HAZARD MITIGATION PLAN UPDATE

Town of North Reading, Massachusetts

NOVEMBER 2021

Town of North Reading

235 North Street

North Reading, MA 01864

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November 2021

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North Reading, MA 01864

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Prepared by:

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

351 Pleasant Street, Suite B # 208 · Northampton, MA 01060
Phone: 413-586-0867 · Fax: 413-727-8282 · www.jamiecaplan.com

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Acknowledgements

The Town of North Reading would like to thank the following people for supporting the development of this plan. This group was considered the Core Team throughout the planning process.

- Robert Bracey, Health Agent, Director, Public Health Department
- Andrew Campagna, Director of Facilities, Department of Public Works
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- Barry Galvin, Deputy Fire Chief, North Reading Fire Department
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- Danielle McKnight, Town Planner, Department of Community Planning
- Joseph Parisi Jr., Director of Public Works, Department of Public Works
- Donald W. Stats, Jr., Fire Chief, North Reading Fire Department
- Joe Thibodeau, Lieutenant, North Reading Police Department

Local Adoption Resolution

TOWN OF NORTH READING, MASSACHUSETTS

BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE

HAZARD MITIGATION PLAN UPDATE

WHEREAS, the Town of North Reading established a Committee to prepare the HAZARD MITIGATION PLAN UPDATE and

WHEREAS, the Town of North Reading participated in the development of the HAZARD MITIGATION PLAN UPDATE;

and WHEREAS, the 2021 HAZARD MITIGATION PLAN UPDATE contains several potential future projects to mitigate potential impacts from natural hazards in the Town of North Reading, and

WHEREAS, a duly noticed public meeting was held by the North Reading Board of Selectmen on _____ for the public and municipality to review prior to consideration of this resolution; and

WHEREAS, the Town of North Reading authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan,

NOW, THEREFORE BE IT RESOLVED that the Town of North Reading Board of Selectmen formally approves and adopts the HAZARD MITIGATION PLAN UPDATE**,** in accordance with M.G.L. c. 40.

ADOPTED AND SIGNED by the North Reading Board of Selectmen on this_____ _____, 2022.

Kathryn M. Manupelli, Chair

Liane R. Gonzalez, Vice Chair

Vincenzo Stuto, Clerk

Stephen J. O'Leary, Member

Richard F. Wallner, Member

Record of Changes

This 2021 Hazard Mitigation Plan Update will be reviewed and approved on a biannual basis by the Core Team and following any major disasters. All updates and revisions to the plan will be tracked and recorded in the following table. This process will ensure the most recent version of the plan is disseminated and implemented by the Town.

Table 1. Summary of Changes.

Date of Change	Entered By	Summary of Changes

Chapter 1. Introduction

The Federal Emergency Management Agency (FEMA) defines mitigation as "the effort to reduce loss of life and property by lessening the impact of disasters. Mitigation is taking actions now – before the next disaster – to reduce human and financial consequences later (analyzing risk, reducing risk, insuring against risk.)"[1]

"The purpose of mitigation planning is to identify policies and actions that can be implemented over the long term to reduce risk and future losses. Mitigation plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. The planning process is as important as the plan itself. It creates a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters."[2]

"Disaster Mitigation Act (DMA) 2000 (Public Law 106-390)[3] provides the legal basis for FEMA mitigation planning requirements for State, local and Indian Tribal governments as a condition of mitigation grant assistance. DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation planning provisions and replacing them with a new set of requirements that emphasize the need for State, local, and Indian Tribal entities to closely coordinate mitigation planning and implementation efforts."[4]

The Town of North Reading, Massachusetts created this plan as part of an ongoing effort to reduce the negative impacts and costs from damages associated with natural hazards, such as nor'easters, floods, and hurricanes. This plan meets the requirements of the Disaster Mitigation Act 2000. More importantly, the plan was created to reduce loss of life, land, and property due to natural hazards that affect the Town of North Reading It is difficult to predict when natural hazards will impact the planning area, but it is accurate to say that they will. By implementing the mitigation actions listed in this plan, the impact of natural hazards will be lessened.

Local Mitigation Plans must be updated at least once every five years to remain eligible for FEMA hazard mitigation project grants. A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years to continue to be eligible for mitigation project grants.

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[1] What is Mitigation? (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/what-mitigation

[2] Multi-Hazard Mitigation Planning. (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/multi-hazard-mitigation-planning

[3] Disaster Mitigation Act of 2000, Pub. L. 106-390, as amended

[4] Disaster Mitigation Act of 2000. (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/media-library/assets/documents/4596?id=1935

Purpose of the Plan

The purpose of the Local Hazard Mitigation Plan is to provide the Town of North Reading with a comprehensive examination of all natural hazards affecting the area, as well as a framework for informed decision-making regarding the selection of cost-effective mitigation actions. When implemented, these mitigation actions will reduce the Town's risk and vulnerability to natural hazards.

This plan is a result of a collaborative effort between the Town of North Reading and the surrounding communities. Throughout the development of the plan, the Core Team consulted the public and key stakeholders for input regarding identified goals, mitigation actions, risk assessment, and mitigation implementation strategy. A sample of key stakeholders who participated, included the Ipswich River Watershed Association, the Massachusetts Emergency Management Agency (MEMA), the Federal Emergency Management Agency (FEMA), and the Department of Conservation and Recreation (DCR.

Guiding principles for plan development

The Core Team adhered to the following guiding principles in the plan's development. [5]

- Focus on mitigation strategy as the plan's primary purpose. All other sections contribute to and inform the mitigation strategy and specific hazard mitigation actions.
- Process is as important as the plan itself. In mitigation planning, as with most other planning efforts, the plan is only as good as the process and people involved in its development. The plan should also serve as the documentation of the planning process.
- This is your community's plan. To have value, the plan must represent the current needs and values of the community and be useful to local officials and stakeholders. Develop the mitigation plan in a way that best serves your community's purpose and people.

Mitigation Goals

The Core Team identified the following list of hazards to profile. They are shown in order of climate change interaction for consistency with the State Hazard Mitigation and Climate Adaptation Plan.

Table 2. Hazards Considered.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	Flooding Drought
Rising Temperatures	Average/Extreme Temperatures Infectious Disease Invasive Species Wildfires

[5] Federal Emergency Management Agency. (2013). *Local Mitigation Planning Handbook,* p. I-2.

Extreme Weather	Hurricanes/Tropical Storms Severe Winter Storm/Nor'easter Tornadoes Other Severe Weather
Non-Climate Influenced Hazards	Earthquake
Technological / Human Caused Hazards	Dam Failure HAZMAT

The hazard mitigation strategy is the culmination of work presented in the planning area profile, risk assessment, and capability assessment. It is also the result of multiple meetings and sustained public outreach. The Core Team developed the four goals shown below. The goals from the 2016 Hazard Mitigation Plan Update were revised to develop this current list. Information about the goal development process is in Chapter 6: Mitigation Strategy. These goals are considered "broad policy-type statements"[6] that represent the long-term vision for mitigating risk to natural hazards in the Town of North Reading.

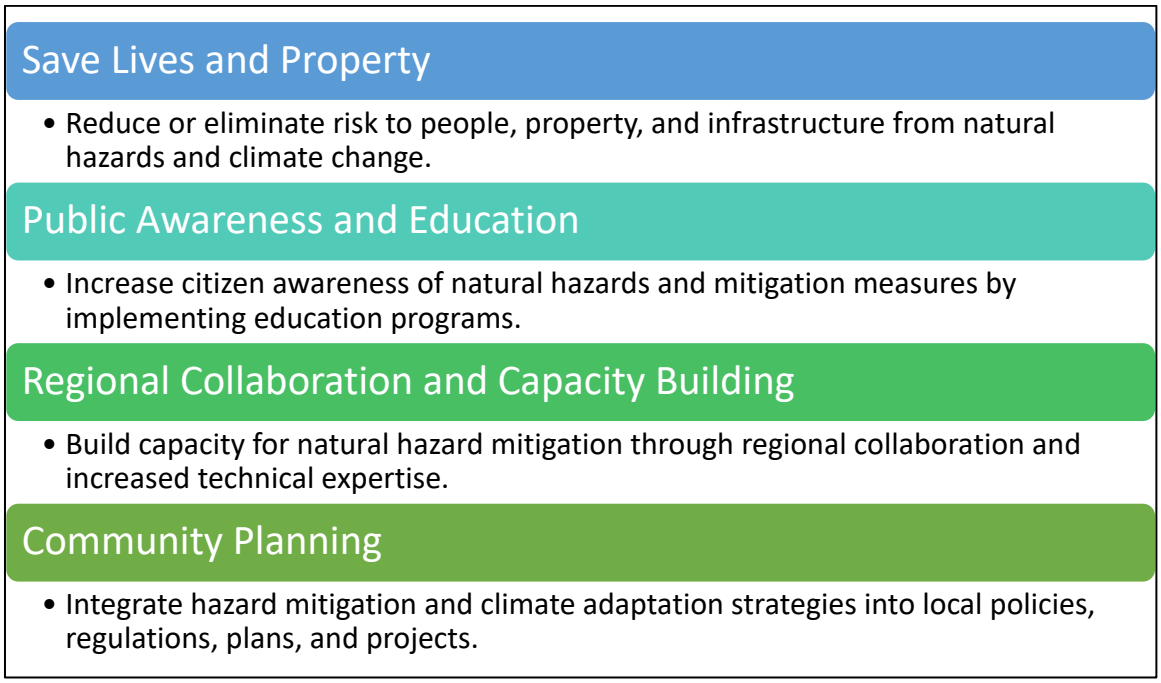

Figure 1. Goal Statements.

Plan Update and Changes

This section details some of the changes incorporated into this plan based on development, status of mitigation actions, and current Town priorities. This plan serves as a total revision and update to the Town of North Reading, Hazard Mitigation Plan Update from 2016.

[6] Federal Emergency Management Agency. (2013). *Local Mitigation Planning Handbook,* p. 6.

Changes in Development

Changes in development have occurred since 2016. The Core Team describes an increase in development. Many new homes and subdivisions have been built, especially communities for people over the age of 55. Several of these subdivisions are currently in development. New construction has increased vulnerability. While none of the new developments are being constructed in designated flood zones, their construction has increased localized flooding in adjacent lots in some cases, despite Town regulations that prohibit this. In addition, the Core Team mentions that detention ponds are filling with silt during construction which has caused breaches to these ponds. Due to this the Town is holding meetings with developers and consulting engineers to mitigate the flooding problems. The Core Team has recommended two mitigation actions specifically for this issue, Review Stormwater Bylaw and Subdivision Regulations Review. The table below indicates major construction since 2015.

Table 3. Subdivisions Built Since 2015.

