opportunity to be engaged and provide feedback through such means as periodic presentations on the plan at town functions, annual questionnaires or surveys, and posting on social media/interactive websites. Public announcements will be made through advertisements in local papers, postings on the Town website, and posters disseminated throughout the Town. A formal public meeting will be held before reviews and updates are official.

Changes will be made to the Plan to accommodate projects that have failed or are not considered feasible after a review for their consistency with STAPLEE, the timeframe, the community's priorities or funding resources. Priorities that were not ranked high, but identified as potential mitigation strategies, will be reviewed as well during the monitoring and update of the plan to determine feasibility of future implementation. In keeping with the process of adopting this Multi-Hazard Mitigation Plan, a public meeting to receive public comment on plan maintenance and updating will be held during the annual review period and before the final product is adopted by the administration. Chapter 8 contains a representation of a draft resolution for Durham to use once a conditional approval is received from HSEM.

Integration with Other Plans

The 2004 and 2012 Multi-Hazard Mitigation Plan was used during periodic updates to the Durham Master Plan. Input on impacts to roads and other critical infrastructure from hazards was included in relevant master plan sections. Both plans were also used during capital improvements planning updates and prioritization of municipal culverts and stream crossings for repair and replacement schedules. Information from the Town's Zoning Ordinance was utilized in the development of this Plan.

This Plan will only enhance mitigation if integrated with all other town plans and activities. Durham will take the necessary steps to incorporate the mitigation strategies and other information contained in this plan with other town activities, plans and mechanisms, such as comprehensive land use planning, capital improvements planning, site plan regulations, and building codes to guide and control development in the Town of Durham, when appropriate. The local government will refer to this Plan and the strategies identified when updating the Town's Master Plan, Capital Improvements Program, Zoning Ordinances and Regulations, and Emergency Operations Plan. The Town Council and the Multi-Hazard Mitigation Planning Committee will work with Town officials to incorporate elements of this Plan into other planning mechanisms, when appropriate. In addition, the Town will review and make note of instances when this has been done and include it as part of their annual review of the Plan.

Chapter 8: Plan Adoption

Conditional Approval Letter from HSEM

James Burdin

From: Hazard Mitigation Planning <HazardMitigationPlanning@dos.nh.gov>
Sent: Wednesday, August 30, 2017 9:44 AM
To: 'James Burdin'
Cc: 'Todd Selig'; Marinaccio, Alexander
Subject: Durham, NH - Approvable Pending Adoption

Good morning!

The Department of Safety, Division of Homeland Security & Emergency Management (HSEM) has completed its review of the Durham, NH Hazard Mitigation Plan and found it approvable pending adoption. Congratulations on a job well done!

With this approval, the jurisdiction meets the local mitigation planning requirements under 44 CFR 201 **pending HSEM's receipt of electronic copies of the adoption documentation and the final plan**.

Acceptable electronic formats include Word or PDF files and must be submitted to us via email at HazardMitigationPlanning@dos.nh.gov. Upon HSEM's receipt of these documents, notification of formal approval will be issued, along with the final Checklist and Assessment.

The approved plan will be submitted to FEMA on the same day the community receives the formal approval notification from HSEM. FEMA will then issue a Letter of Formal Approval to HSEM for dissemination that will confirm the jurisdiction's eligibility to apply for mitigation grants administered by FEMA and identify related issues affecting eligibility, if any. If the plan is not adopted within one calendar year of HSEM's Approval Pending Adoption, the jurisdiction must update the entire plan and resubmit it for HSEM review. If you have questions or wish to discuss this determination further, please contact me at Whitney.Welch@dos.nh.gov or 603-223-3667.

Thank you for submitting the Durham, NH Hazard Mitigation Plan and again, congratulations on your successful community planning efforts.

Sincerely,

Whitney

Hazard Mitigation Planning
NH Homeland Security and Emergency Management
33 Hazen Drive
Concord, NH 03301
NEW: 603-223-3667
603-223-3609 (fax)

1

Certificate of Adoption

TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824
Tel: 603/868-5571
Fax: 603/868-1858

CERTIFICATE OF ADOPTION

A Resolution Adopting the Durham Hazard Mitigation Plan

WHEREAS, the Town of Durham received funding from New Hampshire Homeland Security and Emergency Management under a Pre-Disaster Mitigation Grant to assist in the preparation of the Multi-Hazard Mitigation Plan 2017 Update; and

WHEREAS, several public planning meetings were held between February and May 2017 regarding the development and review of the Multi-Hazard Mitigation Plan 2017 Update; and

WHEREAS, New Hampshire Homeland Security and Emergency Management has rendered its approval of the Multi-Hazard Mitigation Plan 2017 Update, pending adoption, on August 30, 2017; and

WHEREAS, the Multi-Hazard Mitigation Plan 2017 Update contains several potential future projects to mitigate hazard damage in the Town of Durham; and

WHEREAS, the Administrator of the Town of Durham is charged by municipal charter with the preservation of the health, safety, and welfare of persons and property and shall see to the enforcement of the ordinances of the Town, the Town Charter, and the laws of the state of New Hampshire; and

WHEREAS, Section 4.5 of the Durham Town Charter confers upon the Administrator such other powers and duties as may be conferred upon Mayors of cities and Selectmen of towns by general laws; and

NOW, THEREFORE, BE IT RESOLVED that the Durham Administrator does hereby adopt the 2017 update to the All-Hazard Mitigation Plan.

ADOPTED AND SIGNED this **11th** day of **September, 2017.**

Todd I. Selig
Administrator

ATTEST:

Barbara Landgraf Deputy T.C.
Lorrie Pitt, Town Clerk-Tax Collector

Printed on Recycled Paper

Final Approval Letter from FEMA

U.S. Department of Homeland Security
FEMA Region 1
99 High Street, Sixth Floor
Boston, MA 02110-2132

FEMA

DEC 06 2017

Whitney Welch
State Hazard Mitigation Officer
NH Dept. of Safety HS & EM
33 Hazen Drive
Concord, NH 03303

Dear Ms. Welch:

We would like to acknowledge the Town of Durham and the State of New Hampshire for their dedication and commitment to mitigation planning.

As outlined in the FEMA-State Agreement for FEMA-DR-4316 your office has been delegated the authority to review and approve local mitigation plans under the Program Administration by States Pilot Program. On **September 27, 2017** our Agency was notified that your office completed its review of the Multi-Hazard Mitigation Plan Update 2017, Town of Durham, NH and determined it meets the requirements of 44 C.F.R. Pt. 201.

With this plan approval, the Town of Durham is eligible to apply to New Hampshire Homeland Security and Emergency Management for mitigation grants administered by FEMA. Requests for mitigation funding will be evaluated individually according to the specific eligibility requirements identified for each of these programs. A specific mitigation activity or project identified in your community's plan may not meet the eligibility requirements for FEMA funding; even eligible mitigation activities or projects are not automatically approved.

Approved mitigation plans are eligible for points under the National Flood Insurance Program's Community Rating System (CRS). Complete information regarding the CRS can be found at http://www.fema.gov/national-flood-insurance-program-community-rating-system, or through your local floodplain administrator.

The Multi-Hazard Mitigation Plan Update 2017, Town of Durham, NH must be reviewed, revised as appropriate, and resubmitted to New Hampshire Homeland Security and Emergency Management for approval within **five years of the plan approval date of September 27, 2017** in order to maintain eligibility for mitigation grant funding. We encourage the Town to continually update the plan's assessment of vulnerability, adhere to its maintenance schedule, and implement, when possible, the mitigation actions proposed in the plan.

DEC 05 2017

Whitney Welch
Page 2

Once again, thank you for your continued dedication to public service demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please do not hesitate to contact Josiah "Jay" Neiderbach at (617) 832-4926.

Sincerely,

Paul F. Ford
Acting Regional Administrator

PFF: jn

cc: Fallon Reed, Chief of Planning, New Hampshire
Jennifer Gilbert, New Hampshire State NFIP Coordinator
Kayla Henderson, Hazard Mitigation Planner, New Hampshire

Appendices

Appendix A: Bibliography

Appendix B: Planning Process Documentation

Appendix C: Summary of Possible All-Hazard Mitigation Strategies

Appendix D: Technical and Financial Assistance for All-Hazard Mitigation
- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM)
- Flood Mitigation Assistance (FMA)

Appendix E: Climate Adaptation Chapter, 2013

Appendix F: Vulnerability Assessment, 2017

Appendix A: Bibliography

Documents

- Local Mitigation Plan Review Guide, FEMA, October 1, 2011
- Multi-Hazard Mitigation Plans
    - Town of Strafford, 2017
    - Town of Milton, 2017
    - Town of Durham, 2012
- State of New Hampshire Multi-Hazard Mitigation Plan (2013) - State Hazard Mitigation Goals
- Disaster Mitigation Act (DMA) of 2000, Section 101, b1 & b2 and Section 322a http://www.fema.gov/library/viewRecord.do?id=1935
- Economic & Labor Market Information Bureau, NH Employment Security, 2015; Census 2010 and Revenue Information
- NCDC [National Climatic Data Center, National Oceanic and Atmospheric Administration]. 2017. Storm Events

Appendix B: Planning Process Documentation

Agendas

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #1

February 21, 2017
12:00PM – 1:15PM

Durham Town Offices
8 Newmarket Road
Durham, New Hampshire 03824

Agenda

1. Introductions
2. Review update process (Chapter 1)
    a. Responsibilities of committee
    b. In-kind match documentation
    c. Steps towards adoption
3. Committee input on 2012 plan
4. Review and update past mitigation programs, policies, and strategies (Chapter 6)
5. Review past development trends and community profile (Chapter 2)
6. Adjourn

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #2

March 7, 2017
10:00AM-12:00PM

Durham Town Offices
8 Newmarket Road
Durham, New Hampshire 03824

Agenda

1. Introductions
2. Continue to review and update past mitigation programs, policies, and strategies (Chapter 6)
3. Review past development trends and community profile (Chapter 2)
4. Review Critical Facilities and Key Resources (Chapter 3)
5. Adjourn

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #3

March 30, 2017
10:00AM-12:00PM

Durham Town Offices
8 Newmarket Road
Durham, New Hampshire 03824

Agenda

1. Introductions
2. Continue to review Critical Facilities and Key Resources (Chapter 3)
3. Review National Flood Insurance Program (Chapter 4)
4. Review Declared Disasters and Emergency Declarations (Chapter 5 Excerpt)
5. Preview Hazard Vulnerability Table and List of Hazard Events (Chapter 5 Excerpt)
6. Adjourn

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #4

May 4, 2017
10:00AM-12:00PM

Durham Town Offices
8 Newmarket Road
Durham, New Hampshire 03824

Agenda

1. Introductions
2. Review Disasters with emphasis on local impacts (Chapter 5)
3. Identify new strategies and actions (Chapter 6)
4. Adjourn

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #5

May 25, 2017
10:00AM-12:00PM

Durham Town Offices
8 Newmarket Road
Durham, New Hampshire 03824

Agenda

1. Introductions
2. Finish review of disasters with emphasis on local impacts (Chapter 5 – cyber threats and large crowd events)
3. Identify new strategies and actions (Chapter 6 – cyber threats and large crowd events)
4. Review new mitigation strategies and prepare Implementation Plan
5. Discuss the plan wrap-up, adoption, and approval process
6. Adjourn