Name	Status	Year	Housing Units	Project Type
Pulte Homes/Martins Landing Berry Way, formerly 104 Lowell Road	Under Construction	2022	502 55+ units	Residential
35-37 Main Street	Completed	2020	Commercial – retail, office & storage	Mixed use, 3-story building with ground floor retail and storage
Ipswich River Townhouses	Completed	2015	14 units	Residential condominiums
Charles Street Extension Subdivision	Under Construction	2021 status	11 lots	
20 Elm Street	Proposed and under litigation	N/A	200 units	
39 Chestnut/9 Flint	Under Review	N/A	13 House lots	
148-150—Park Street	Under Review	N/A	50 Units	Residential project for over 55 housing. Zoning is approved and

Name	Status	Year	Housing Units	Project Type
				site plan review is expected shortly.
25-29 Main Street	Completed	2021	Commercial	Retail/office building
Woodcutter Road/Grand Legacy Subdivision	Under Construction	N/A	7 lots	

Additional information regarding development, such as population changes and land use may be found in Chapter 2. Planning Area Profile. Additional information regarding vulnerability is included in Chapter 4. Risk Assessment. Finally, the Core Team did amend hazard mitigation actions to mitigate risk based on current and future development patterns.

Progress in Mitigation Efforts

Chapter 6: Mitigation Strategy details the previously identified mitigation actions from the 2016 Hazard Mitigation Plan Update and their status in 2021. Each of these actions is listed as completed, in progress, or delayed. A description of the status is given. The Core Team used this information to determine if the actions should now be considered capabilities of the Town or if they should move forward into this new plan. The current mitigation action list represents present and future needs for North Reading.

Changes in Priority Since 2016

The biggest change in priority since the 2016 Hazard Mitigation Plan Update is how the Town understands the current and potential impacts of climate change. North Reading completed a Municipal Vulnerability Preparedness Plan in 2018 which identified climate change impacts and key climate change adaptation actions the Town can take for improved resiliency. The goal statements were revised to include climate change. The Town has noted that construction activity presents a risk of localized flooding. The Core Team has added two mitigation actions to address these impacts:

- Review Stormwater Bylaw, and
- Subdivision Regulations Review.

The Core Team also recognized that the drop in National Flood Insurance Policies (NFIP) since 2016 does not accurately reflect the need for NFIP policies. The Core Team concludes that the drop in insured properties may be due to the increase in fully paid mortgages on older homes situated in flood zones which eliminates the requirement to carry flood insurance. In response to this, the Core Team added a mitigation action to increase NFIP participation as well as several hazard education actions.

The previous plan listed in mitigation actions in priority order 1-24. This order was achieved using a modified STAPLEE criteria that considered life safety, property protection, technical feasibility, political support, legal authority, environmental impactions, social impact, administrative capacity, existence of a local champion, and other community objectives to rank priority. While this system proved effective, for this plan update a simpler method was employed that achieved similar results. The current system ranked actions in the categories of high, medium, or low. Having buckets of similarly ranked actions represents the reality of how actions are chosen for implementation. The ranking included all the benefit cost considerations from the 2016 system by lumping them together and then rating them high, medium, or low.

The other significant change in priority was due to the Covid-19 Pandemic. The Core Team added Infectious Disease to the list of hazards reviewed. Like communities nationwide the Covid-19 Pandemic impacted local government function and citizen expectations. This plan was created through virtual meetings to avoid the spread of disease. The mitigation actions created include consideration of infectious disease risk and mitigation, primarily through citizen education and increased local government capacity.

The priority that has not changed since 2016, is the Town's priority to mitigate flood risk. This is seen in the MVP actions identified in 2018 and carries into the mitigation actions for this 2021 plan.

Authority and Assurances

The Town of North Reading will continue to comply with all applicable Federal laws and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 201.6. It will amend its plan whenever necessary to reflect changes in town, State or Federal laws and regulations, as required in 44 CFR 201.6.

The Core Team recognizes the following FEMA publications:

- Local Mitigation Planning Handbook (March 2013)
- Local Mitigation Plan Review Guide (October 2011)
- Demonstrating Good Practices Within Local Hazard Mitigation Plans (January 2017, FEMA Region 1)

Plan Adoption

The Town of North Reading will adopt the Plan when it has received "approved-pending adoption" status from the Federal Emergency Management Agency (FEMA). The Certificate of Adoption is included on page 3.

Document Overview

Below is a summary of the Hazard Mitigation Plan Update chapters, including appendices. The planning process closely adhered to FEMA guidelines and to the intent of those guidelines.

Chapter 2: Planning Area Profile
The Planning Area Profile chapter describes the Town of North Reading completely, including history, population, government, and infrastructure.

Chapter 3: Planning Process
The Planning Process chapter documents the methodology and approach of the hazard mitigation planning process. The chapter summarizes the Core Team meetings and the public outreach process (including public meetings). This chapter guides the reader through the process of generating this plan and reflects its open and inclusive public involvement process.

Chapter 4: Risk Assessment
The Risk Assessment identifies the natural hazard risks to the Town of North Reading and its citizens. The risk assessment looks at current and future vulnerabilities based on land use development including structures and infrastructure. Included in this chapter is a list of critical facilities identified by the Core Team.

Chapter 5: Capability Assessment
The Capability Assessment looks at the Town's ability to mitigate risk prior to and following disaster. This chapter is structured around the following four categories: planning and regulatory, administrative, and technical, financial, and education and outreach. The chapter concludes with information regarding the National Flood Insurance Program.

Chapter 6: Mitigation Strategy
This chapter provides a blueprint for reducing losses identified in the Risk Assessment. The chapter presents the hazard mitigation goals and identifies mitigation actions in order of priority. Each mitigation action includes essential details, such as Town lead, potential funding sources, and implementation timeframe.

Chapter 7: Plan Implementation and Maintenance
The Plan Implementation and Maintenance establishes a system and mechanism for periodically monitoring, evaluating, and updating the Hazard Mitigation Plan. It also includes a plan for continuing public outreach and monitoring the implementation of the identified mitigation actions.

Appendices
The Appendices includes documentation regarding the planning process, such as Core Team and public meeting attendees. It also includes preliminary flood insurance rate maps.

Chapter 2: Planning Area Profile

The Town of North Reading is a 13.3 square mile suburban town in Middlesex County, set entirely within the watershed of the Ipswich River. It was created as an independent town in 1853 and retains several simple and well-preserved mid-18th century homes. The Town of North Reading is in Northeastern Massachusetts, bordered by Wilmington on the west, Andover and North Andover on the north, Middleton, and Lynnfield on the east, and Reading on the south (see Figure 1 below). North Reading is 10 miles south of Lawrence and 15 miles north of Boston. North Reading has a total population of 15,344 as of July 1, 2021.[7]

According to City-Data.com, North Reading has a median household income above the Massachusetts state average, an unemployment rate significantly below the state average, and a renting percentage significantly below the state average.[8] The three figures below show:

- Figure 2. Town of North Reading Map.
- Figure 3. North Reading Location in Massachusetts.
- Figure 4. Street Atlas.

[7] North Reading, MA 01864 Zip Code Profile. (2015). MA Hometown Locator. Retrieved August 31, 2021, from http://massachusetts.hometownlocator.com/zip-codes/data,zipcode,01864.cfm

[8] http://www.city-data.com/city/North-Reading-Massachusetts.html

Town of North Reading Boundary Map

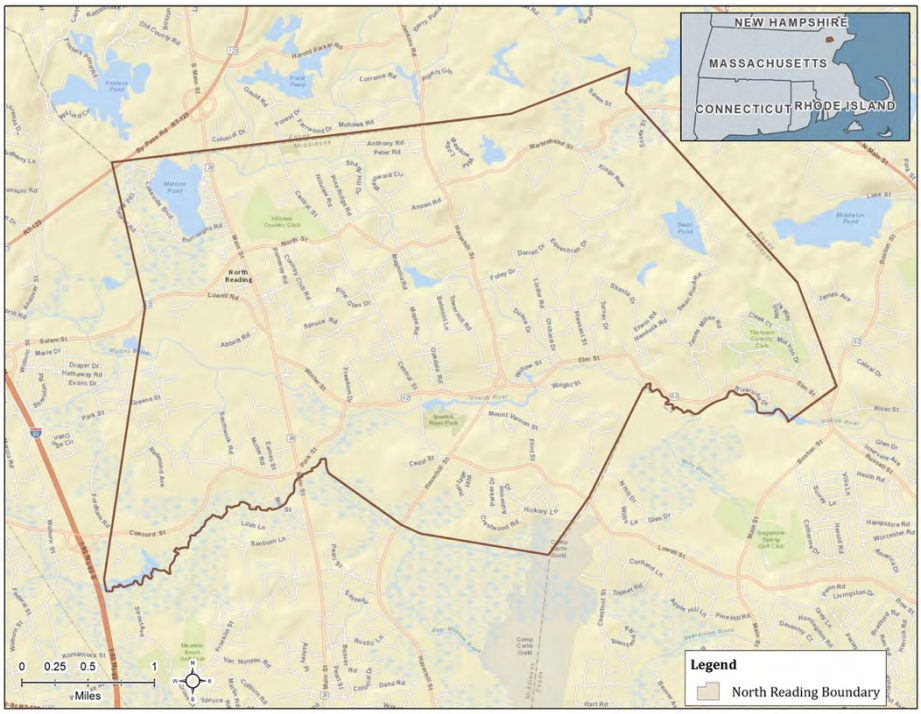

Figure 2. Town of North Reading Map.

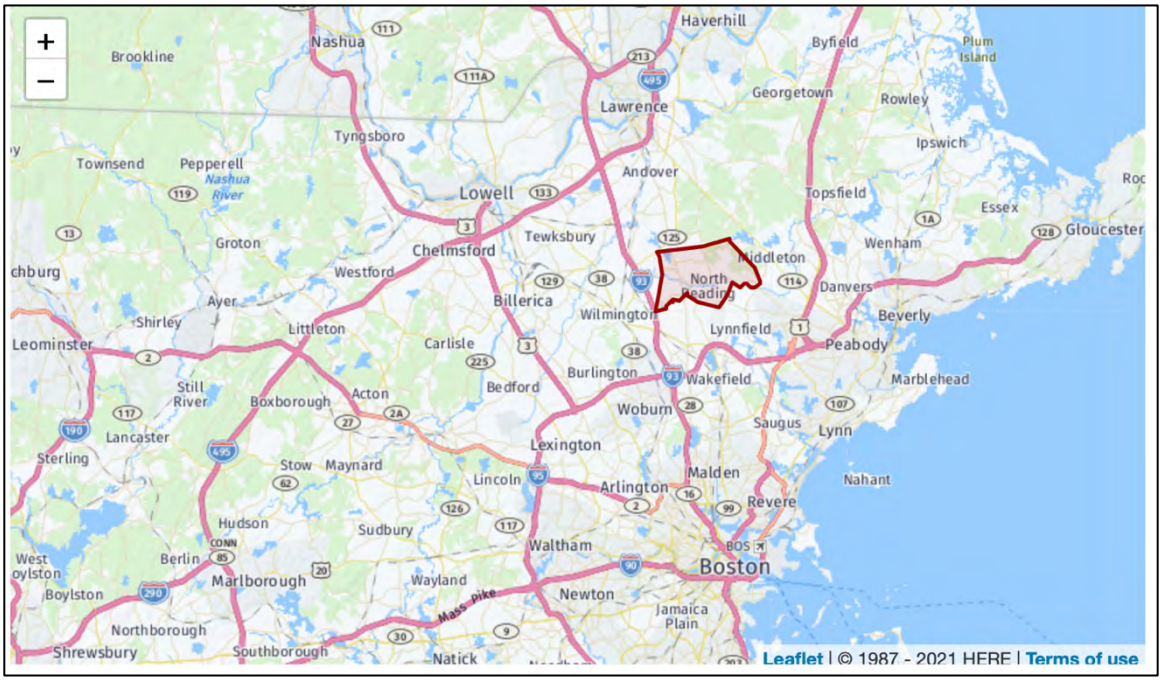

Figure 3. North Reading Location in Massachusetts. [9]

[9] https://massachusetts.hometownlocator.com/counties/subdivisions/data,n,town%20of%20north%20reading,id,2501748955,cfips,017.cfm

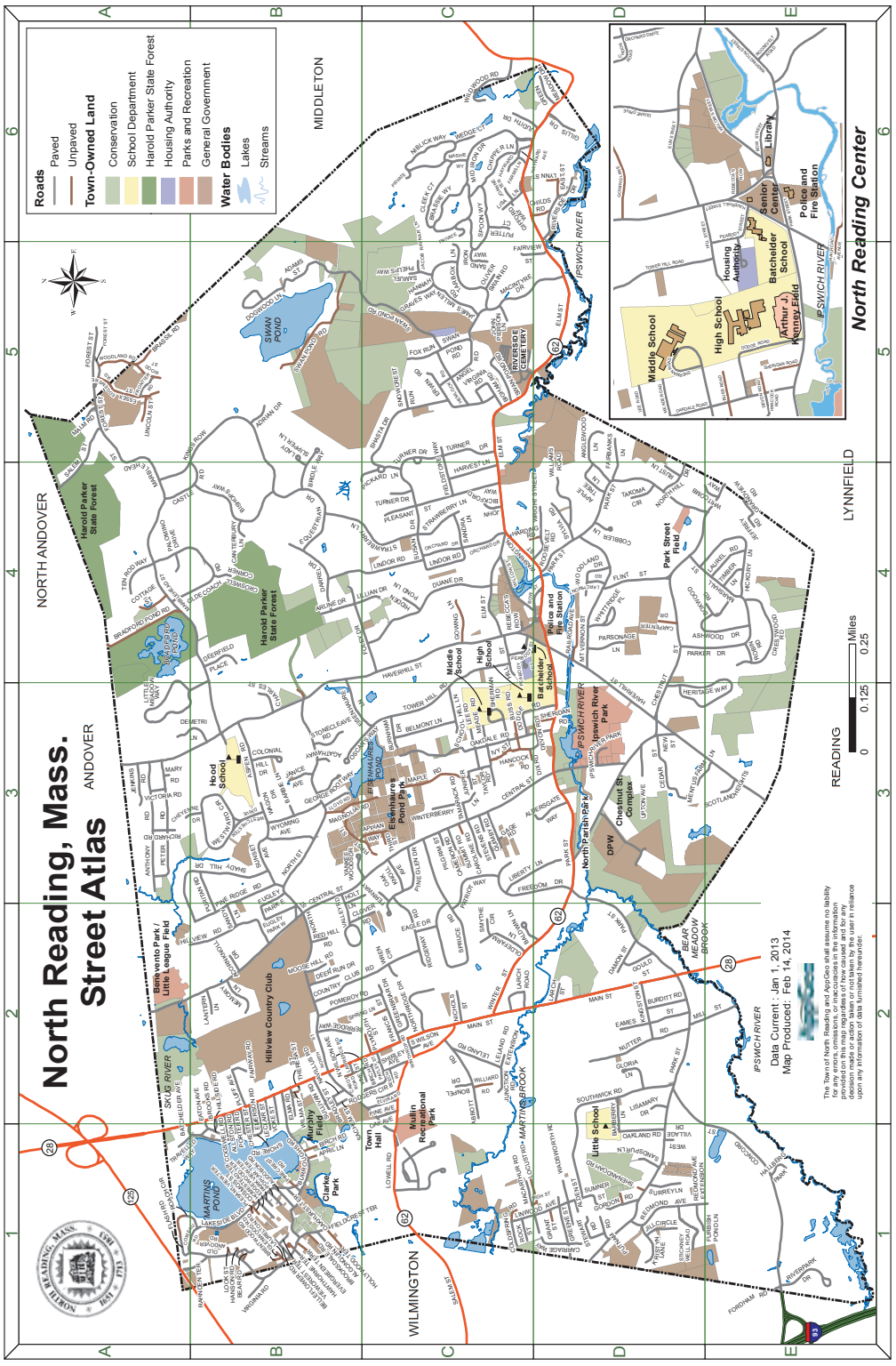

Figure 4. Street Atlas.

History

North Reading was incorporated as a town in 1853, having earlier (1713) been the North Parish and part of what is now Wakefield and Reading, the First and West Parishes, respectively. The earliest human residents were the Algonquin people of the Massachusetts language group, whose campgrounds adjacent to several waterways have been documented by archaeologists. Many artifacts are now at the Peabody Museum at Phillips Academy. Most of the European settlers later worked at clearing and farming land. "As the population grew, occupations diversified, a service sector developed, with schools, mills, taverns, shoe shops (a winter occupation for farmers), tannery, railroad station, fire engine company, and a militia-training field."[10]

"Original grants of large farmsteads along the river during the mid-17th century brought six families to the settlement before 1680. The economy of the Town in the 17th and 18th century was based on subsistence farming with limited crop production. There was a sawmill on Lob's Pond by 1694 and grist and sawmills at the village center by 1794. Some small-scale boot and shoe making was underway by 1820, and by 1850 small sheds or shops to make shoes were attached to almost every house in Town. These shops produced cheap footwear that was sold south to clothe slaves, and the Civil War destroyed the Town's industry. The principal products of the Town in the early 20th century were milk, apples, and fruits. The Town center retains a federal style meeting house and affluent Federal village with a well-preserved district of period houses, and townspeople are very proud of the fact that their town center retains its complete historic fabric."[11]

The economy of the Town in the 17th and 18th century was based on subsistence farming with limited hop production. There was a sawmill by 1694 and grist and sawmills at the village center by 1794. Some small-scale boot and shoe making shops were underway by 1820, and by 1850 small sheds or shops to make shoes were attached to almost every house in Town. These shops mainly produced cheap footwear that was sold in the south to clothe slaves. The Civil War effectively destroyed the Town's industry. By the early 20th century, the principal products of the Town were milk, apples, and fruits.[12] Like many rural communities, the railroad brought immense change to North Reading. The introduction of the railroad provided a means to transport freight between the large mills in Lawrence and Lowell and introduced a way for passengers to travel far beyond their Town borders. The railroad came to North Reading in 1850 and joined South Danvers (now Peabody) to Tewksbury where it connected to the Lowell mills via the Lowell and Lawrence Railroad. By 1887, the Boston and Maine Railroad took over the line. Passenger service along the route ended in 1932, and freight service between North Reading and Wilmington ended in 1935.[13]

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[10] Town of North Reading Open Space and Recreation Plan. Retrieved on February 3, 2015 from http://www.northreadingma.gov/pages/NReadingMA_Recreation/Open%20Space%20Plans/OSRP2007/OSRP2007_Draft.pdf.

[11] Community Profiles – North Reading. Massachusetts Department of Housing and Community Development. Retrieved on December 8, 2014, from www.mass.gov/hed/docs/dhcd/profiles/199.doc.

[12] Ibid.

[13] Town of North Reading Open Space and Recreation Plan. Retrieved on February 3, 2015

After World War II, North Reading began to transform into the community it remains today, an outlying suburb of the Boston Metro area. Much of the agricultural land has been developed as housing. Although there is some local industry concentrated within the southwestern portion of Town and commercial development along Main Street (Route 28), it is predominantly a residential community.

Natural Resources

Geography

The Town is a suburban community, which retains some of the character of its early rural heritage. Gentle rises and flat meadows descend to the Ipswich River Basin, which traces a path through the southern portion of the Town just south of the historic Town center. Smaller streams and brooks meander through the central and western portions of North Reading with four ponds and connected wetland systems scattered throughout the northern half of the Town. Much of the undeveloped land is forested and there are traces of stonewall from the Town's early agricultural heritage.

The landform of North Reading is generally from flat to gently rolling. The highest elevation is 230 feet above mean sea level on United States Geological Survey datum, with an average elevation of approximately 100 feet. The advance and retreat of the continental ice sheet from more than 10,000 years ago left North Reading's pre-glacial bedrock covered with a variety of glacial deposits. As a result, it has a direct bearing on the suitability of much of the Town's land for development and other purposes. The town's glacial deposits that were left by departed ice sheets have two general types, a) compact basal till, and b) outwash deposits, which form the parent material for most of the Town's soils.

Compact basal till was formed beneath the actively moving ice sheet and is an unsorted assemblage of all particle sizes including clay, silt, sands, gravel, and boulders. The composition of basal till is very dense, hence commonly referred to as "hardpan." Infiltration is extremely slow through the hardpan, and as a result water is often perched in the soil above the dense till layer. Consequently, many soils formed in basal till have severe limitations for septic disposal. These soils are often wet during the spring but become very dry during the summer months. In North Reading, many of the till deposits occur in conjunction with shallow-to-bedrock areas. Some till areas have sandier layers near the surface and may be suitable for development. However, many of the wetlands, which are found on the tops and slopes of hills, are the result of an underlying basal till deposit. As the ice sheet melted, glacial outwash deposits were formed in front of the "stalled" ice sheet. Similarly, kame terraces were formed between stagnant ice and adjacent hillsides. Both formations contain stratified (layered) deposits of sand and gravel. Meltwater leaving the glacier carried gravel, sand, silt, and clay particles with it, leaving the stones and boulders behind in the stagnant ice. Because gravel and sand are relatively heavy, these materials were deposited in well-sorted layers close to the melting ice, while the water continued to carry the lighter silts and clays away from the glacier. Because of the well-sorted coarse textured deposits, which lack

http://www.northreadingma.gov/pages/NReadingMA_Recreation/Open%20Space%20Plans/OSRP2007/OSRP2007_Draft.pdf

silts and clays, many soils formed in these areas yield rapid “perc” test rates and are viewed as good building sites. However, the extremely rapid permeability of many of these soils may be a disadvantage in aquifer recharge areas, as contaminants can quickly enter the groundwater. While many of these deposits are very well-drained, wetlands are found in outwash plains when they are in a low position on the landscape. A good surface indicator of an outwash plain is the presence of “kettle hole” depressions in a relatively level area, which lacks surface stones and boulders. Kettle holes were formed as outwash buried remnant ice blocks, which later melted, leaving the circular “kettle hole” depressions that often hold a small pond or wetland.