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #1

February 21, 2017
12:00PM – 1:15PM

Durham Town Offices
8 Newmarket Road
Durham, NH 03824

Sign In

Name	Position/Affiliation	Email Address	Time Spend Preparing for Meeting
Rachel Gasowski	Parks & Recreation	rgasowski@ci.durham.nh.us	~~1 month~~
Audrey Cline	Codes	acline@ci.durham.nh.us	~~1 month~~ 15 minutes
Luke Vincent	IT	lvincent@ci.durham.nh.us	30 min
MICHAEL BEHRENDT	PLANNING	MBEHRENDT@ci.DURHAM.NH.US	~~1 hour~~ ½ hour
John Parry	U.S. Forest ~~Service~~ Service	jparry@fs.fed.us	0
Todd Selig	Administrator	TSELIG@ci.durham.nh.us	1.5 HR
DAVE KURZ	Police Chief	dkurz@ci.durham.nh.us	1 month
Mike Lynch	PUBLIC WORKS	MLYNCH@CI.DURHAM.NH.US	1 HOUR
DAVE EMANUEL	ASST. FIRE CHIEF	DEMANUEL@CI.DURHAM.NH.US	2 HR
Kenny Rotner	TOWN COUNCILOR	tlsinnh@aol.com	15 mins.
Mary Ellen Humphrey	Economic Development Director	mehumphrey@ci.durham.nh.us	30min.
April Talon	Town Engineer Durham	atalon@ci.durham.nh.us	0

*Volunteer rate = $23.56

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #2

March 7, 2017
10:00AM – 12:00PM

Durham Town Offices
8 Newmarket Road
Durham, NH 03824

Sign In

Name	Position/Affiliation	Email Address	Time Spend Preparing for Meeting
Jim Rice	Assessor	JRice@ci.Durham.NH.US	30 min
Todd Selig	Administrator	TSelig@ci.durham.nh.us	30 min.
Mary Ellen Humphrey	Economic Developer	mary.ellen.humphrey@gmail.com	1 hour
Michael Behrendt	Town Planner	MBehrendt@ci.durham.nh.us	30 min
Mike Lynch	DPW Director	MLynch@ci.Durham.nh.us	20 min
Craig Jablonski	Business Manager	gjablonski@ci.durham.nh.us	30 min
Kenny Rotner	Town Council	Hslinh@aol.com	45 min
Audrey Cline	CEO/Building Official	acline@ci.durham.nh.us	30
Corey Landry	Fire Chief	Clandry@ci.durham.NH.US	30
DAVE KURZ	POLICE CHIEF	dkurz@ci.durham.nh.us	30

*Volunteer rate = $23.56

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #3

March 30, 2017
10:00AM – 12:00PM

Durham Town Offices
8 Newmarket Road
Durham, NH 03824

Sign In

Name	Position/Affiliation	Email Address	Time Spend Preparing for Meeting	Is your attendance at this meeting paid for by federal funds?
Mary Ellen Humphrey	Economic Dev. Dir.	mehumphrey@ci.durhamnh.us	1 hour	Yes/No
DAVE KURZ	Police Chief	dkurz@ci.durham.nh.us	1 hour	Yes/No
Audrey Cline	Code Official	acline@ci.durham.nh.us	10	Yes/No
[illegible]	RPC - Director	[illegible]@ci.durham.nh.us	30 min	Yes/No
Kenny Rotner	Town Councilor	[illegible]	45 mins	Yes/No
Todd Selig	Administrator	tselig@ci.durham.nh.us	30 min	Yes/No
DAVE EMANUEL	ASST. FIRE CHIEF	DEMANUEL@CI.DURHAM.NH.US	30	Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No

*Volunteer rate = $23.56

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #4

May 4, 2017
10:00AM – 12:00PM

Durham Town Offices
8 Newmarket Road
Durham, NH 03824

Sign In

Name	Position/Affiliation	Email Address	Time Spend Preparing for Meeting	Is your attendance at this meeting paid for by federal funds?
Mary Ellen Humphrey	Econ. Dev. Director	mehumphrey@ci.durham.nh.us	1 hour	Yes/No
John Parry	Resident U.S. Forest Service	jparry@fs.fed.us	30 min.	Yes/No
David Kurz	Police Chief	dkurz@ci.durham.nh.us	30	Yes/No
Audrey Cline	Code Enforcement	acline@ci.durham.nh.us	30	Yes/No
Mike Lynch	Director, DPW	mlynch@ci.durham.nh.us	30 min	Yes/No
Kenny Rotner	TOWN COUNCIL	tlsinnh@aol.com	30 min	Yes/No
DAVE EMANUEL	ASST. FIRE CHIEF	DEmanuel@ci.durham.nh.us	30 min	Yes/No
Todd Selig	Administrator	TSelig@ci.durham.nh.us	1 hr	Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No

*Volunteer rate = $23.56

Town of Durham, New Hampshire

Multi-Hazard Mitigation Planning Committee Meeting #5

May 25, 2017
10:00AM – 12:00PM

Durham Town Offices
8 Newmarket Road
Durham, NH 03824

Sign In

Name	Position/Affiliation	Email Address	Time Spend Preparing for Meeting	Is your attendance this meeting paid fo by federal funds?
Todd Selig	Administrator	tselig@ci.durham.nh.us	30 min	Yes/No
Dave Kurz	Police Chief	dkurz@ci.durham.nh.us	½ hr	Yes/No
Luke Vincent	IT Manager	lvincent@ci.durham.nh.us	½ hr	Yes/No
MICHAEL BEHREND	TOWN PLANNER	MBEHREND@CI.DURHAM.NH.US	½ Hour	Yes/No
Kenny Rother	TOWN COUNCIL	TISINNH@AOL.COM	20 min	Yes/No
DAVE EMANUEL	ASST. FIRE CHIEF	DEMANUEL@CI.DURHAM.NH.US	0.5 HR	Yes/No
April Talon	Town Engineer	atalon@ci.durham.nh.us		Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No
				Yes/No

*Volunteer rate = $23.56

Appendix C: Summary of Possible All-Hazard Mitigation Strategies

I. RIVERINE MITIGATION

A. Prevention

Prevention measures are intended to keep the problem from occurring in the first place, and/or keep it from getting worse. Future development should not increase flood damage. Building, zoning, planning, and/or code enforcement personnel usually administer preventative measures.

1. **Planning and Zoning[48] -** Land use plans are put in place to guide future development, recommending where - and where not - development should occur and where it should not. Sensitive and vulnerable lands can be designated for uses that would not be incompatible with occasional flood events - such as parks or wildlife refugees. A Capital Improvements Program (CIP) can recommend the setting aside of funds for public acquisition of these designated lands. The zoning ordinance can regulate development in these sensitive areas by limiting or preventing some or all development - for example, by designating floodplain overlay, conservation, or agricultural districts.

2. **Open Space Preservation -** Preserving open space is the best way to prevent flooding and flood damage. Open space preservation should not, however, be limited to the floodplain, since other areas within the watershed may contribute to controlling the runoff that exacerbates flooding. Land Use and Capital Improvement Plans should identify areas to be preserved by acquisition and other means, such as purchasing easements. Aside from outright purchase, open space can also be protected through maintenance agreements with the landowners, or by requiring developers to dedicate land for flood flow, drainage and storage.

3. **Floodplain Development Regulations -** Floodplain development regulations typically do not prohibit development in the special flood hazard area, but they do impose construction standards on what is built there. The intent is to protect roads and structures from flood damage and to prevent the development from aggravating the flood potential. Floodplain development regulations are generally incorporated into subdivision regulations, building codes, and floodplain ordinances.
    a. **Subdivision Regulations:** These regulations govern how land will be divided into separate lots or sites. They should require that any flood hazard areas be shown on the plat, and that every lot has a buildable area that is above the base flood elevation.
    b. **Building Codes**: Standards can be incorporated into building codes that address flood proofing for all new and improved or repaired buildings.
    c. **Floodplain Ordinances:** Communities that participate in the National Flood Insurance Program are required to adopt the minimum floodplain management regulations, as developed by FEMA. The regulations set minimum standards for subdivision regulations and building codes. Communities may adopt more stringent standards than those set forth by FEMA.
4. **Stormwater Management** - Development outside of a floodplain can contribute significantly to flooding by covering impervious surfaces, which increases storm water runoff. Storm water management is usually addressed in subdivision regulations. Developers are typically required to build retention or detention basins to minimize any increase in runoff caused by new or expanded impervious surfaces, or new drainage systems. Generally, there is a prohibition against storm water leaving the site at a rate higher than it did before the development. One technique is to use wet basins as part of the landscaping plan of a development. It might even be possible to site these basins

[48] All zoning should be carefully reviewed on a consistent basis by municipal officials to make sure guidelines are up-to-date and towns are acting in accordance with best management practices.

based on a watershed analysis. Since detention only controls the runoff rates and not volumes, other measures must be employed for storm water infiltration - for example, swales, infiltration trenches, vegetative filter strips, and permeable paving blocks.

5. **Drainage System Maintenance -** Ongoing maintenance of channel and detention basins is necessary if these facilities are to function effectively and efficiently over time. A maintenance program should include regulations that prevent dumping in or altering water courses or storage basins; regrading and filling should also be regulated. Any maintenance program should include a public education component, so that the public becomes aware of the reasons for the regulations. Many people do not realize the consequences of filling in a ditch or wetland, or regrading.

B. Property Protection

Property protection measures are used to modify buildings subject to flood damage, rather than to keep floodwaters away. These may be less expensive to implement, as they are often carried out on a cost-sharing basis. In addition, many of these measures do not affect a building's appearance or use, which makes them particularly suitable for historical sites and landmarks.

1. **Relocation -** Moving structures out of the floodplain is the surest and safest way to protect against damage. Relocation is expensive, however, so this approach will probably not be used except in extreme circumstances. Communities that have areas subject to severe storm surges, ice jams, etc. might want to consider establishing a relocation program, incorporating available assistance.

2. **Acquisition -** Acquisition by a governmental entity of land in a floodplain serves two main purposes: 1) it ensures that the problem of structures in the floodplain will be addressed; and 2) it has the potential to convert problem areas into community assets, with accompanying environmental benefits. Acquisition is more cost effective than relocation in those areas that are subject to storm surges, ice jams, or flash flooding. Acquisition, followed by demolition, is the most appropriate strategy for those buildings that are simply too expensive to move, as well as for dilapidated structures that are not worth saving or protecting. Acquisition and subsequent relocation can be expensive, however, there are government grants and loans that can be applied toward such efforts.

3. **Building Elevation -** Elevating a building above the base flood elevation is the best on-site protection strategy. The building could be raised to allow water to run underneath it, or fill could be brought in to elevate the site on which the building sits. This approach is cheaper than relocation, and tends to be less disruptive to a neighborhood. Elevation is required by law for new and substantially improved residences in a floodplain, and is commonly practiced in flood hazard areas nationwide.

4. **Floodproofing -** If a building cannot be relocated or elevated, it may be floodproofed. This approach works well in areas of low flood threat. Floodproofing can be accomplished through barriers to flooding, or by treatment to the structure itself.
    a. **Barriers:** Levees, floodwalls and berms can keep floodwaters from reaching a building. These are useful, however, only in areas subject to shallow flooding.
    b. **Dry Floodproofing:** This method seals a building against the water by coating the walls with waterproofing compounds or plastic sheeting. Openings, such as doors, windows, etc. are closed either permanently with removable shields or with sandbags.
    c. **Wet Floodproofing:** This technique is usually considered a last resort measure, since water is intentionally allowed into the building in order to minimize pressure on the structure. Approaches range from moving

valuable items to higher floors to rebuilding the floodable area. An advantage over other approaches is that simply by moving household goods out of the range of floodwaters, thousands of dollars can be saved in damages.

5. **Sewer Backup Protection -** Storm water overloads can cause backup into basements through sanitary sewer lines. Houses that have any kind of connection to a sanitary sewer system - whether it is downspouts, footing drain tile, and/or sump pumps, can be flooded during a heavy rain event. To prevent this, there should be no such connections to the system, and all rain and ground water should be directed onto the ground, away from the building. Other protections include:
    a. Floor drain plugs and floor drain standpipe, which keep water from flowing out of the lowest opening in the house.
    b. Overhead sewer - keeps water in the sewer line during a backup.
    c. Backup valve - allows sewage to flow out while preventing backups from flowing into the house.

6. **Insurance** - Above and beyond standard homeowner insurance, there is other coverage a homeowner can purchase to protect against flood hazard. Two of the most common are National Flood Insurance and basement backup insurance.
    a. ***National Flood Insurance:*** When a community participates in the National Flood Insurance Program, any local insurance agent is able to sell separate flood insurance policies under rules and rates set by FEMA. Rates do not change after claims are paid because they are set on a national basis.
    b. ***Basement Backup Insurance:*** National Flood Insurance offers an additional deductible for seepage and sewer backup, provided there is a general condition of flooding in the area that was the proximate cause of the basement getting wet. Most exclude damage from surface flooding that would be covered by the NFIP.