The USDA has determined that about 39% of the soils in North Reading are favorable for residential development, because the Town is not served by municipal sewers, instead relies on sub-surface disposal of sanitary waste. The favorable soils are typically better drained. Sandier soils, which are found in outwash deposits, yield acceptable percolation rates pursuant to the requirements of Title V of the State Sanitary Code. Soils that drain faster than 2 minutes per inch are considered poor filters of sewage and should be considered a constraint to development in aquifer recharge areas. Most of the remaining soils are from moist to wet because of its imperfect drainage property (including many areas underlain by dense basal till), shallowness to bedrock, or a high-water table during a portion of the year. Other soils unfavorable to development are steeply sloped, or contain densely packed glacial till, which is too impermeable for septic systems. Like much of New England, glaciation has left significant obstacles to development in North Reading.

The native vegetation of North Reading is an integral part of the Town’s regional character. The tall oaks and huge white pines, which were prized by the king’s shipbuilders for masts, clearly show that this is not the shore, nor the inland bottomlands, nor the limestone areas of the Berkshires. They are indicators of the dry, sandy, acidic soils across the northerly half of Town. By contrast, the fern-covered forests elsewhere in Town indicate that water is nearby, and the area is probably a floodplain.
North Reading, despite recent intensity of development, still contains a few large tracts of forestland. The University of Massachusetts carried out an analysis of land use and vegetative based on 1971 aerial photography, classified slightly more than 5,000 acres (57.7% of the Town) as forest. Of this, approximately 50.5% hardwoods, 9% softwoods, and about 40.5% mixed forest. These forests were predominately well-stocked with large 40-80-foot trees. Follow-up research in 1994 by the Town’s Planning Department estimated remaining forest cover of less than 2,938 acres or 34% of the Town. Some of this forested acreage is state or municipally owned, while the remainder is in private ownership. The most extensive tract of forested land extends from Haverhill Street to the eastern Town boundary on the north side of Elm Street.

Rivers and Ponds

As part of the Ipswich River Watershed area, North Reading is in one of the most historically and ecologically significant river systems in the region. The Ipswich River is part of the Great Marsh ecosystem which extends to New Hampshire, and more than 330,000 people depend on the river and its aquifers for drinking water. The Ipswich River is considered a highly stressed river basin since segments

of the river run dry on a regular basis. American Rivers, a national river organization, designated the Ipswich River as the third most endangered river in America in 2003. North Reading's water resources include rivers and streams, ponds, wetlands, flood areas. Figure three shows the Rivers and Ponds in and around North Reading.

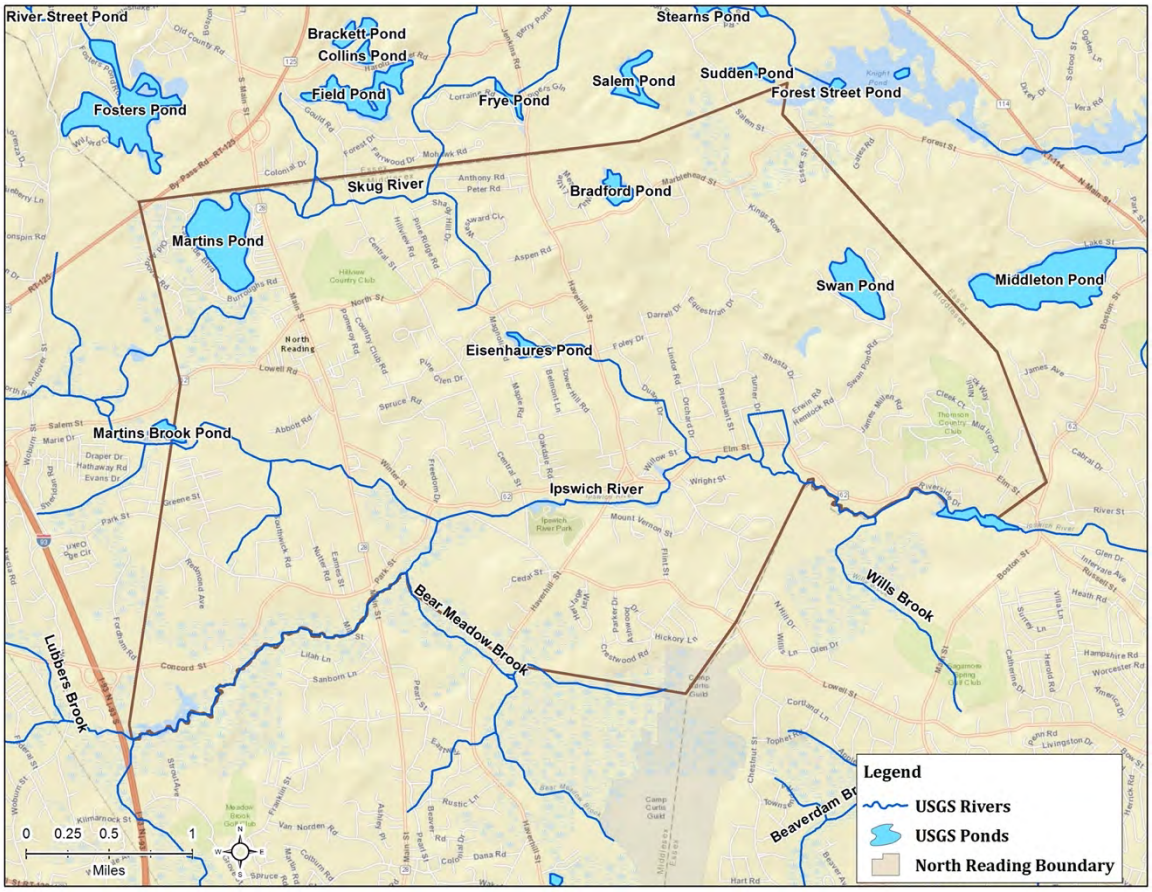


Figure 5. Rivers and Ponds in and around North Reading.

The Skug River, which originates along the Andover-North Andover border, enters North Reading on its northern border and flows westerly into Martins Pond. Martins Brook flows out of Martins Pond, enters Wilmington, re-enters North Reading, and forms an important tributary to the Ipswich River. It also contributes to groundwater supply at the Town's Central Street wells, and during the dry season groundwater is replenished by stream flow.

The Ipswich River forms the southern boundary of the Town between the Wilmington town line (at the southwest corner of North Reading) and Beaver Brook. The river continues to flow easterly from Beaver Brook through the south-central region of town, and then forms the southeastern border between North Reading and Lynnfield.

The largest of the Town's ponds include Martins Pond, Eisenhauer's Pond, Bradford Pond, Swan Pond, and Furbish Pond. Three of the ponds are likely greater than ten acres in size in their natural state,

which would classify them as Great Ponds of the Commonwealth. "The Massachusetts Public Waterfront Act (Chapter 91) protects pedestrian access and "public strolling rights" to these water bodies, while other ponds can be owned privately by surrounding landowners and public access can be prohibited."[14] Only Martins Pond and Swan Pond were officially surveyed by the state Department of Environmental Protection (DEP) as being greater than ten acres in area.[15]

Most of Martins Pond is surrounded by older private development – former vacation homes that are now year-round residences. A portion of the shoreline includes a park (Clarke Park) and a boat launch. For two decades now, The Martins Pond Association is a local organization that has been advocating and providing stewardship services that support the Pond. With funding help from Massachusetts Department of Environmental Protection (DEP), North Reading and the Association have undertaken a shoreline restoration and sediment reduction project and a stormwater reduction project.

"Swan Pond is in the least densely populated sector of Town. The Town of Danvers has rights to use Swan Pond as a public water supply. Access is permitted on Swan Pond for non-motorized boats. The shoreline of Eisenhauer's Pond has conservation easements among new upscale private home subdivisions. In addition, Bradford Pond lies within the State Forest. While Furbish Pond is part of a quaking bog on Town-owned land, it is presently inaccessible for public use as a nature study resource. The Town holdings here are surrounded by industrial and residential development."[16]

North Reading has a wetlands by-law that extends state and federal wetland regulations and restricts development in wetland areas. Protecting wetlands is an essential component to mitigating flood risk. Wetlands provide a habitat for wildlife, and they also serve as a space to absorb surface water. Impacting wetlands with development can negatively impact the groundwater level. The figure below shows the wetlands and habitat in North Reading.

[14] Town of North Reading Open Space and Recreation Plan. Retrieved on February 3, 2015 from http://www.northreadingma.gov/pages/NReadingMA_Recreation/Open%20Space%20Plans/OSRP2007/OSRP2007_Draft.pdf

[15] Town of North Reading Open Space and Recreation Plan. Retrieved on February 3, 2015 from http://www.northreadingma.gov/pages/NReadingMA_Recreation/Open%20Space%20Plans/OSRP2007/OSRP2007_Draft.pdf

[16] Town of North Reading Open Space and Recreation Plan. Retrieved on February 3, 2015 from http://www.northreadingma.gov/pages/NReadingMA_Recreation/Open%20Space%20Plans/OSRP2007/OSRP2007_Draft.pdf

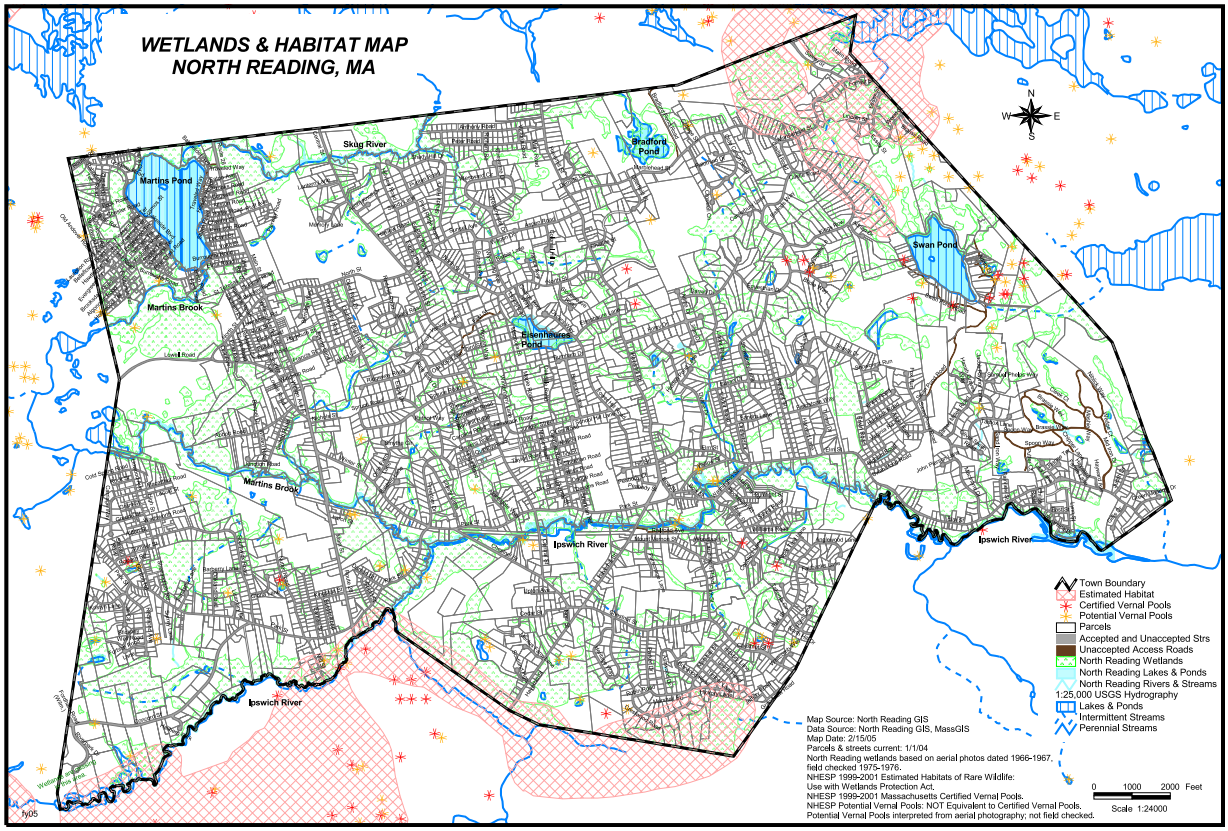


Figure 6. Wetlands and Habitat.

Town Government

An Open Town Meeting, a five-person Board of Selectmen, and Town Administrators run the Town of North Reading. Michael P. Gilleberto is currently the Town Administrator. Each member of the Board of Selectmen serves a three-year term. "The Board may enact rules and regulations in a variety of areas, as well as establish town policies and procedures on many issues, unless such issues are delegated by law or vote of the Town Meeting to another officer or board."[17] The Board appoints the Town Administrator who supervises the operation of Town departments.

Population and Housing

According to the latest estimates provided by the U.S. Census Bureau (2019), North Reading's total population is 15,865 which equates to a current population density of nearly 1,133 people per square mile.[18] The North Reading population has grown about 0.27% since 2010 and is expected to continue to rise at about 0.28% from 2020-2025.[19] The Figure below from the North Reading Master Plan 2020-2030 show some demographic trends.

[17] Board of Selectmen. (2015). North Reading Massachusetts. Retrieved on December 11, 2014 from http://www.northreadingma.gov/Pages/NReadingMA_Selectmen/index

[18] https://www.census.gov/quickfacts/northreadingtownmiddlesexcountymassachusetts

[19] https://massachusetts.hometownlocator.com/counties/subdivisions/data,n,town%20of%20north%20reading,id,2501748955,cfips,017.cfm#demographic

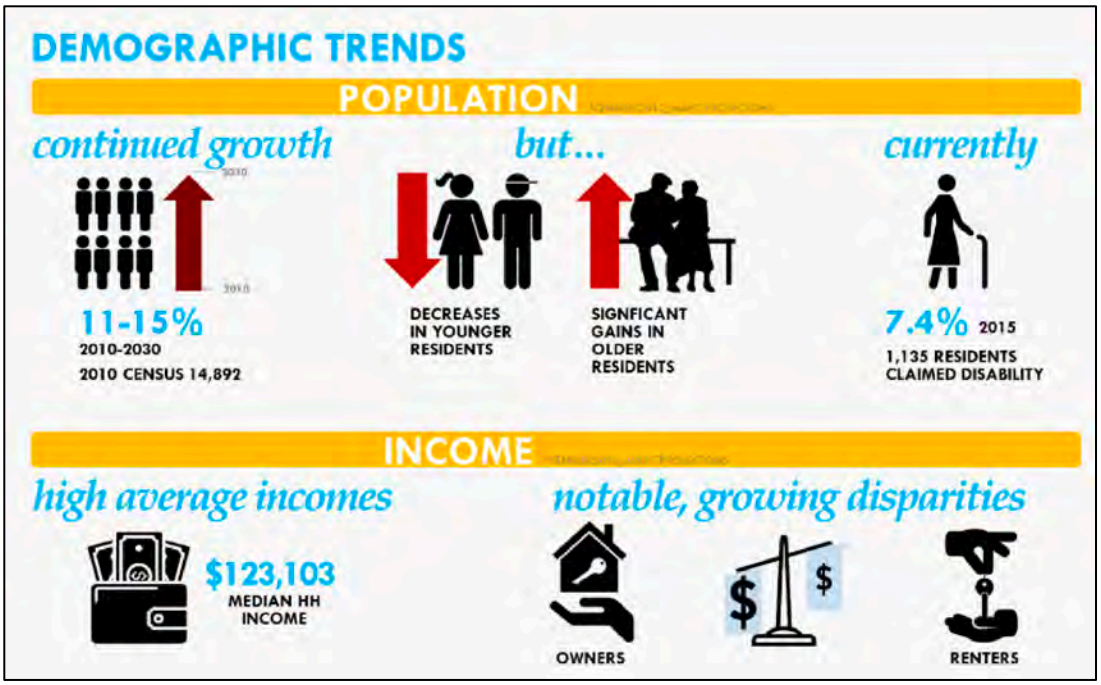


Figure 7. Demographic Trends.

The population increases are increasing the need for housing, illustrated in the figure below also from the North Reading Master Plan.

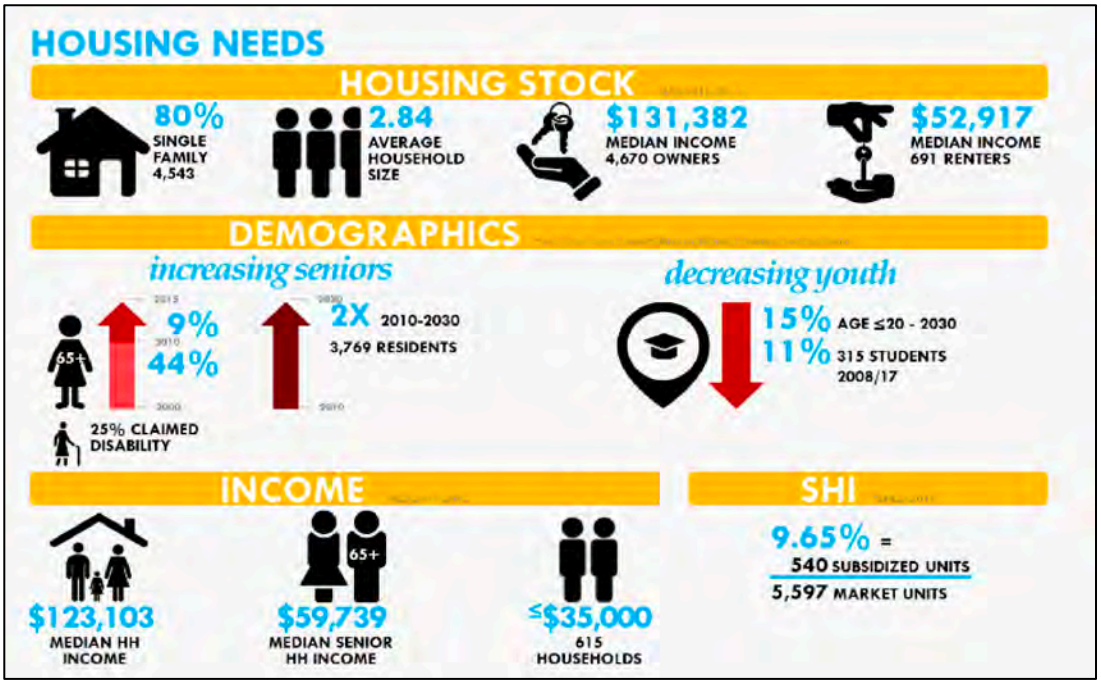


Figure 8. Housing Needs.

Major Employers

North Reading has several businesses that employ over one hundred employees. The largest employer is Teradyne Inc., although it is unclear how many of their employees work at the North Reading headquarters. "Teradyne (NYSE:TER) is a leading supplier of Automatic Test Equipment (ATE) used to test semiconductors, wireless products, data storage and complex electronic systems that serve consumer, communications, industrial and government customers. With sales of over $1.43 billion in 2013, Teradyne currently employs approximately 3,900 people worldwide. Headquartered in North Reading, Massachusetts with 70 locations throughout Asia, Europe and North America, Teradyne employees share a customer-centric approach."[20] Moynihan Lumber has over thirteen acres of land and occupies at least 8 buildings. Some of their land abuts rivers in the Town. The Table below shows the top ten employers in North Reading.

Table 4. Top Ten Employers in North Reading. [21]

Company	Location	# of Employees	Industry Code
Teradyne Inc	River Park Dr.	1,000-4,999	4236
Gerald S Jamgochian & Co	Park St.	250-499	5239
Dec Tam Corp	Concord St.	100-249	5629
Dynamics Electrical	Concord St.	100-249	2382
Electrical Dynamics Inc.	Concord St.	100-249	2382
Kitty's Restaurant & Lounge	Main St.	100-249	7221
Moynihan Lumber & Hardware	Chestnut St.	100-249	4441
USPS	Main St.	100-249	5419
Walmart	Main St.	100-249	4521
YRC	Concord St.	100-249	4842

Infrastructure

For the purposes of description, infrastructure includes roads and bridges, water supply, sewer and wastewater disposal, solid waste, and public facilities.

[20] About Teradyne. (2015). Teradyne. Retrieved on December 8, 2014 from http://www.teradyne.com/about-us.
[21] Town of North Reading Open Space and Recreation Plan. (2013). Prepared by Brown Walker Planners, Inc. with the North Reading Open Space Plan Committee. P.15.

Roads and Bridges

According to city-data.com, the following represents the National Bridge Inventory in North Reading.

National Bridge Inventory (NBI) Statistics	
Number of bridges	7
Total length	30ft / 8.8m
Total costs	$6,755,000
Total average daily traffic	110,100
Total average daily truck traffic	5,879
Total future (year 2031) average daily traffic	182,096

Figure 9. Road and Bridge Inventory.[22]

Water Supply

The Town has two sources of drinking water: wells located along the Skug River, Martins Brook and the Ipswich River; and the Town of Andover water supply system. "The Town of North Reading lies within the watershed of the Ipswich River. The Ipswich River is part of the Great Marsh ecosystem which extends to New Hampshire, and more than 330,000 people depend on the river and its aquifers for drinking water. The Ipswich River is considered a highly stressed river basin, due to the fact that segments of the river run dry on a regular basis."[23]

Before 1936, North Reading relied upon private wells for its water. From 1936 to 1954, the Town imported water from Wilmington. Between 1954 and 1980, five well fields were developed within the Town. Additional water, as needed has been imported from Andover beginning in 1995. Today North Reading provides about 1.37 million gallons of water per day (500 million gallons a year) to its residents and businesses. About seventy percent of which is purchased from Andover at a rate that is not considered advantageous to the Town. The balance comes from the Town's public supply system. In addition, about 15% of homes in North Reading now have irrigation wells to supplement the public supply.