C. Natural Resource Protection

Preserving or restoring natural areas or the natural functions of floodplain and watershed areas provide the benefits of eliminating or minimizing losses from floods, as well as improving water quality and wildlife habitats. Parks, recreation, or conservation agencies usually implement such activities. Protection can also be provided through various zoning measures that are specifically designed to protect natural resources.

1. **Wetlands Protection** - Wetlands are capable of storing large amounts of floodwaters, slowing and reducing downstream flows, and filtering the water. Any development that is proposed in a wetland is regulated by either federal and/or state agencies. Depending on the location, the project might fall under the jurisdiction of the U.S. Army Corps of Engineers, which in turn, calls upon several other agencies to review the proposal. In New Hampshire, the N.H. Wetlands Board must approve any project that impacts a wetland. Many communities in New Hampshire also have local wetland ordinances.

   Generally, the goal is to protect wetlands by preventing development that would adversely affect them. Mitigation techniques are often employed, which might consist of creating a wetland on another site to replace what would be lost through the development. This is not an ideal practice since it takes many years for a new wetland to achieve the same level of quality as an existing one, if it can at all.

2. **Erosion and Sedimentation Control -** Controlling erosion and sediment runoff during construction and on farmland is important, since eroding soil will typically end up in downstream waterways. Because sediment tends to settle where the water flow is slower, it will gradually fill in channels and lakes, reducing their ability to carry or store floodwaters.

3. **Best Management Practices -** Best Management Practices (BMPs) are measures that reduce non-point source pollutants that enter waterways. Non-point source pollutants are carried by storm water to waterways, and include such things as lawn fertilizers, pesticides, farm chemicals, and oils from street surfaces and industrial sites. BMPs can be incorporated into many aspects of new developments and ongoing land use practices. In New Hampshire, the Department of Environmental Services has developed Best Management Practices for a range of activities, from farming to earth excavations.

D. Emergency Services

Emergency services protect people during and after a flood. Many communities in New Hampshire have emergency management programs in place, administered by an emergency management director (very often the local police or fire chief).

1. **Flood Warning -** On large rivers, the National Weather Service handles early recognition. Communities on smaller rivers must develop their own warning systems. Warnings may be disseminated in a variety of ways, such as sirens, radio, television, mobile public address systems, or door-to-door contact. It seems that multiple or redundant systems are the most effective, giving people more than one opportunity to be warned.
2. **Flood Response -** Flood response refers to actions that are designed to prevent or reduce damage or injury, once a flood threat is recognized. Such actions and the appropriate parties include:
   a. Activating the emergency operations center (emergency director)
   b. Sandbagging designated areas (Highway Department)
   c. Closing streets and bridges (police department)
   d. Shutting off power to threatened areas (public service)

e. Releasing children from school (school district)
f. Ordering an evacuation (emergency director)
g. Opening evacuation shelters (churches, schools, Red Cross, municipal facilities)

These actions should be part of a flood response plan, which should be developed in coordination with the persons and agencies that share the responsibilities. Drills and exercises should be conducted so that the key participants know what they are supposed to do.

3. **Critical Facilities Protection -** Protecting critical facilities is vital, since expending efforts on these facilities can draw workers and resources away from protecting other parts of town. Critical facilities fall into two categories:
    a. **Buildings or locations vital to the flood response effort:**
        i. Emergency operations centers
        ii. Police and fire stations
        iii. Highway garages
        iv. Selected roads and bridges
        v. Evacuation routes
    b. **Buildings or locations that, if flooded, would create disasters:**
        i. Hazardous materials facilities
        ii. Schools

All such facilities should have their own flood response plan that is coordinated with the community's plan. Schools will typically be required by the state to have emergency response plans in place.

4. **Health and Safety Maintenance -** The flood response plan should identify appropriate measures to prevent danger to health and safety. Such measures include:
    a. Patrolling evacuated areas to prevent looting
    b. Vaccinating residents for tetanus
    c. Clearing streets
    d. Cleaning up debris

The Plan should also identify which agencies will be responsible for carrying out the identified measures. A public information program can be helpful to educate residents on the benefits of taking health and safety precautions.

E. Structural Projects

Structural projects are used to prevent floodwaters from reaching properties. These are all man-made structures, and can be grouped into the six types discussed below. The shortcomings of structural approaches are:

- Can be very expensive
- Disturb the land, disrupt natural water flows, & destroy natural habitats.
- Are built to an anticipated flood event, and may be exceeded by a greater-than expected flood
- Can create a false sense of security.

1. **Diversions -** A diversion is simply a new channel that sends floodwater to a different location, thereby reducing flooding along an existing watercourse. Diversions can be surface channels, overflow weirs, or tunnels. During normal flows, the water stays in the old channel. During flood flows, the stream spills over the diversion channel or

tunnel, which carries the excess water to the receiving lake or river. Diversions are limited by topography; they won't work everywhere. Unless the receiving water body is relatively close to the flood prone stream and the land in between is low and vacant, the cost of creating a diversion can be prohibitive. Where topography and land use are not favorable, a more expensive tunnel is needed. In either case, care must be taken to ensure that the diversion does not create a flooding problem somewhere else.

2. **Levees/Floodwalls -** Probably the best known structural flood control measure is either a levee (a barrier of earth) or a floodwall made of steel or concrete erected between the watercourse and the land. If space is a consideration, floodwalls are typically used, since levees need more space. Levees and floodwalls should be set back out of the floodway, so that they will not divert floodwater onto other properties.

3. **Reservoirs -** Reservoirs control flooding by holding water behind dams or in storage basins. After a flood peaks, water is released or pumped out slowly at a rate the river downstream can handle. Reservoirs are suitable for protecting existing development, and they may be the only flood control measure that can protect development close to a watercourse. They are most efficient in deeper valleys or on smaller rivers where there is less water to store. Reservoirs might consist of man-made holes dug to hold the approximate amount of floodwaters, or even abandoned quarries. As with other structural projects, reservoirs:
    a. are expensive
    b. occupy a lot of land
    c. require periodic maintenance
    d. may fail to prevent damage from floods that exceed their design levels
    e. may eliminate the natural and beneficial functions of the floodplain.

4. **Channel Modifications -** Channel modifications include making a channel wider, deeper, smoother, or straighter. These techniques will result in more water being carried away, but, as with other techniques mentioned, it is important to ensure that the modifications do not create or increase a flooding problem downstream.

5. **Dredging:** Dredging is often cost-prohibitive because the dredged material must be disposed of in another location; the stream will usually fill back in with sediment. Dredging is usually undertaken only on larger rivers, and then only to maintain a navigation channel.

6. **Drainage Modifications:** These include man-made ditches and storm sewers that help drain areas where the surface drainage system is inadequate or where underground drainage ways may be safer or more attractive. These approaches are usually designed to carry the runoff from smaller, more frequent storms.

7. **Storm Sewers -** Mitigation techniques for storm sewers include installing new sewers, enlarging small pipes, street improvements, and preventing back flow. Because drainage ditches and storm sewers convey water faster to other locations, improvements are only recommended for small local problems where the receiving body of water can absorb the increased flows without increased flooding. In many developments, streets are used as part of the drainage system, to carry or hold water from larger, less frequent storms. The streets collect runoff and convey it to a receiving sewer, ditch, or stream. Allowing water to stand in the streets and then draining it slowly can be a more effective and less expensive measure than enlarging sewers and ditches.

F. Public Information

Public information activities are intended to advise property owners, potential property owners, and visitors about the particular hazards associated with a property, ways to protect people and property from these hazards, and the natural and beneficial functions of a floodplain.

1. **Map Information -** Flood maps developed by FEMA outline the boundaries of the flood hazard areas. These maps can be used by anyone interested in a particular property to determine if it is flood-prone. These maps are available from FEMA, the NH Homeland Security and Emergency Management (HSEM), the NH Office of Strategic Initiatives (OSI), or your regional planning commission.

2. **Outreach Projects -** Outreach projects are proactive; they give the public information even if they have not asked for it. Outreach projects are designed to encourage people to seek out more information and take steps to protect themselves and their properties. Examples of outreach activities include:
    a. Presentations at meetings of neighborhood groups
    b. Mass mailings or newsletters to all residents
    c. Notices directed to floodplain residents
    d. Displays in public buildings, malls, etc.
    e. Newspaper articles and special sections
    f. Radio and TV news releases and interview shows
    g. A local flood proofing video for cable TV programs and to loan to organizations
    h. A detailed property owner handbook tailored for local conditions. Research has shown that outreach programs work, although awareness is not enough. People need to know what they can do about the hazards, so projects should include information on protection measures. Research also shows that locally designed and run programs are much more effective than national advertising.
3. **Real Estate Disclosure -** Disclosure of information regarding flood-prone properties is important if potential buyers are to be in a position to mitigate damage. Federally regulated lending institutions are required to advise applicants that a property is in the floodplain. However, this requirement needs to be met only five days prior to closing, and by that time, the applicant is typically committed to the purchase. State laws and local real estate practice can help by making this information available to prospective buyers early in the process.

4. **Library -** Your local library can serve as a repository for pertinent information on flooding and flood protection. Some libraries also maintain their own public information campaigns, augmenting the activities of the various governmental agencies involved in flood mitigation.

5. **Technical Assistance -** Certain types of technical assistance are available from the NFIP Coordinator, FEMA, and the Natural Resources Conservation District. Community officials can also set up a service delivery program to provide one-on-one sessions with property owners. An example of technical assistance is the *flood audit*, in which a specialist visits a property. Following the visit, the owner is provided with a written report detailing the past and potential flood depths and recommending alternative protection measures.

6. **Environmental Education -** Education can be a great mitigating tool if people can learn what not to do before damage occurs. The sooner the education begins the better. Environmental education programs for children can be taught in the schools, park and recreation departments, conservation associations, or youth organizations. An activity can be as involved as course curriculum development or as simple as an explanatory sign near a river. Education programs do not have to be limited to children. Adults can benefit from knowledge of flooding and mitigation measures; decision makers, armed with this knowledge, can make a difference in their communities

.

II. EARTHQUAKES

A. Preventive

1. Planning/zoning to keep critical facilities away from fault lines
2. Planning, zoning and building codes to avoid areas below steep slopes or soils subject to liquefaction
3. Building codes to prohibit loose masonry overhangs, etc.