[22] http://www.city-data.com/city/North-Reading-Massachusetts.html
[23] Town of North Reading Open Space and Recreation Plan. (2013). Prepared by Borwn Walker Planners, Inc. with the North Reading Open Space Plan Committee. P.40.

North Reading has public wellfields adjacent to the Skug River (Central Street wellfield), near Martins Pond (Lakeside wellfield and Route 125 wellfield), and near Martins Brook where it re-enters the Town from Wilmington (Railroad Bed wellfield). In addition, the Town owns and maintains two water treatment plants, pumping stations, three water storage tanks, approximately 80 miles of water mains, 750 fire hydrants and 4,600 water service connections and water meters. Water use restrictions (odd/even outdoor water use) have been in place year-round due to extremely low flows in the Ipswich River for several years and the Department continues to investigate ways to reduce water consumption further. Initiatives include a rain barrel program that provides rain barrels at a reduced price to encourage alternative non-potable water use and educational outreach that focuses on reducing water use for lawns and gardens.

In conjunction, the Town is revising its drought and restriction plan and is seeking funding to develop a Capital Improvement Plan. The Town's long-term goal to lower water costs and improve capacity and efficiency is to purchase its water from the Massachusetts Water Resource Authority (MWRA).

Aquifer Recharge Areas

An aquifer is a groundwater supply capable of yielding a significant volume of water for a useful well. Aquifers of sufficient capacity to serve as a municipal water supply are scarce and found only in locations with certain geologic and hydrologic conditions. Most aquifers with such a volume were formed in valleys carved into bedrock millions of years ago by ancient rivers that drained the continent. North Reading's aquifers and its primary recharge areas are in the area around Martins Pond and in various areas along the Ipswich River and Martins Brook.

Sewer and Wastewater Disposal

North Reading has no public sewer system or wastewater treatment facility. The High School complex and some larger developments operate private on-site wastewater treatment plants. However, development of a wastewater system is being explored as a strategy to protect the town's water resources and to increase business development within the community.

In 2007, North Reading completed a Comprehensive Wastewater Management Plan that recommended a series of steps the Town could take to develop a wastewater disposal system for areas in need. The sites recommended as most appropriate however, have not proven to be suitable. To eliminate the need for an independent treatment plant, the Town is currently reviewing the report to seek alternative development strategies. Distributing waste to the public system in Lawrence appears to be the most viable option at this point in the inquiry.

Storm Water Management

The Town of North Reading has a Stormwater Management Plan in place to protect water resources and prevent flooding. Through the Department of Public Works, residents receive information about the cause and effect of stormwater and the town's policies, regulations, and initiatives that address it.
In 2010 the Town created the Water and Wastewater Commission to focus on stormwater issues and guide community decisions and actions. The same year, it also adopted updated stormwater rules and

regulations. These newly adopted regulations provide greater clarity of the Town's Stormwater Management Bylaw and improve effectiveness of its administration and enforcement. The Department of Public Works continually updates its Geographic Information System (GIS) mapping of stormwater infrastructure.

According to the 2013 Annual Report, the "Town is in compliance for 2013" in terms of storm water management. In addition, the "Engineering Office and the Martins Pond Association completed the MA 319 grant titled 'North Reading Stormwater Infiltration Project "ROAR"' on June 30, 2013. Storm drainage was installed on Shore Road and Plymouth Street."[24]

Solid Waste Disposal

The Solid Waste and Recycling Division of the Department of Public Works is responsible for the collection of residential solid waste (trash) and recyclable materials from the residents of North Reading. The Town currently contracts with JRM Hauling for solid waste removal services, which charges the Town on a per ton basis. While the Town pays for every pound of solid waste hauled, it pays the same for recycling regardless of the amount or recyclables collected. Recycling more to reduce solid waste is therefore a viable strategy for reducing service costs that impact how tax dollars are spent.

The Town has in place several policies and initiatives to help reduce solid waste production. Residents are currently limited to four (4) 30-gallon containers or bags per week, not exceeding 50 pounds in weight. In addition, one large item per week (mattresses, sofas, etc.) is permitted. A recent curb audit determined that 89% of households recycle and 89.5% of households produce two or fewer allowed containers a week, suggesting that an appropriate strategy to further reduce waste may be to reduce the container limit from four to three. The audit also found that generally, those households with greater than two containers were not recycling. The Town's efforts to reduce solid waste has helped the community reduce trash production from an average of 65 pounds per household per week in 2005 to 48 pounds per week in 2010. Recycling accounts for roughly 25% of the Town's solid waste.

Public Facilities

North Reading operates five schools which are itemized in the table below.

Table 5. North Reading Schools.[25]

School	Address	Number of Students
North Reading High school	19 Sherman Rd	727
North Reading Middle School	191 Park Street	635
L. D. Batchelder Elementary School	175 Park Street	519

[24] Town of North Reading Annual Report. December 31, 2013. P. 115.
[25] http://www.city-data.com/city/North-Reading-Massachusetts.html

School	Address	Number of Students
J Turner Hood Elementary School	298a Haverhill St	473
E Ethel Little Elementary School	7 Barberry Lane	419

Recreation

The Town of North Reading includes Ipswich River Park, a "49-acre site at the junction of Haverhill, Central and Chestnut Streets. The property was taken by eminent domain and settled for a price of $1,450,000. In 1994 and 1995 the Town applied for and received a total of $1,000,000 in development grants from the Land and Water Conservation Fund and from the Urban Self-Help Program. Another $25,000 was received as a canoe launch grant from the Public Access Board. By accepting these grants, The Town matched $724,000. Half of the matching funds needed were supported through the Hillview Enterprise Fund and the balance through fundraising. The Land Utilization Committee spearheaded the fund-raising.

Planning and building Ipswich River Park has been truly a community project. Established for active and passive recreation, this park is dedicated to all North Reading citizens-past, present, and future-and promises to hold "something for everyone."[26]

The Parks and Recreation Department also "maintains Benevento Memorial Park (baseball fields, restrooms and concession/storage facility), Chestnut Street Complex (softball field, soccer fields, basketball court and Kid Spot playground, concession/storage facility); Clarke Park at Martin's Pond (boat dock, sand volleyball court, basketball court, playground, sheltered picnic area, bathroom/storage facilities); Arthur J. Kenney Field (synthetic turf field and track, press box, concession/storage facilities); Ipswich River Park (soccer fields, baseball field, softball field, tennis courts, basketball courts, street hockey rink, skate park, horseshoe pits, gazebo picnic area, pavilion picnic area concession/storage facility, bathroom facilities, park maintenance building and Recreation center); Rita J. Mullin Softball Field; Town Hall Softball Field; North Parish Park; Park Street (basketball court) and we assist the school department with maintenance on fields that youth sports actively participate."[27]

Historic Properties

The Town of North Reading has a "Center Village" historic district that was established by a town meeting held in 1993. Two other historic districts of significance are West Village (Park Street West near Nutter Road and Mill Street) and Saddler's Neck (specifically near the intersection of Haverhill and Chestnut Streets). The Town has three town-owned cemeteries that range from less than an acre to 30 acres in size.

[26] Ipswich River Park. (2015). Parks and Recreation Department. Retrieved on November 9, 2014 from http://www.ipswichriverpark.org/home.html

[27] Town of North Reading Annual Report. December 31, 2013, p. 132

The Town owns six historical buildings/sites:

1. **Town Common**: In 1713, the Town Common was constructed as the Reading Town Common (North Reading split from Reading in 1853).

2. **Meeting House**: The Meeting House dates to 1829 and is still used by the Town's senior citizens and for general town meetings.

3. **Damon Tavern**: The David Damon Tavern was built in 1817 and is located on Bow Street. It was a halfway stop for the Salem-Lowell and Boston-Haverhill routes coaching roads, and also served as the town's first Post Office. The tavern was open to the public as soon as The North Reading Historical and Antiquarian Society restored it.

4. **Putnam House**: In 1717 the inhabitants of the North Reading Parish voted for Reverend Daniel Putnam to become their minister, in 1720 they built him a home that is still standing at 27 Bow Street. The North Reading Historical and Antiquarian Society restored the Putnam House and use it for its headquarters.[28]

5. **Flint House**: The building that houses the Flint Memorial Library was first built in 1874 by Harriet Flint on the west end of the island formed by Park and Bow Street (known then as Flint Memorial Hall). In 1875, the library was installed in the southeast corner of the ground floor and remained there until 1958 when it was relocated across the street to the Weeks Memorial Building (formerly the Damon Tavern). During the 1970's, the Flint Building, which was being used as the Town Hall, but began to fall into disrepair. Town offices were moved in December of 1988 and the building was left vacant. In 1991, the building was renovated and became what is now the Town's Public Library.

6. **West Village School House**: "The North Reading Minit and Militia disassembled and reconstructed the West Village Schoolhouse, now nestled at the far northeast corner of the Putnam House property. Built circa 1845, this school originally served the residents of the western section of town. Until the 1980's, the building was near the northwest corner of Park and Main Street (the present location of the Eastgate Liquors parking lot). It had been an automobile repair shop for many years and was slated to be demolished to make room for new construction. The Minit men dismantled the structure and stored parts of it in several places throughout the Town. Over a period of several years, they gradually reconstructed the school in its present location. The local treasure has been returned to the 19th century, complete with chalkboards, teacher's desk, student desks, "pot-bellied stove", and a working bell in its steeple. The building has a volunteer teacher, in appropriate dress, who often hosts classes for the local elementary schools."[29]

Land Use and Development Trends

The figure below shows the land owned by North Reading.

[28] Reverend Daniel Putnam House. (2015). North Reading Historical and Antiquarian Society. Retrieved on December 11, 2014, from http://nreadinghistory.org/Putnam_House.html

[29] West Village School House. (2015). North Reading Historical and Antiquarian Society. Retrieved on November 9, 2014 from http://nreadinghistory.org/West_Village_School_House.html

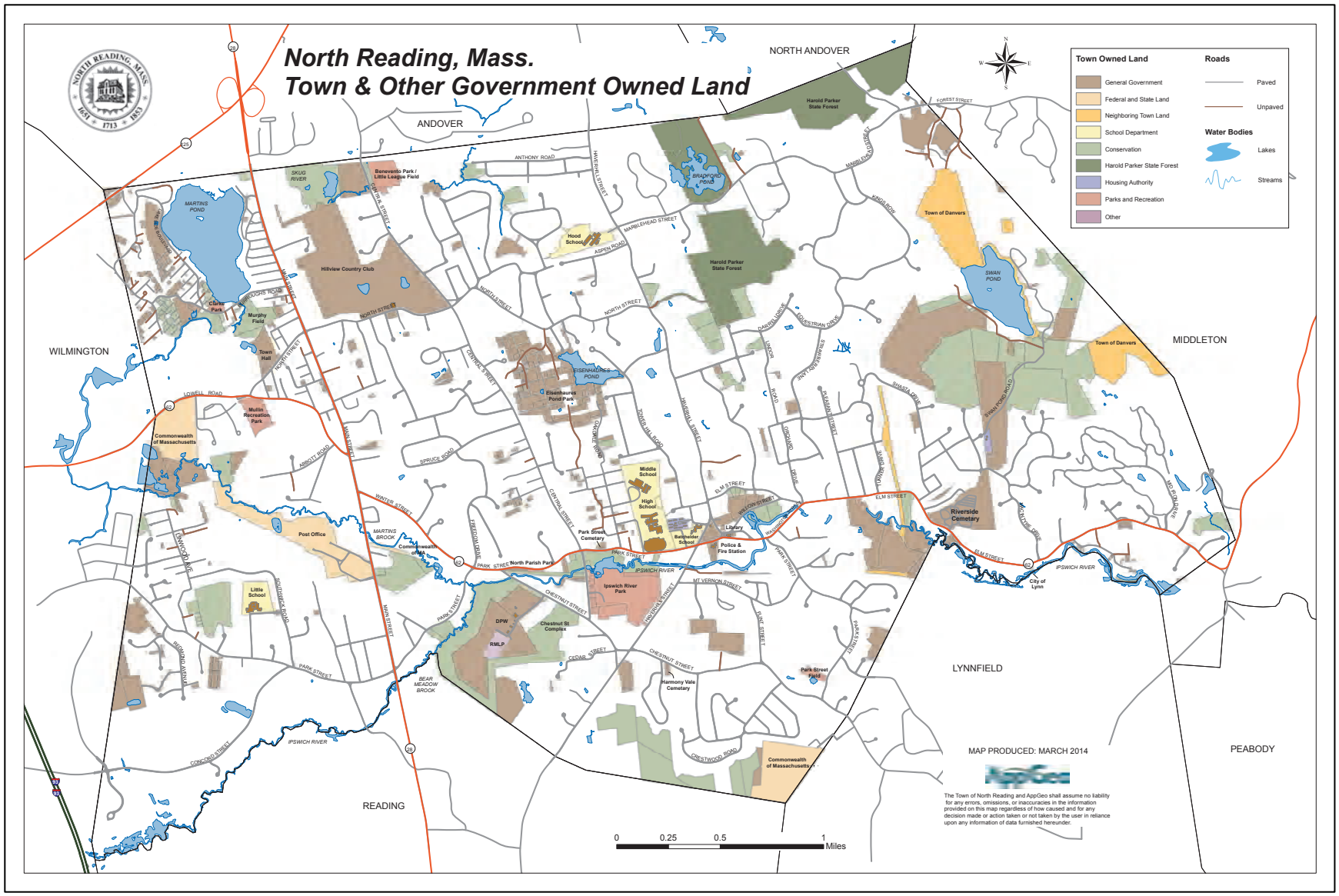


Figure 10. Town-owned Land Map.

According to Master Plan[30] 89% of the Town's land is dedicated to residential use and 11% is dedicated to commercial and industrial uses. The majority, 71% of residential land is zoned for approximately, minimum one-acre lot single family homes, and 10.5% for minimum half-acre lot single family homes. Below is the Town's Zoning map and Subdivision map. The maps below were provided by the Town's Geographic Information Systems technician.

[30] Master Plan, p.15

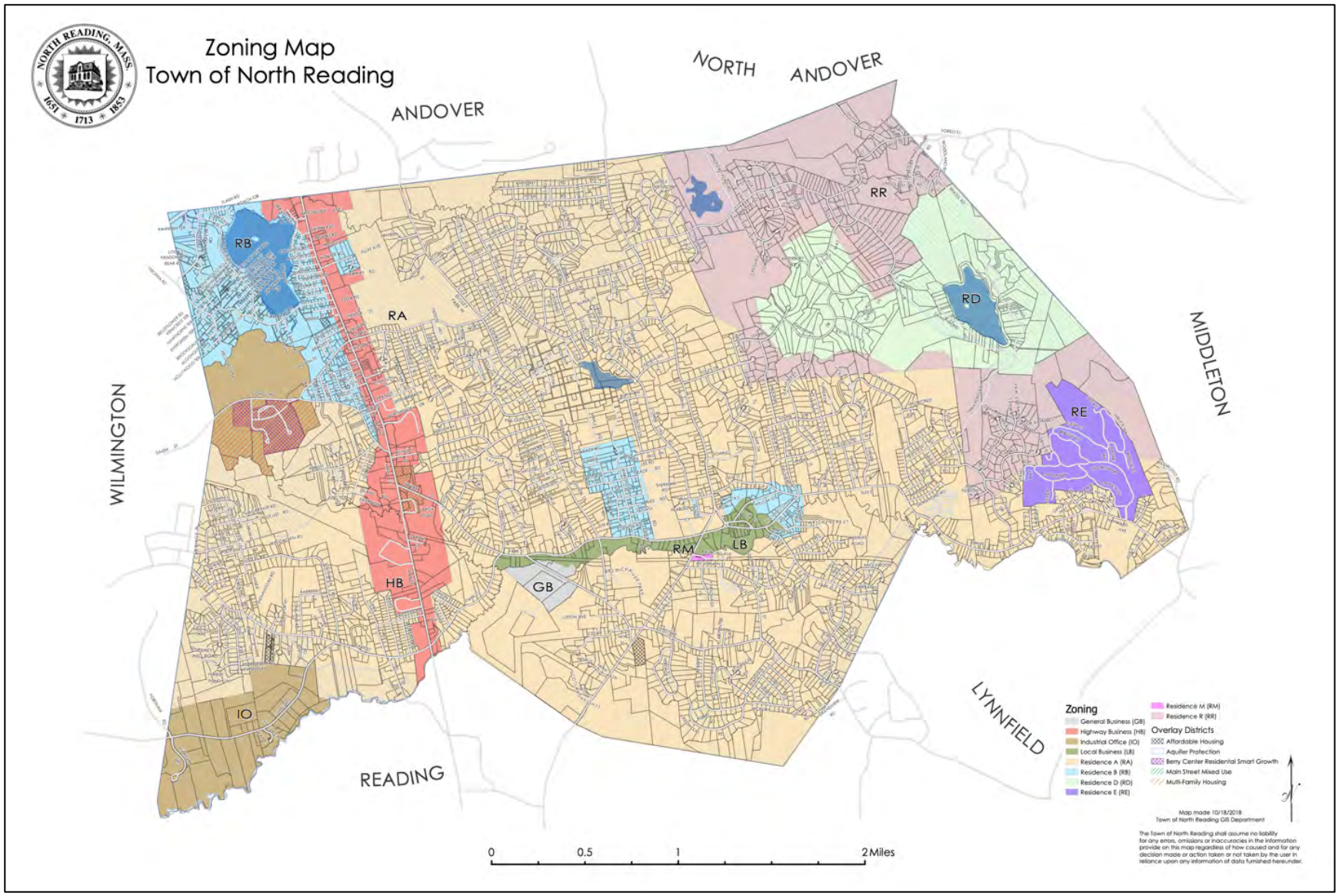


Figure 11. Zoning Map.

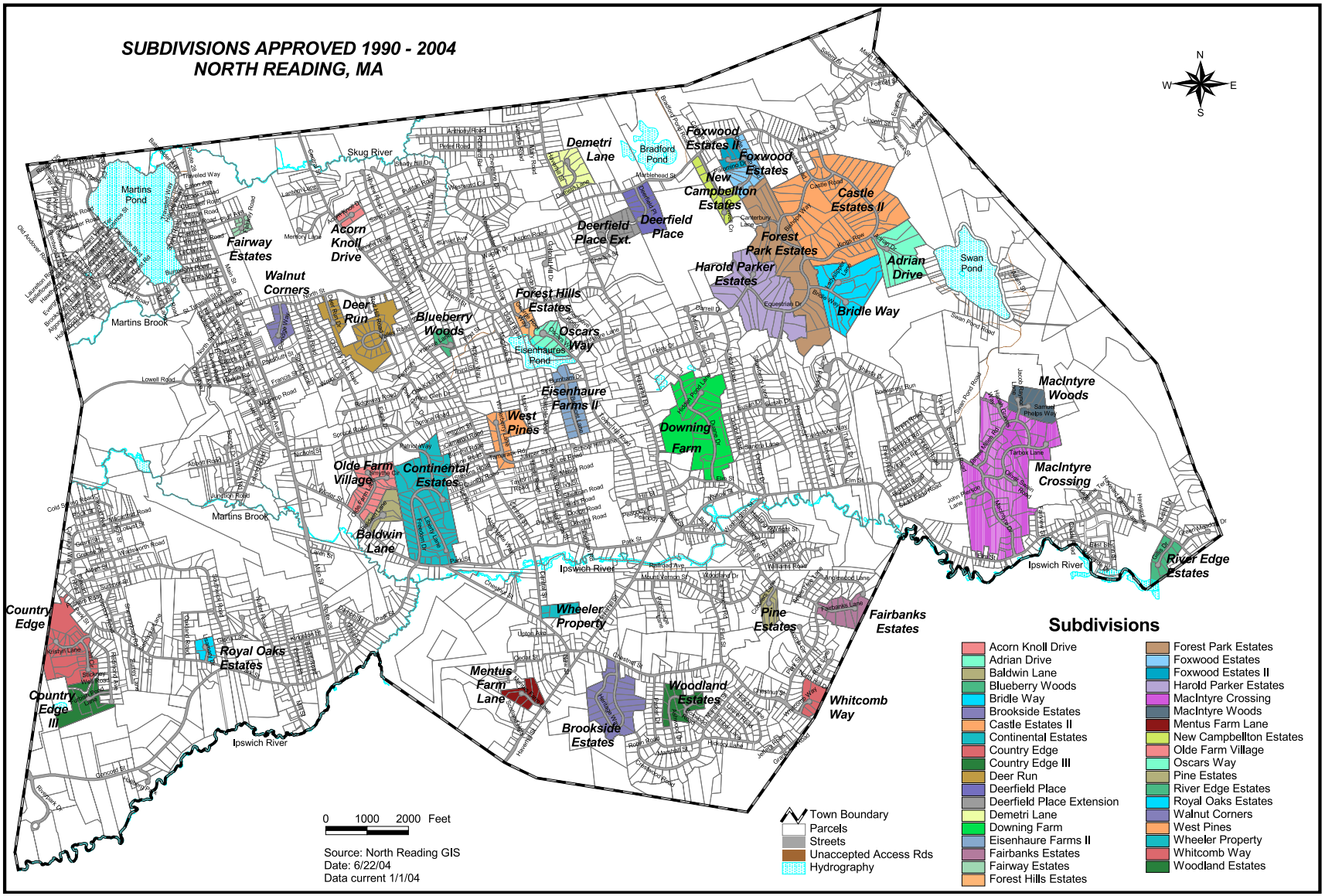


Figure 12. Subdivision Map.