B. Property Protection

1. Acquire and clear hazard areas
2. Retrofitting to add braces, remove overhangs
3. Apply Mylar to windows and glass surfaces to protect from shattering glass
4. Tie down major appliances, provide flexible utility connections
5. Earthquake insurance riders

C. Emergency Services

1. Earthquake response plans to account for secondary problems, such as fires and hazardous material spills

D. Structural Projects

1. Slope stabilization

III. DAM FAILURE

A. Preventive

1. Dam failure inundation maps
2. Planning/zoning/open space preservation to keep area clear
3. Building codes with flood elevation based on dam failure
4. Dam safety inspections
5. Draining the reservoir when conditions appear unsafe

B. Property Protection

1. Acquisition of buildings in the path of a dam breach flood
2. Flood insurance

C. Emergency Services

1. Dam condition monitoring
2. Warning and evacuation plans based on dam failure

D. Structural Projects

1. Dam improvements, spillway enlargements
2. Remove unsafe dams

IV. WILDFIRES

A. Preventive

1. Zoning districts to reflect fire risk zones
2. Planning and zoning to restrict development in areas near fire protection and water resources

3. Requiring new subdivisions to space buildings, provide firebreaks, on-site water storage, wide roads, multiple accesses
4. Building code standards for roof materials and spark arrestors
5. Maintenance programs to clear dead and dry brush, trees
6. Regulation on open fires

B. Property Protection

1. Retrofitting of roofs and adding spark arrestors
2. Landscaping to keep bushes and trees away from structures
3. Insurance rates based on distance from fire protection

C. Natural Resource Protection

1. Prohibit development in high-risk areas

D. Emergency Services

1. Fire Fighting

V. WINTER STORMS

A. Prevention

1. Building code standards for light frame construction, especially for wind-resistant roofs

B. Property Protection

1. Storm shutters and windows
2. Hurricane straps on roofs and overhangs
3. Seal outside and inside of storm windows and check seals in spring and fall
4. Family and/or company severe weather action plan & drills:
    a. include a NOAA Weather Radio
    b. designate a shelter area or location
    c. keep a disaster supply kit, including stored food and water
    d. keep snow removal equipment in good repair; have extra shovels, sand, rock, salt and gas
    e. know how to turn off water, gas, and electricity at home or work

C. Natural Resource Protection

1. Maintenance program for trimming trees and shrubs

D. Emergency Services

1. Early warning systems/NOAA Weather Radio
2. Evacuation plans

Appendix D: Technical & Financial Assistance for All-Hazard Mitigation

FEMA's Hazard Mitigation Assistance (HMA) grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages. Currently, FEMA administers the following HMA grant programs[49]:

- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM)
- Flood Mitigation Assistance (FMA)

FEMA's HMA grants are provided to eligible Applicants (States/Tribes/Territories) that, in turn, provide sub-grants to local governments and communities. The Applicant selects and prioritizes subapplications developed and submitted to them by subapplicants. These subapplications are submitted to FEMA for consideration of funding. Prospective subapplicants should consult the office designated as their Applicant for further information regarding specific program and application requirements. Contact information for the FEMA Regional Offices and State Hazard Mitigation Officers is available on the FEMA website, www.fema.gov.

HMA Grant Programs

The HMA grant programs provide funding opportunities for pre- and post-disaster mitigation. While the statutory origins of the programs differ, all share the common goal of reducing the risk of loss of life and property due to Natural Hazards. Brief descriptions of the HMA grant programs can be found below. For more information on the individual programs, or to see information related to a specific Fiscal Year, please click on one of the program links.

A. Hazard Mitigation Grant Program (HMGP)

HMGP assists in implementing long-term hazard mitigation measures following Presidential disaster declarations. Funding is available to implement projects in accordance with State, Tribal, and local priorities.

What is the Hazard Mitigation Grant Program?

The Hazard Mitigation Grant Program (HMGP) provides grants to States and local governments to implement long-term hazard mitigation measures after a major disaster declaration. Authorized under Section 404 of the Stafford Act and administered by FEMA, HMGP was created to reduce the loss of life and property due to natural disasters. The program enables mitigation measures to be implemented during the immediate recovery from a disaster.

Who is eligible to apply?

Hazard Mitigation Grant Program funding is only available to applicants that reside within a presidentially declared disaster area. Eligible applicants are:

- State and local governments
- Indian tribes or other tribal organizations
- Certain non-profit organizations

[49] Information in Appendix E is taken from the following website and links to specific programs unless otherwise noted; http://www.fema.gov/government/grant/hma/index.shtm

Individual homeowners and businesses may not apply directly to the program; however a community may apply on their behalf.

How are potential projects selected and identified?
The State's administrative plan governs how projects are selected for funding. However, proposed projects must meet certain minimum criteria. These criteria are designed to ensure that the most cost-effective and appropriate projects are selected for funding. Both the law and the regulations require that the projects are part of an overall mitigation strategy for the disaster area.

The State prioritizes and selects project applications developed and submitted by local jurisdictions. The State forwards applications consistent with State mitigation planning objectives to FEMA for eligibility review. Funding for this grant program is limited and States and local communities must make difficult decisions as to the most effective use of grant funds.

For more information on the **Hazard Mitigation Grant Program (HMGP),** go to:
http://www.fema.gov/government/grant/hmgp/index.shtm

B. Pre-Disaster Mitigation (PDM)
PDM provides funds on an annual basis for hazard mitigation planning and the implementation of mitigation projects prior to a disaster. The goal of the PDM program is to reduce overall risk to the population and structures, while at the same time, also reducing reliance on Federal funding from actual disaster declarations.

Program Overview
The Pre-Disaster Mitigation (PDM) program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event.

Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. PDM grants are to be awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds.

C. Flood Mitigation Assistance (FMA)
FMA provides funds on an annual basis so that measures can be taken to reduce or eliminate risk of flood damage to buildings insured under the National Flood Insurance Program.

Program Overview

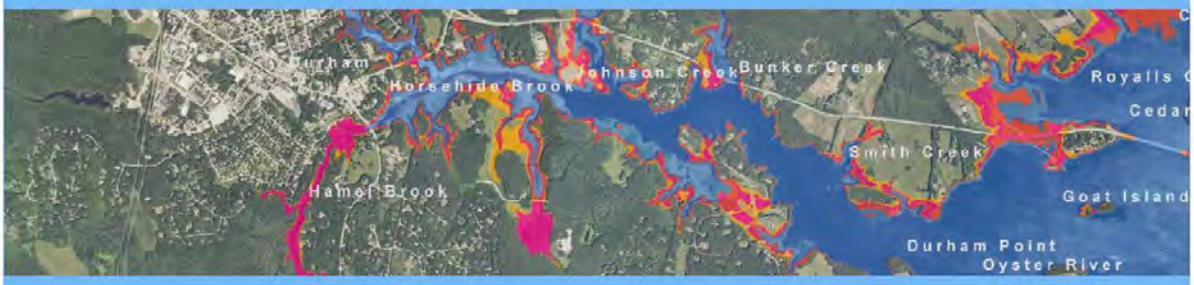
The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP).

FEMA provides FMA funds to assist States and communities implement measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program.

Types of FMA Grants

Three types of FMA grants are available to States and communities:

- Planning Grants to prepare Flood Mitigation Plans. Only NFIP-participating communities with approved Flood Mitigation Plans can apply for FMA Project grants
- Project Grants to implement measures to reduce flood losses, such as elevation, acquisition, or relocation of NFIP-insured structures. States are encouraged to prioritize FMA funds for applications that include repetitive loss properties; these include structures with 2 or more losses each with a claim of at least $1,000 within any ten-year period since 1978.
- Technical Assistance Grants for the State to help administer the FMA program and activities. Up to ten percent (10%) of Project grants may be awarded to States for Technical Assistance Grants



Climate Adaptation Chapter:

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

June 25, 2013

Final

Prepared By

Strafford Regional Planning Commission

150 Wakefield Street, Suite 12

Rochester, NH 03867

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NH Department of Environmental Services, Coastal Program
University of New Hampshire, Earth Systems Research Center
Carbon Solutions New England
Town of Durham

The 2013 Town of Durham Leadership Committee

Twelve people comprised the Leadership Committee and were instrumental in completing this plan:

Michael Behrendt	Town Planner
Stefanie Frazee	Parks and Recreation Director
Gail Jablonski	Business Manager
Thomas F. Johnson	Health Officer/Building Inspector/Zoning Administrator
David Kurz	Chief of Police
Corey Landry	Fire Chief
Michael Lynch	Department of Public Works Director
Tom Madden	Library Director
Lorrie Pitt	Town Clerk/Tax Collector
Jim Rice	Town Assessor
Todd Selig	Administrator
Luke Vincent	Manager of Information Technology

Six people either attended meetings and/or provided input in the development of this plan:

Diana Carroll	Town Council Member
Robin Mower	Town Council Member
Dave Howland	Town Council Member
Derek Sowers	Durham Conservation Commission
Chris Skoglund	Resident of the Town of Durham
Cameron Wake	Carbon Solutions New England Director

Plan Prepared and Authored By:
Kyle Pimental, Regional Planner
Strafford Regional Planning Commission
150 Wakefield Street, Suite 12
Rochester, NH 03867
603-994-3500
www.strafford.org

Table of Contents

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.

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[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.

[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

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

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

C-RiSe

CLIMATE RISK IN THE SEACOAST

Assessing Vulnerability of Municipal Assets and Resources to Sea Level Rise

Rollinsford • Dover • Madbury • Durham • Newmarket • Newfields • Exeter • Stratham • Greenland • Newington

TOWN OF DURHAM, NEW HAMPSHIRE

Vulnerability Assessment

of projected impacts from sea-level rise and coastal storm surge flooding

Prepared by the

Strafford Regional Planning Commission

February, 2017

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Jim Rice	Assessor, Town of Durham
Michael Behrendt	Town Planner, Town of Durham
Judy Haskell	Interim Library Director, Town of Durham
Mary Ellen Humphrey	Director of Economic Development, Town of Durham
Todd Selig	Town Administrator, Town of Durham

Cover Photo Credit(s): April Talon, Town Engineer; Kyle Pimental, Principal Regional Planner (SRPC)

Notes on Use and Applicability of this Report and Results:

The purpose of this vulnerability assessment report is to provide a broad overview of the potential risk and vulnerability of state, municipal and public assets as a result of projected changes in sea-levels and coastal storm surge. This report should be used for preliminary and general planning purposes only, not for parcel level or site specific analyses. The vulnerability assessment performed was limited by several factors including the vertical accuracy of elevation data (derived from LiDAR) and the static analysis applied to map coastal areas subject to future flooding which does not consider wave action and other coastal dynamics. Also, the estimated flood impacts to buildings and infrastructure are based upon the elevations of the land surrounding them, not the elevation of any structure itself.

PLANNING TO REDUCE RISK AND VULNERABILITY

New Hampshire's economy and quality of life have historically been linked to its shores, its vast expanses of productive saltmarshes, and inland coastal rivers and estuaries. Increased flooding has the potential to place coastal populations at risk, threaten infrastructure, intensify coastal hazards and ultimately impact homes, businesses, public infrastructure, recreation areas, and natural resources. Accounting for changes in sea level and coastal storms will help lead to informed decisions for public and private risk and vulnerability.

New Hampshire seacoast municipalities are confronted by land use and hazard management concerns that include extreme weather events, storm surges, flooding and erosion. These issues are intensified by recent increases in the frequency and intensity of extreme storm events and increases in sea level.

What is a Vulnerability Assessment?

A vulnerability assessment identifies and measures impacts of flooding from sea level rise and storm surge on built structures, human populations and natural environments. Factors that influence vulnerability include development patterns, natural features and topography. The assessment evaluates existing and future conditions such as:

- inland extent and depth of flooding
- impacts to natural and human systems
- changes in impacts between different flood levels

How can the vulnerability assessment be used?

Information from a vulnerability assessment can help guide common sense solutions, strategies and recommendations for local governments, businesses, and citizens to enable them to adopt programs, policies, business practices and make informed decisions (see below).

Planning for the long-term effects of sea level rise may also help communities better prepare in the short-term for periodic flooding from severe coastal storms. Results from a vulnerability assessment can be incorporated into various municipal planning, regulatory and management documents.

How will the vulnerability assessment benefit the community?

The Climate Risk in the Seacoast assessment 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

Master Plan	Capital Improvement Plan	Land Conservation Plan
Zoning Ordinance	Site Plan Regulations	Subdivision Regulations
Roadway Management	Stormwater Management Plan	Facilities Management Plan

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Project Partners:

MAPPING AND ASSESSMENT METHODS

Vulnerability Assessment: Sea Level Rise and Storm Surge Scenarios

The *Climate Risk in the Seacoast* (C-RiSe) vulnerability assessment project produced maps and statistical data about the potential impacts from sea-level rise and storm surge to infrastructure, critical facilities transportation systems, and natural resources in ten inland coastal communities. Three sea-level scenarios were evaluated accounting for a range from the intermediate-low to the highest projected sea-levels at the year 2100.

TABLE 1: Sea-Level and Storm Surge Scenarios in Durham

Sea Level (SLR) Scenarios	SLR	SLR	SLR	SLR + storm surge	SLR + storm surge	SLR + storm surge
Sea Level Rise	1.7ft	4.0ft	6.3ft	--	--	--
Sea Level Rise + Storm Surge	--	--	--	1.7ft + storm surge	4.0ft + storm surge	6.3ft + storm surge

Note: Storm surge is the area flooded by the 100-year/1% change storm event

Baseline: Flooding from the sea-level rise scenarios and sea-level rise plus storm surge scenarios evaluated in this study were mapped from Mean Higher High Water (MHHW) which is 4.4 feet in the coastal region of NH. *Mean Higher High Water is the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. The National Tidal Datum Epoch (NTDE) refers to the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken. The present NTDE is 1983 through 2001 and is considered for revision every 20-25 years (the next revision would be in the 2020-2025 timeframe).*[1]

Storm Surge: *Storm surge is the rise of water level accompanying intense coastal storm events such as a tropical storm, hurricane or Nor'easter, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm event.*[2] Storm surge is mapped using the 100-year/1% chance flood events from the Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014. These maps account for the limit of moderate wave action in coastal areas. This assessment does not take into account additional flooding and impacts related to more severe wave action, wind action, erosion and other dynamic coastal processes.

Sea-Level Rise Scenarios

The sea-level rise projections used in this study are based on an earlier study completed in 2011 by Wake et al and are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel in 2014.[3]

[1] NOAA website at http://tidesandcurrents.noaa.gov/datum_options.html
[2] EPA website at http://epa.gov/climatechange/glossary.html
[3] For more information on how sea level rise scenarios were mapped, visit: http://granitweb.sr.unh.edu/MetadataForViewers/NHCoastalViewer/RelatedDocuments/Sea_Level_Rise_Narrative_rev20150106_FinalReport.pdf

As shown in Figures 1 and 2 and in the graphics below, while slightly different than the scenarios cited in the 2014 report, the sea level rise scenarios used in the Climate Risk in the Seacoast assessment yield coverage estimates of flooding that are within the mapping margin of error for the scenarios in both the 2011 and 2014 reports.

Figure 1: 2014 Sea Level Rise Scenarios (based on greenhouse gas emissions)

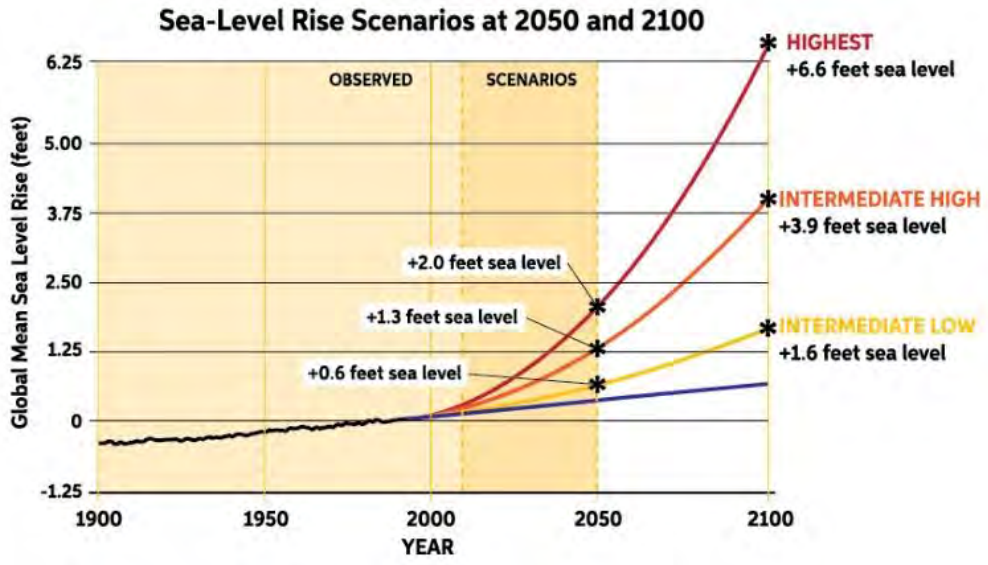
	Lower Emissions (B1)		Higher Emissions (A1fi)	
	2050	2100	2050	2100
Current Elevation of MHHW [a,b]	4.43	4.43	4.43	4.43
100-Year Flood Height	7.78	7.78	7.78	7.78
Subsidence	0.012	0.016	0.012	0.016
Eustatic SLR	1.0	2.5	1.7	6.3
Total Stillwater Elevation [a,c]	**13.2**	**14.7**	**13.9**	**18.5**

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

Table 13. Preliminary estimates of future 100-year flood Stillwater elevations at the Fort Point Tide gauge under lower and higher emission scenarios (feet relative to NAVD[a]).

Source: Wake CP, E Burakowski, E Kelsey, K Hayhoe, A Stoner, C Watson, E Douglas (2011) *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future*. Carbon Solutions New England Report for the Great Bay (New Hampshire) Stewards.

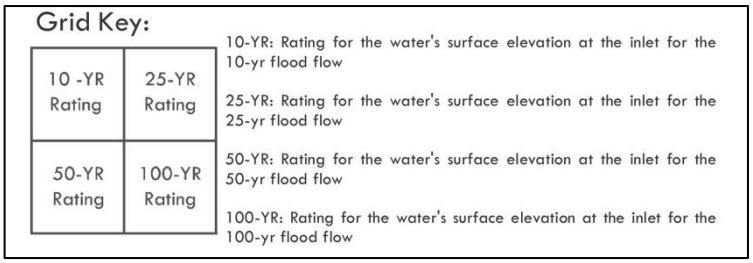
Figure 2: 2014 Sea Level Rise Scenarios (based on greenhouse gas emissions)



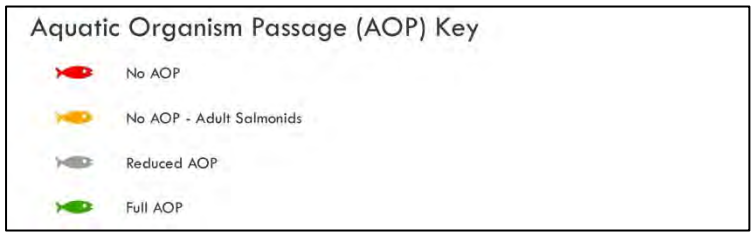
Source: Wake CP, Kirshen P, Huber M, Knuuti K, and Stampone M (2014) *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends*, prepared by the Science and Technical Advisory Panel for the New Hampshire Coastal Risks and Hazards Commission.

Data, Methods, Calculations, and Results of Hydrologic and Hydraulic Modeling for Road Crossing

The C-Rise project assessed both aquatic organism passage capacity and hydraulic flow capacity of ten road crossings in each of the ten inland coastal municipalities. The assessment was based on runoff associated with the current 10-, 25-, 50- and 100-year storm events. For each storm, each crossing was assigned a hydraulic rating and an aquatic organism passage (AOP) rating; both ratings are described in greater detail below.

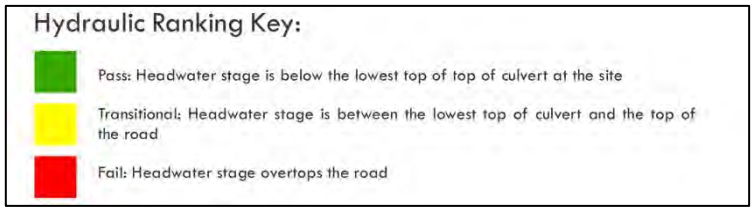


The AOP rating is labeled by color; Red, Orange, Gray, and Green. Ratings of Red and Orange mean that there is estimated to be little to no AOP at that crossing, with Red being no AOP for all species and Orange meaning no AOP for all species except for adult Salmonids. A rating of Gray means that there is reduced AOP at the crossing for all species. A rating of Green means that AOP is expected to be possible for all species.



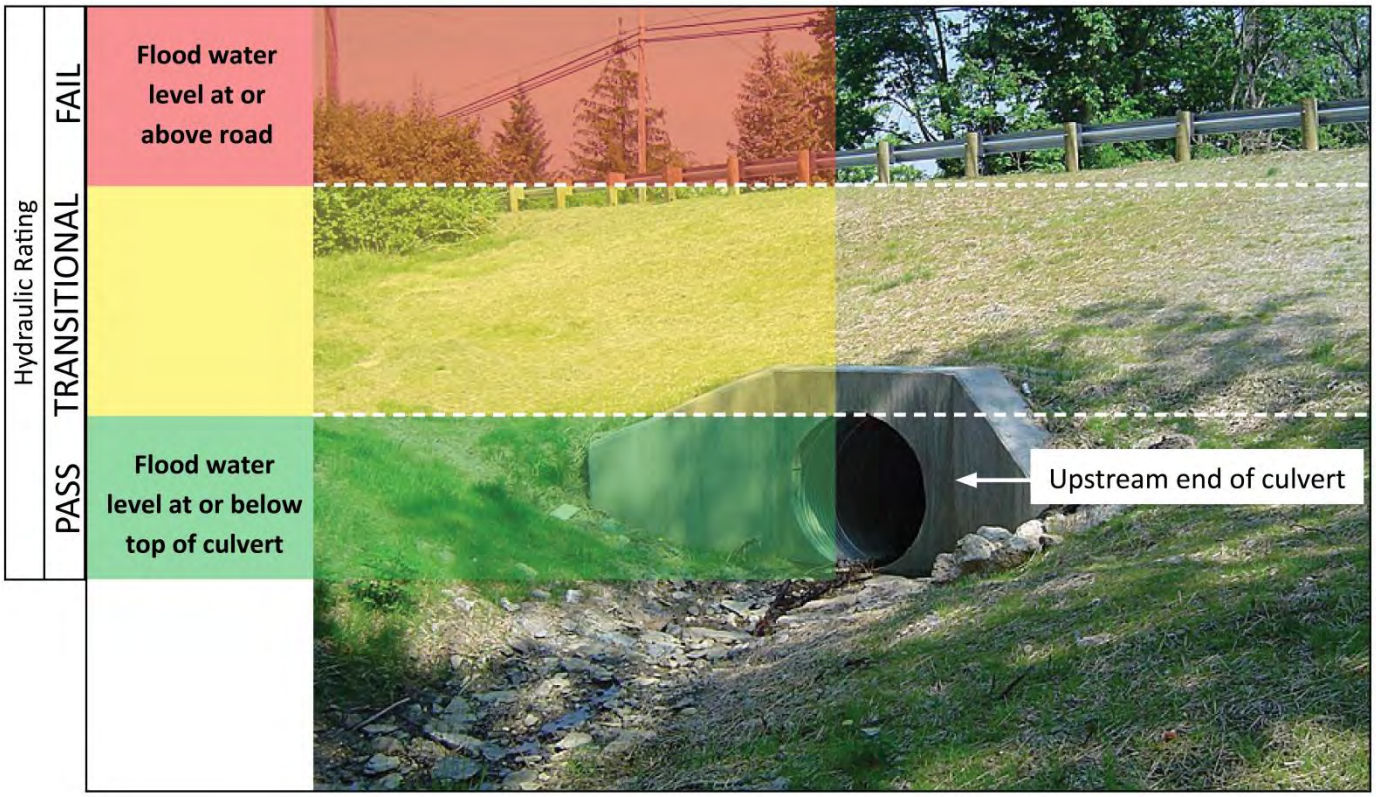
The AOP ratings were developed using the New Hampshire protocol for assessment, which was borrowed directly from the Vermont Culvert Aquatic Organism Passage Screening Tool. This tool uses physical data collected at each crossing and may be used to rate each culvert at a crossing for AOP. At a crossing with multiple culverts, if one culvert is more passable than another, then that culvert is considered to be the path that organisms would utilize. Thus, the best rating for a culvert at a crossing is used as the rating for the crossing as a whole.

The hydraulic rating is color-coded similar to the AOP rating. The peak flows of the 10-, 25-, 50-, and 100-year storm events were used to assess the ability of the culvert to pass the flow (measured by the depth of water upstream of the culvert – known as the headwater depth) was determined and compared to culvert and road elevations. The ratings for hydraulics are: Pass (green), Transitional (yellow), and Fail (red). These ratings describe the depth of the water at the inlet (the Headwater) for the flows for each of the selected storm events compared to culvert and road elevations. A rating of Pass means that the headwater depth is below the lowest top-of-pipe elevation of any culvert at the crossing; a rating of Fail means that the headwater depth is above the road surface; and a rating of Transitional means that the headwater depth is somewhere between these two elevations (see Figure 3).



The hydraulic ratings describe the headwater depth (upstream of the culvert) for each storm event flood. The headwater depths are calculated using field-collected culvert and crossing data. The flood flows were calculated by one of two methods: 1) runoff from rainfall, or 2) regression equation. For all watershed areas smaller than one square mile, the Curve Number[4] method was used; and for watersheds larger than one square mile, flows were calculated using the Regression Equations[5] published by the USGS for New Hampshire. Once the flows at each crossing were calculated, they were input into the Federal Highway Administration's free culvert analysis software, HY-8, along with the necessary culvert and crossing data collected at each location. The program then calculated the headwater depth for each of the flows at each of the sites. This headwater depth is what is shown in the results, and are compared to the pipe crown and roadway elevations to determine the Hydraulic Ratings.

Figure 3: Hydraulic rating diagram



[4] A number from zero to 100 that describes how much rainfall runs off versus is lost to infiltration: a high curve number implies most of the rainfall runs off.

[5] An equation that describes a mathematical relationship between two variables in which one variable is used to predict the other.

Assets and Resources Evaluated

Table 2 lists the three major categories and a detailed list of the assets and resources evaluated as part of the Climate Risk in the Seacoast vulnerability assessment. The assets and resources evaluated are listed in subsequent tables in this report only if they are affected by one or more of the sea-level rise and/or coastal storm surge scenarios.

TABLE 2: Assets and Resources Evaluated for the Vulnerability Assessment

Category	Assets and Resources
State and Municipal Infrastructure	Climate Ready Culverts Federal and State Historic Register Properties Other Assets: graveyards, water access, transmission lines
Municipal Critical Facilities	Municipal Critical Facilities (as identified in Hazard Mitigation Plans)
Transportation Assets & Roadways	State and Local Roadways Bridges Regional and Municipal Evacuation Routes Urban Compact Areas NHDOT Transportation Infrastructure NHDOT Ten-year and Long Range Plan Projects
Natural Resources	Freshwater and Tidal Wetlands Aquifers and Wellhead Protection Areas Uplands Floodplains Wildlife Action Plan – Tier 1 and Tier 2 habitats Land Conservation Plan – Conservation focus areas (not mapped)
Land Use	Residential structures

Map Design and Organization

The Climate Risk in the Seacoast map set is comprised of two components: a map depicting the extent of projected flooding from the three sea-level rise scenarios in shades of green, and a map depicting the three sea-level rise plus storm surge scenarios in shades of pink. Each of the asset categorized evaluated are displayed on these two maps. Two scenario maps are shown on the following page.

Extent of Flooding from Sea Level Rise and Storm Surge

The green and pink color schemes are arranged from lightest to darkest with increasing flood levels and extents.

Figure 4: Sea Level Rise Scenarios 1.7ft, 4.0ft, and 6.3ft

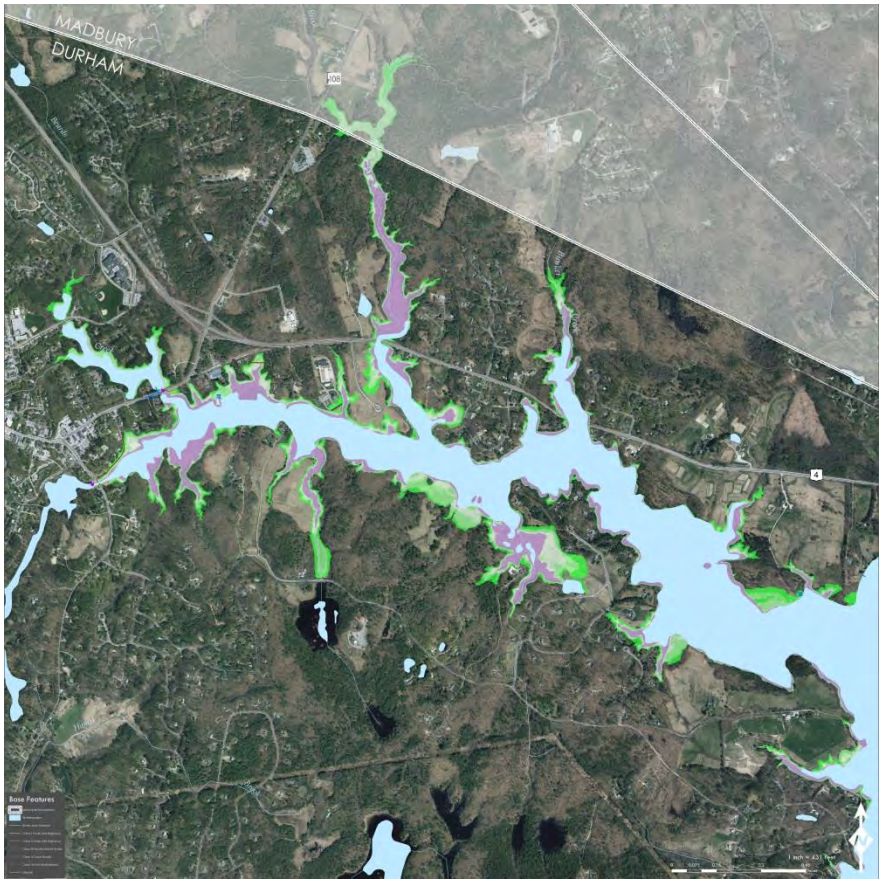
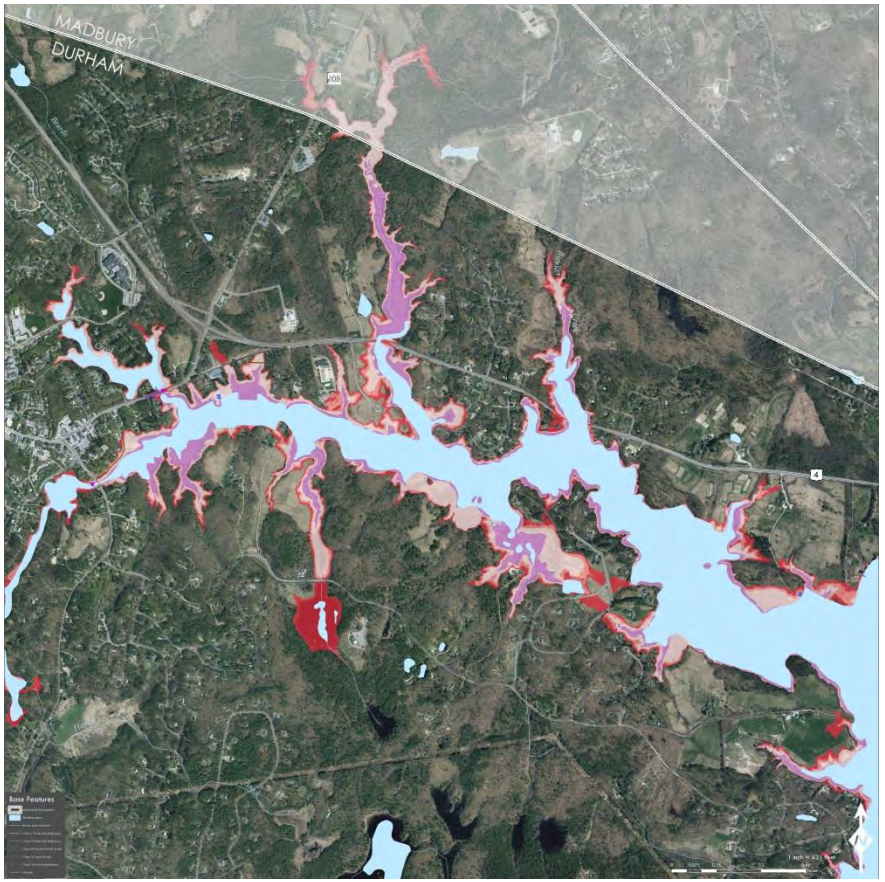


Figure 5: Sea Level Rise Scenarios 1.7ft, 4.0ft, and 6.3ft + storm surge



Note: Storm surge = 100-year/1% chance flood.

OVERVIEW

The Town of Durham is located in southeastern NH within Strafford County. It is bounded by the City of Dover to the northeast, Madbury and Lee to the northwest, Newmarket to the south, and Newington to the southeast. Durham's land area covers roughly 22.4 square miles and a water area of 2.4 square miles. With an estimated population of 15,182 (2013), Durham is the second most populated municipality in SRPC's coastal region, behind only Dover. However, it should be noted that population figures include both full-time and part-time residents, including students. According to Durham's Housing and Demographic chapter to their Master Plan, it is estimated that Durham's full-time resident population is between 5,500 and 6,200 individuals. The inland coastal portion of Durham that is most susceptible to coastal flooding is located in low areas along the Oyster River and its tributaries; at the confluence of the Oyster River and Little Bay; and along the shores of both Little and Great Bay. These areas are all within the coastal floodplain area, making them particularly vulnerable to flooding from seasonal high tides, coastal storms, and sea-level rise.

Ongoing and Completed Projects

In 2013, Durham developed a Climate Adaption Chapter as an appendix to their Hazard Mitigation Plan, entitled "Developing Strategies to Protect Areas at Risk from Flooding due to Climate Change and Sea Level Rise." This plan presented climate change and sea level rise estimates; developed strategies that protect areas at risk from flooding; and identified various regulatory and non-regulatory options for the town's consideration.

In 2016, Durham participated in a training workshop conducted by the New Hampshire Office of Energy and Planning, NH GRANIT, and the Strafford Regional Planning Commission. The purpose of this workshop was to provide an introduction to the FEMA's Flood Risk Products, present community-specific flood risk data and information, and show how the flood risk data and information can be used in planning initiatives to increase flood resiliency.

VULNERABILITY ASSESSMENT RESULTS

Key findings for the Town of Durham are reported in the tables below based on evaluation of the 1.7 feet (intermediate-low), 4.0 feet (intermediate), and 6.3 feet (highest) sea-level rise projections at the year 2100, and these same sea-level rise projections with an additional 100-year storm surge. Table 3 provides data on the total acreage of each sea level rise scenario. Table 4 provides a summary of assessment data that was analyzed as part of this project.

TABLE 3: Total Acreage of Sea Level Rise Scenarios in Durham

	Sea-Level Scenarios					
Community	1.7ft SLR (acres)	4.0ft SLR (acres)	6.3ft SLR (acres)	1.7ft SLR + storm surge (acres)	4.0ft SLR + storm surge (acres)	6.3ft SLR + storm surge (acres)
Durham	43.85	116.82	216.27	162.00	264.09	385.81

TABLE 4: Summary of Assessment Data

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Infrastructure (# of sites)	2			4		
Critical Facilities (# of sites)	3			5		
Transportation Assets (# of sites)	8			8		
Residential Structures (# of homes)	0	0	6	4	7	14
Uplands (acres)	22.98	79.93	168.64	120.37	197.95	304.39
Roadways (miles)	0.00	0.25	0.68	0.41	0.85	1.57
Freshwater Wetlands (acres)	11.71	24.48	36.81	31.91	55.52	80.50
Tidal Wetlands (acres)	18398	28.44	31.90	30.47	32.31	33.13
Aquifers (acres)	2.10	8.96	28.72	20.71	31.38	40.56
Wellhead Protection Areas (acres)	2.87	8.89	17.29	12.52	19.95	29.06
Conserved and Public Lands (acres)	15.19	39.47	77.39	57.12	90.07	127.56
Wildlife Action Plan (acres)	27.60	69.90	136.12	100.54	163.74	244.14
Conservation Focus Areas (acres)	15.44	41.50	80.70	60.61	90.58	136.92
100-year Floodplain (acres)	43.85	104.54	120.11	114.20	140.70	168.33

Notes: Upland refers to land above mean higher high water (highest tidal extent). Storm surge is the area flooded by the 100-year/1% chance storm event.

The data indicates that Durham's uplands, floodplains, conserved lands, and lands identified as important habitat (Wildlife Action Plan) are the most vulnerable to flooding from sea level rise and coastal storm surge. In Durham, floodplains are moderately sensitive to flooding from sea-level rise. Roughly 55 percent of the highest sea-level rise scenario (6.3ft) falls within the existing FEMA 100-year floodplain. The town can expect to see further flooding impacts from sea level rise when there is a storm surge on top of the 4.0ft and 6.3ft scenarios. Even so, the 4.0ft scenario with a storm surge falls within 53 percent of the floodplain and the 6.3ft scenario with a storm surge falls with 44 percent of the floodplain. Compared to other municipalities in the region, most of Durham's key infrastructure, community assets, and natural resources are protected.

As shown in *Maps 1 and 2 Extent of Projected Tidal Flooding*, Durham can expect to see impacts along the Oyster River and its tributaries; at the confluence of the Oyster River and Little Bay; and along the shores of both Little and Great Bay. There are a handful of critical facilities impacted, including water and sewer pipes, a sewer lift station, and two dams. Several transportation assets are impacted, including evacuation routes on Routes 4 and 108, future NHDOT projects, and local urban compact areas that should also be considered during long-term planning efforts.

The complete detailed vulnerability assessment information and recommendations are provided in the following sections of this report.

SUMMARY OF VULNERABILITY ASSESSMENT RESULTS BY ASSET TYPE

Infrastructure

Maps 3 and 4 Critical Facilities and Infrastructure show state and municipal infrastructure types affected by sea-level rise and coastal storm surge flooding. Table 5 reports when specific infrastructure types are affected by each sea-level rise and coastal storm surge scenario.

TABLE 5: Infrastructure

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
State and Municipal Infrastructure (# of facilities)						
Water Access	2			2		
Graveyards	0			1		
Historic District	0			1		
Total # of Sites	2			4		

There were four municipal infrastructure assets identified as being vulnerable from either projected sea-level rise or coastal storm surge flooding. They included two water access points at Jackson's Landing and Wagon Hill; one graveyard on Durham Point Road; and an area of the Durham Historic District along Main Street/Newmarket Road.

Municipal Critical Facilities

Maps 3 and 4 Critical Facilities and Infrastructure show the municipal critical facilities affected by sea-level rise and coastal storm surge flooding. Table 6 reports when specific municipal critical facilities are affected by each sea-level rise and coastal storm surge scenario.

TABLE 6: Municipal Critical Facilities

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Municipal Critical Facilities (miles & # of facilities)						
Sewer Pipes	0.02	0.05	0.16	0.13	0.19	0.26
Water Pipes	0.00	0.00	0.01	0.01	0.01	0.11
Total miles impacted	0.02	0.05	0.17	0.14	0.20	0.37
Primary Sewer Lift Station	1			1		
Dams	0			2		
Total # of Sites	3			5		

NOTE: Municipal Critical Facilities as identified in the Town's Hazard Mitigation Plan.

There were five municipal critical facilities identified as being vulnerable from either projected sea-level rise or coastal storm surge flooding. They included minor impacts to sewer and water pipes; one primary sewer lift station near Beards Creek Dam; and two dams (Mill Pond Dam and Beards Creek Dam).

Transportation

Maps 5 and 6 Road and Transportation Assets show the state and municipal roadways affected by sea-level rise and coastal storm surge flooding. Table 7 reports the miles of state and local roadways affected by each flood scenario. Table 8 provides greater detail as to which roads are impacted. Table 9 details other transportation assets, including information on urban compact areas, evacuation routes, and future NHDOT projects.

TABLE 7: State and Municipal Roadways and Infrastructure (miles)

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Roadway Type						
State	0.00	0.03	0.08	0.05	0.10	0.48
Local	0.00	0.11	0.45	0.24	0.58	0.77
Private	0.00	0.10	0.14	0.11	0.16	0.30
Not Maintained	0.00	0.01	0.01	0.01	0.01	0.02
Total Road Miles	0.00	0.25	0.68	0.41	0.85	1.57

There are some areas of Durham's existing municipal roadway network that are sensitive to sea-level rise and coastal storm flooding, with a total of just over a mile and half of roadway being impacted under the 6.3ft of sea-level rise + a storm surge scenario.

TABLE 8: Durham's Road Asset Impacts

Sea Level Rise (SLR) Scenarios		SLR 6.3ft	SLR 6.3ft + storm surge
Road Name	Road Class	Miles Impacted	Miles Impacted
Adams Point Road	Private	0.11	0.12
Back River Road	Local	0.13	0.30
Bay Road	Local	0.01	0.03
Bunker Lane	Not Maintained	0.01	0.02
Cedar Point Road	Local	0.17	0.24
Colony Cover Road	Private	0.00	0.01
Dover Road	State	0.00	0.08
Jacksons Landing	Local	0.01	0.01
Newmarket Road	State	0.01	0.01
No Name	Private	0.03	0.17
Old Landing Road	Local	0.12	0.14

Piscataqua Road	State	0.07	0.39
Riverview Road	Local	0.00	0.03
Watson Road	Local	0.00	0.01
Total Road Miles	-	0.68	1.57

This analysis determined that, in Durham, there are a handful of state, local, or private roads vulnerable to sea-level rise and coastal storm flooding. Roadways that experience the largest stretches of inundation include sections of Back River Road, Cedar Point Road, and Piscataqua Road. Maps 5 and 6 provide a visual representation of these impacts.

TABLE 9: Durham's Other Transportation Asset Impacts

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Roadway Type						
Urban Comact Areas (acres)	17.9			24.4		
Evacuation Routes (# of sites)	3			3		
NHDOT Projects (# of sites)	5			5		

Items in Table 9 are other transportation related assets that are vulnerable to sea-level rise and coastal storm flooding, including: parts of the town's urban compact zone located in the neighborhoods near Route 108 along the Oyster River and Beards Creek; three evacuation routes along Route 4, Route 108, and Back River Road; and five NHDOT future planning projects on Bay Road over Great Bay inlet, Route 4 over Johnson Creek, Route 4 over Bunker Creek, Route 108 bridge replacement over Oyster River, and Route 108 bike shoulder construction.

Natural Resources

Maps 7 and 8 Land Resources and *Map 9 and 10 Water Resources* show natural resources affected by sea-level rise and coastal storm surge flooding. Table 10 reports the number of acres for each natural land resource affected by each sea-level rise and coastal storm surge scenario. Table 11 reports the number of acres for each natural water resource.

TABLE 10: Natural Land Resources (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Natural Land Resources (acres)						
Conservation Lands	15.19	39.47	77.39	57.12	90.07	127.56
Wildlife Action Plan	27.60	69.90	136.12	100.54	163.74	244.14
Conservation Focus Areas (acres)	15.44	41.50	80.70	60.61	90.58	136.92
Total land resources	58.23	150.87	294.21	218.27	344.39	508.62

* As part of this analysis, conservation focus areas were calculated; however due to their overlap with data from the Wildlife Action Plan, they were not mapped.

Durham's natural land resources are quite sensitive to sea-level rise and coastal storm flooding. Impacted natural resources include: thirty conservation easements and/or town owned lands (the Rollins tract, Smith Trust, and Wagon Hill Farm represent approximately 40% of all the protected lands that are impacted by the highest scenario with a storm surge) as well as important lands identified in the Wildlife Action Plan along the Oyster River and its tributaries, and along the shoreline of Little and Great Bay.

TABLE 11: Natural Water Resources (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Natural Water Resources (acres)						
Wellhead Protection Areas	2.87	8.89	17.29	12.52	19.95	29.06
Estuarine and Marine Wetlands	18.98	28.44	31.90	30.47	32.31	33.13
Freshwater Wetlands	11.71	24.48	36.81	31.91	55.52	80.50
Stratified Drift Aquifers	2.10	8.96	28.72	20.71	31.38	40.56
Total water resources	35.66	70.77	114.72	95.61	139.16	183.25

In terms of spatial extent and total acreage, Durham's water resources are not quite as sensitive as that of its land resources. The town's freshwater wetlands along with its stratified drift aquifers are the most impacted water resources. The total acreage (using the highest scenarios) of the town's freshwater wetlands more than doubles in size with a storm surge. Another consideration is the town's groundwater resources – the Johnson Creek Wellhead Protection Area has been identified as an area that may experience future issues. While this study did not analyze the potential impacts from salt water intrusion, this may be a future challenge the town should investigate.

Land Use

Maps 1 and 2 Extent of Projected Tidal Flooding show upland affected by sea-level rise and coastal storm surge flooding above mean higher high water. Upland refers to land above mean higher high water (highest tidal extent). Table 12 reports the number of acres of upland affected by each flood scenario.

TABLE 12: Uplands (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Uplands (acres)						
Acres	22.98	79.93	168.64	120.37	197.95	304.39
% Upland	0.17	0.58	1.23	0.87	1.44	2.21

Total Upland in Durham = 13,766 acres.

Roughly 2% of Durham's uplands are impacted. Durham's inland coastal area has some low lying areas, mainly in the eastern part of town along Little and Great Bay, and along Oyster River and its tributaries, which has experienced significant riverine flooding in the past.

Parcels and Assessed Value

Table 13 reports the number of parcels affected by each of the six scenarios evaluated and the aggregated assessed value of these parcels. The degree to which the parcel and any development on the parcel are affected by sea-level rise or storm related flooding was not analyzed. Affected parcels were identified based on their location either partially or fully within the extent of the scenarios evaluated. Table 14 reports the number of residential structures affected by each of the six scenarios evaluated and the aggregated assessed value of these homes.

TABLE 13: Parcels and Assessed Value by Scenario

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Parcels and Assessed Value						
Parcels Affected (# of parcels)	207	227	241	235	263	298
Aggregate Value of Parcels ($ value)	$101,760,806	$134,883,867	$138,707,949	$136,601,357	$144,892,381	$152,865,099

For Durham, the number of impacted parcels ranges from roughly 207 to 298 and values of $101,760,806 to $152,865,099 respectively. This analysis shows that there is a significant jump in impacted parcel values between the 1.7ft and 6.3ft scenarios. This includes 34 more parcels at an estimated increase in value of $36,947,140, and represents a 36% increase.

TABLE 14: Residential Structures and Assessed Value

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Residential Structures and Assessed Value						
Structures Affected (# of homes)	0	0	6	4	7	14
Assessed Value of homes ($ value)	$0	$0	$1,981,758	$1,581,048	$2,381,571	$5,597,384

Durham does not experience any residential impacts under the first two sea-level rise scenarios. However, the town does have a total of six residential structures that are impacted under the 6.3ft sea-level rise scenario and fourteen structures under the 6.3ft of sea-level plus coastal storm flooding. Assessed values range from roughly $2 million to $5.6 million.

Climate Ready Culverts

Maps 11 and 12 Climate Ready Culverts Maps show areas within the 100-year floodplain affected by sea-level rise and coastal storm surge flooding. Table 15 reports the hydraulic and aquatic organism passage ratings for the ten culverts chosen for this analysis.

TABLE 15: Climate Ready Culvert Analysis

Culvert Crossing ID & Location	*Precipitation Flood Flow				***Aquatic Organism Passage (AOP) Rating
	10-yr	25-yr	50-yr	100-yr	
	**Hydraulic Rating				
Culvert Crossing ID & Location					
#28: Madbury Rd over Littlehole Creek	Fail	Fail	Fail	Fail	No AOP
#29: Edgewood Rd over Littlehole Creek	Transitional	Fail	Fail	Fail	Reduced AOP
#30: Bagdad Rd over Littlehole Creek	Fail	Fail	Fail	Fail	Reduced AOP
#31: Madbury Rd over Reservoir Brook	Transitional	Transitional	Transitional	Transitional	Full AOP
#32: Griffith Dr over Unnamed Stream	Fail	Fail	Fail	Fail	Reduced AOP
#33: Bennett Rd over Woodman Brook	Fail	Fail	Fail	Fail	No AOP
#34: Bennett Rd over LaRoche Brook	Fail	Fail	Fail	Fail	Reduced AOP
#35: Bennett Rd over Beaudette Brook	Fail	Fail	Fail	Fail	Reduced AOP
#36: Longmarsh Rd over Longmarsh Brook	Fail	Fail	Fail	Fail	Reduced AOP
#37: Route 108 over Hamel Brook	Fail	Fail	Fail	Fail	Full AOP

**10-YR: Rating for the water's surface elevation at the inlet for the 10-yr flood flow; 25-YR: Rating for the water's surface elevation at the inlet for the 25-yr flood flow; 50-YR: Rating for the water's surface elevation at the inlet for the 50-yr flood flow; 100-YR: Rating for the water's surface elevation at the inlet for the 100-yr flood flow*

***Pass: Headwater stage is below the lowest top of the culvert at the site; Transitional: Headwater stage is between the lowest top of culvert and the top of the road; Fail: Headwater stage overtops the road;*

**** No AOP: For all aquatic organisms including adult salmonids; No AOP – Adult Salmonids: For all aquatic organisms except adult salmonids; Reduced AOP: For all aquatic organisms; Full AOP: for all aquatic organisms*

According to the hydraulic component of the analysis, of the ten culverts chosen, none were able to pass the 10-yr storm event; eight failed; and two ranked transitional. For the 25-yr storm event, nine culverts failed; and one was ranked transitional. For the 50-yr storm event, nine culverts failed; and one was ranked transitional. For the 100-yr storm event, nine culverts failed, and one was ranked transitional. It should be noted that staff from the Public Works Department were aware that these culverts had experienced significant flooding issues in the past and wanted more data.

According to the aquatic organism passage component of the analysis, of the nine culverts chosen, two were able to fully accommodate species to navigate through the culvert; six were reduced; and two failed to provide the opportunity for species to successfully navigate the culvert.

FEMA Flood Hazard Areas

Maps 11 and 12 Climate Ready Culverts Maps show areas within the 100-year affected by sea-level rise and coastal storm surge flooding. The three sea-level rise scenarios generally fall within the current 100-year floodplain, extending beyond into the 500-year floodplain in certain areas.

From a floodplain management perspective, limiting development and/or strengthening existing regulations within the current 100-year floodplain will provide protection against flood impacts from long term sea level rise. Table 16 reports the acreage within the current 100-year floodplain affected by each flood scenario.

TABLE 16: FEMA Flood Hazard Areas (acres) Impacted

Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
FEMA Flood Hazard Areas						
100-yr floodplain impacted (acres)	43.85	104.54	120.11	114.2	140.7	168.33
Percentage of SLR within the floodplain	100%	89.49	55.54%	70.49%	53.28%	43.63%

Floodplain assessment based on Flood Insurance Rate Maps (FIRMs) released by FEMA in September, 2015.

In Durham, the 100-year floodplain is highly sensitive to flooding from sea-level rise mostly along the Oyster River and its tributaries, and along both the shoreline of Little and Great Bay. According to this analysis, roughly 55 percent of the highest sea-level rise scenario (6.3ft) falls within the existing FEMA 100-year floodplain. The town can expect to see further flooding impacts from sea level rise when there is a storm surge on top of the 4.0ft and 6.3ft scenarios. Even so, the 4.0ft scenario with a storm surge falls within 53 percent of the floodplain and the 6.3ft scenario with a storm surge falls with 44 percent of the floodplain.

ISSUES AND CONSIDERATIONS

The following issues and considerations of local and regional importance were identified during project meetings with municipal staff and land use board and commission members.

- The results of the climate ready culvert analysis will assist the town during long-term planning decisions in regard to the placement, design and size of new culverts or when upgrades and repairs are being made to existing culverts.

- According to the hydraulic component of the analysis, of the ten culverts chosen, none were able to pass the 10-yr storm event, eight failed, and two ranked transitional. The vulnerability and risk of future failure at these locations will become greater with an expected increase in the frequency of extreme precipitation events.

- Improving the town's floodplain management by regulating development within the current 100-year floodplain will mitigate impacts from future long term sea-level rise. The town can incorporate higher freeboard standards into existing regulatory and management frameworks within the Town's Special Floodplain Hazard Overlay District.

- Four municipal infrastructure assets were identified as vulnerable from either projected sea-level rise or coastal storm surge, which include water access points at Jackson's Landing and Wagon Hill, one graveyard on Durham Point Road, and an area of the Durham Historic District along Main Street/Newmarket Road.

- Municipal critical facilities identified as vulnerable from either projected sea-level rise or coastal storm surge include impacts to sewer and water pipes, one primary sewer lift station near Beards Creek Dam, and two dams (Mill Pond Dam and Beards Creek Dam).

- Roadways that can expect to experience the largest stretches of inundation due to flooding from sea-level rise and coastal storm surge include sections of Back River Road, Cedar Point Road, and Piscataqua Road. Flooding to these areas may disrupt local commuting patterns and cause challenges for emergency responders.

- Other transportation related assets vulnerable to sea-level rise and coastal storm flooding, include parts of the town's urban compact zone located in the neighborhoods near Route 108 along the Oyster River and Beards Creek; three evacuation routes along Route 4, Route 108, and Back River Road; and five NHDOT future planning projects on Bay Road over Great Bay inlet, Route 4 over Johnson Creek, Route 4 over Bunker Creek, Route 108 bridge replacement over Oyster River, and Route 108 bike shoulder construction.

- Protecting both freshwater and tidal wetlands will improve floodplain storage capacity, assist to adequately separate development and infrastructure from these areas, and allow for the inland migration of tidal marsh systems and conversion of freshwater systems to tidal systems to accommodate projected changes in sea-levels.

- Providing information about potential flood hazards to businesses and residents, and early notification of flood risk during a coastal storm event would enhance public safety and preparedness.

- Land conservation efforts along Oyster River and its tributaries, at the confluence of the Oyster River and Little Bay, and along the shores of both Little and Great Bay would mitigate future flooding impacts by guiding development away from those areas and increasing flood storage capacity.

- The Town's Johnson Creek wellhead protection area is vulnerable to sea-level rise projections and drinking water resources may be impacted by salt water intrusion. This issue needs further study to identify how saltwater is likely to change the salinity of existing freshwater sources along the coast. Additionally, as sea levels rise, groundwater table elevations are pushed upward, resulting in higher groundwater elevations at significant distances from the coast.

RECOMMENDATIONS

The following recommendations are short-term climate adaptation actions that can be included in Durham's Hazard Mitigation Plan, Master Plan and other planning and policy documents. These actions are focused on strengthening land use development standards, resource protection, municipal policy and plans, and public support to create more resilient development, infrastructure and natural systems.

REGULATORY

R1 - Elevate Structures 2 feet Above Base Flood Elevation. Adopt standards in the town's existing floodplain hazard overlay district that require all new development and redevelopment to be elevated 2 feet above the base flood elevation. Two feet of additional elevation will ensure that structures are protected from flooding based on the highest sea-level rise projection of 2 feet by 2050 (the Town currently requires new development to be built 1ft above BFE).

R2 - Coastal Flood Hazard Overlay District. In the town's zoning ordinance, adopt a Coastal Flood Hazard Overlay District that includes performance based standards that protect against flood impacts from sea-level rise and coastal storm surge. Establish the overlay district boundaries based on current flood hazard areas on FEMA Flood Insurance Rate Maps and projected future high risk flood areas mapped by the C-RiSe Vulnerability Assessment. (Also see similar recommendation in the Community Outreach and Engagement section below.)

R3 - Coastal Buffers and Tidal Marshes. Adopt buffer requirements for setbacks to wetlands that include consideration of climate change in order to protect land that allows coastal habitats and populations to adapt to changing conditions and also provides ecosystem services that protect people, structures, and facilities.

R4 – Culvert Maintenance and Improvement. Adopt ecosystem-friendly approaches in the placement and design of freshwater and tidal stream crossings in order to restore or maintain natural flow regimes to increase ecosystem resilience to extreme weather events and other coastal hazards.

PLANNING AND POLICY

P1 - Natural Hazards Mitigation Plan. Incorporate the vulnerability assessment information and recommendations from the C-RiSe report into the town's next Natural Hazards Mitigation Plan update. Continue revising and updating the assessment information and climate adaptation recommendations in future updates of the Plan as new data and information becomes available.

P2 - Master Plan Coastal Hazards Chapter. Adopt a Coastal Hazards Chapter in the Town's Master Plan that incorporates information and recommendations from the C-RiSe Vulnerability Assessment Profile.

P3 - Capital Infrastructure and Investments. Incorporate consideration of impacts to municipal infrastructure, including water access at Jackson's Landing and Wagon Hill and areas of the Durham Historic District in current and future capital infrastructure projects. Evaluate the extent of sea-level rise and storm surge flooding on individual facilities, including sewer and water pipes; the lift station near Beards Creek; and both Mill Pond and Beards Creek dams.

P4 - Land Conservation. Land conservation offers the greatest opportunities to provide for adaptation to the effects of sea-level rise and coastal storm flooding and climate change impacts.

- Incorporate new scoring criteria into existing land conservation prioritization efforts that consider climate adaptation benefits when evaluating land for conservation purposes.
- Support funding and resources for conservation, land management programs, and land stewardship activities.

P5 - Evacuation Planning. Prepare evacuation plans and coordinate these plans with towns in the coastal region to implement timely and comprehensive planning and notification for coastal storm events.

- Mark evacuation routes with signage and communicate routes to the public with information on the town's website and printed maps.

P6 – Drinking Water Protection. Conduct an investigation of the vulnerability of public drinking water supplies to salt water intrusion. Ongoing groundwater modeling at the University of New Hampshire is investigating the effects of climate change, including sea-level rise, precipitation and temperature, on groundwater levels and the impacts to roads in coastal New Hampshire. The groundwater modeling study will have broader applications as it can be expanded to investigate the effects of climate change on drinking water supply, base flow to streams, and the hydrology of wetlands.

P7 – Road Maintenance. Evaluate the extent of sea-level rise and storm surge flooding to sections of roadway on Back River Road, Cedar Point Road, and Piscataqua Road. Ensure that all future transportation related projects within identified vulnerable areas take projected sea-level rise scenarios into account.

COMMUNITY OUTREACH AND ENGAGEMENT

O1 - Implement FEMA's High Water Mark Initiative. Communities implement the High Water Mark Initiative by providing information on past floods, such as documenting high water marks in public places, and posting maps and photographs of past floods on their website. High water marks can be displayed on public buildings or on permanently installed markers.

O2 - Coastal Flood Hazard Overlay District. Use the Coastal Flood Hazard Overlay District as a tool to inform property owners of existing and future risks and hazards based on projected sea-level rise and coastal storm surge flooding.

O2 - Living Shorelines and Landscaping. Maintaining natural shorelines is an effective way to preserve the functions of shoreline systems (marshes, dunes, estuaries) in providing valuable services including flood storage, recreational areas, and commercial harvesting of fish and shellfish.

- Provide information to property owners about living shorelines and the importance of retaining the functions of natural shorelines, and implementing landscaping best practices.
- Implement living shorelines projects on town lands to demonstrate best practices, and the benefits and effectiveness of living shorelines approaches.

APPENDIX – MAP SET

Map 1: Extent of Projected Tidal Flooding - SLR 1.7', 4.0' and 6.3'
Map 2: Extent of Projected Tidal Flooding - SLR + Storm Surge
Map 3: Critical Facilities and Infrastructure - SLR 1.7', 4.0' and 6.3'
Map 4: Critical Facilities and Infrastructure - SLR + Storm Surge
Map 5: Roads and Transportation Assets - SLR 1.7', 4.0' and 6.3'
Map 6: Roads and Transportation Assets - SLR + Storm Surge
Map 7: Land Resources - SLR 1.7', 4.0' and 6.3'
Map 8: Land Resources - SLR + Storm Surge
Map 9: Water Resources - SLR 1.7', 4.0' and 6.3'
Map 10: Water Resources - SLR + Storm Surge
Map 11: Climate Ready Culverts - SLR 1.7', 4.0' and 6.3'
Map 12: Climate Ready Culverts - SLR + Storm Surge