North Reading has set-aside a significant amount of land for open space. According to the Master Plan, 71% or 902 acres of the Town are set aside for water resource protection, conservation, and active and passive recreational use. These 902 acres of public-owned land represent approximately 14% of the Town's total land area. The map below shows these areas.

Figure 13. Land Use Map.

The Town's Master Plan includes six goals specific to land use and future development. The priorities are having Main Street become a "traditional main street" by becoming a mixed-use space that includes multi-family, upper-story residences, hotels, and businesses. The Town would also like to redevelop Main Street so it "mimics features of traditional New England shopping villages."[31] These goals support the Town's vision depicted in the graphic below from the Master Plan.

[31] North Reading Master Plan 2020-2030, MAPC, p.29.

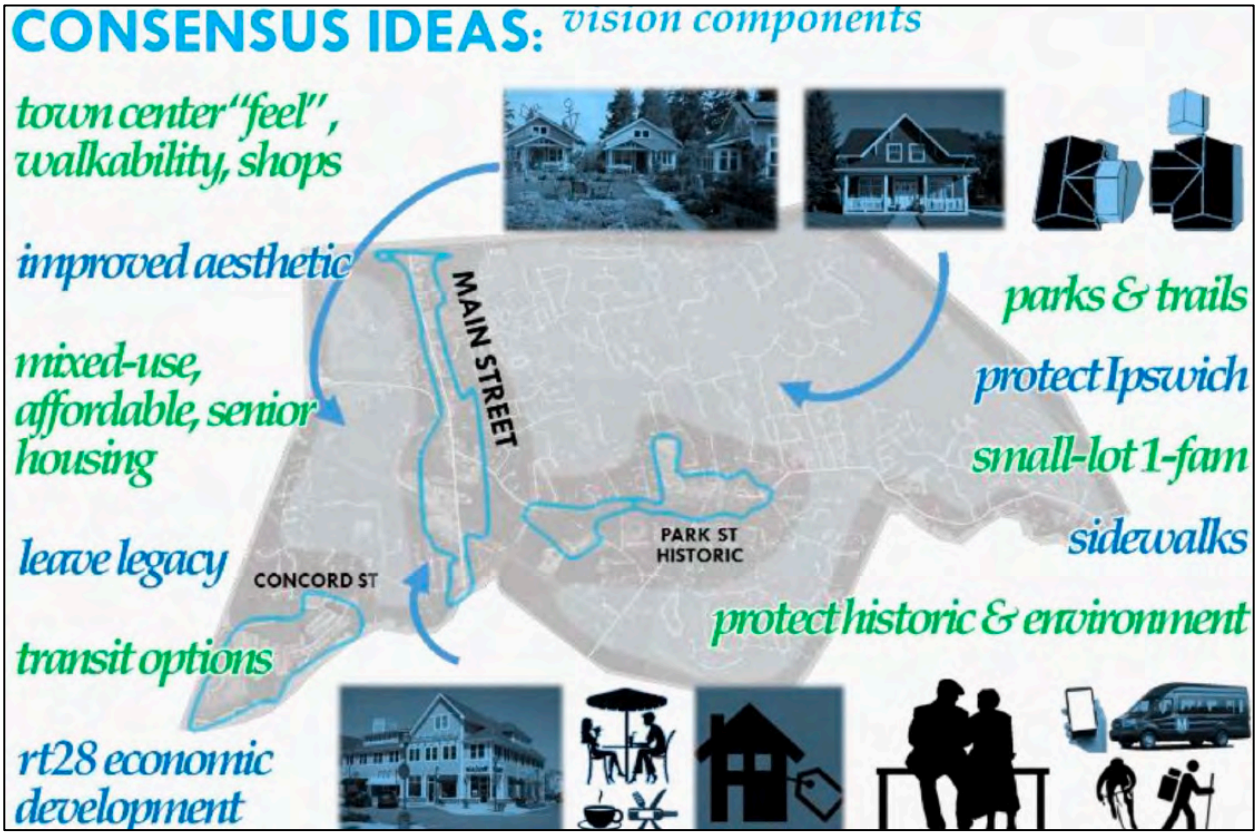


Figure 14. Master Plan Vision Statement Consensus Ideas.

The Master Plan also lists nine "overarching consensus goals" which the Hazard Mitigation Plan supports, and the core Team considered when developing the mitigation strategy.

1. Attract private investment and redevelopment
2. Make desired leisure-retail and needed condo/apartments viable
3. Create a shopping district with leisure retail
4. Address housing demand by allowing more options
5. Create attractive roadway and new robust Town center
6. Make zoning clearer
7. Support water and wastewater infrastructure
8. Protect drinking water quality
9. Encourage economic development

Regional Resources

Medical Resources

North Reading does not have a hospital or medical center located within the Town. Therefore, residents either rely on facilities in adjacent communities in the area or hospitals in the City of Boston, such as Mass General, Beth Israel, Boston City, Boston Children's, and Brigham and Women's. North Reading does have a nursing home called Green Grove Nursing Home, a rehabilitation center called Meadow View Care and Rehabilitation center and a convalescent home also called Meadow View Convalescent Home.
There is one long-term care facility in North Reading called Meadowview Healthcare. In addition to hospitals located in the City of Boston, below is a list of hospitals in the area:

- Holy Family; Methuen, MA
- Lahey Clinic; Burlington, MA
- Lawrence General Hospital; Lawrence, MA
- Melrose-Wakefield Hospital; Melrose, MA
- Winchester Hospital; Winchester, MA

Transportation Resources

North Reading maintains 94 miles of roadways. Its major arteries include Routes 28 (Main Street) and Route 62 (Lowell/Winter/Park/Elm streets). Indirect access to Interstate 95 is available via exits 39 and 40 in Wilmington. North Reading is well-sited between I-93 and I-95 and I-495 and Rte. 128 providing convenient access to commercial and industrial facilities, downtown Boston, and skiing and beach resorts. The principal highways through North Reading are road 28 (north-south) and road 62 (east-west). North Reading is situated in the Greater Boston Area, which has excellent rail, air, and highway facilities. State Route 128 and Interstate Route 495 divide the region into inner and outer zones, which are connected by numerous "spokes" providing direct access to the airport, port, and intermodal facilities of Boston.

The Town is a member of the Massachusetts Bay Transportation Authority (MBTA) but receives no public transportation services. Commuter rail service to Boston's North Station is available from Reading Station and travel time from Reading Station to North Station is between 28 to 31 minutes.
Regional Airports are in Lawrence, MA (private) and in Bedford, MA (Hanscom Field - Commercial). Logan Airport is a major international airport located in Boston, approximately 20 miles from North Reading.

Government Resources

North Reading is a part of the 101 cities and towns in the Boston metropolitan area that are represented by the Metropolitan Area Planning Council (MAPC). MAPC works with communities through eight sub-regional organizations whose members are appointed by chief elected officials and planning boards. North Reading is a member of the North Suburban Subregion (NSPC), which also includes the

communities of Wilmington, Reading, Lynnfield, Wakefield, Stoneham, Woburn, Burlington, and Winchester.

Chapter 3. Planning Process

The planning process was developed in full compliance with the current planning requirements of the Federal Emergency Management Agency (FEMA) per the following rules and regulations:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288), as amended by the Disaster Mitigation Act of 2000
- Code of Federal Regulations – Title 44, Chapter 1, Part 201 (§201.6: Local Mitigation Plans)
- Federal Emergency Management Agency *Local Mitigation Plan Review Guide* (dated October 1, 2011)

In addition, the plan was prepared with the suggestions found in the Demonstrating Good Practices Within Local Hazard Mitigation Plans, FEMA Region 1, January 2017.

The planning process for this updated mitigation plan occurred during the fall of 2021. The Town developed a Municipal Vulnerability Preparedness (MVP) Program summary of findings in 2018. This planning effort contributed to the update of the mitigation plan. Fire Chief Don Stats led the planning effort with support from Theophilos Kuliopulos, Emergency Manager and a Core Team of Town staff. Chief Stats facilitated all activities related to the mitigation plan update, including meeting logistics, data gathering, and public outreach.

Core Team

A Core Team was formed to support the planning process. This team included Town employees as well as stakeholders. A list of Core Team members is shown in the list below. The Core Team met four times, August 10, 2021, September 23, 2021, October 28, 2021, and November 15, 2021. All the meetings were conducted via Zoom due to the Covid-19 Pandemic. A list of participants at each of these meetings is included in Appendix A.

- Robert Bracey, Health Agent, Director, Public Health Department
- Andrew Campagna, Director of Facilities, Department of Public Works
- Mark Clark, Water Superintendent, Department of Public Works
- Robert Collins, Human Resources Director, Department of Human Resources
- Barry Galvin, Deputy Fire Chief, North Reading Fire Department
- Michael P. Gilleberto, Town Administrator, Town of North Reading
- John Klipfel, Town Engineer, Department of Public Works
- Theophilos Kuliopulos, Emergency Manager, Department of Emergency Management
- Danielle McKnight, Town Planner, Department of Community Planning
- Joseph P. Parisi, Director of Public Works, Department of Public Works
- Donald W. Stats, Jr., Fire Chief, North Reading Fire Department

- Joe Thibodeau, Lieutenant, North Reading Police Department

The first Core Team meeting, August 10, 2021, was an opportunity for Chief Stats and the Consulting Team to introduce the project and expectations for the Core Team. These included providing supporting data, identifying, and prioritizing mitigation actions, conducting public outreach, and reviewing the draft and final mitigation plan. During this meeting the Core Team chose the hazards to include in the plan and chose to organize them by Primary Climate Change Interaction for consistency with the Massachusetts State Hazard Mitigation and Climate Adaptation Plan. They also added two hazards to the list from the 2016 North Reading Hazard Mitigation Plan, invasive species, and infectious disease. Current critical facilities were identified and a list of future infrastructure and building developments were discussed.

The second Core Team meeting, September 23, 2021, provided an opportunity for the Core Team to discuss in detail the Town's capabilities to mitigate risk and a list of supporting documents maintained by the Town such as the Master Plan, Open Space & Recreation Plan, and the Drought Management Plan. The Core Team reviewed National Flood Insurance Policy (NFIP) reports provided by Joy Duperault, MA State NFIP Coordinator, Department of Conservation & Recreation. The Core Team commented on the significant decrease in NFIP policies from 2016 (82 policies) to 2021 (43 policies). The flood risk has not significantly decreased and the decrease in policies may be due to homes being owned outright which removes the requirement of flood insurance. Discussion at this meeting led to the development of mitigation actions regarding hazard education and education promoting the value of flood insurance. The Core Team reviewed the goal statements from the 2016 Hazard Mitigation Plan and removed the statement specific to disaster response and added climate change to the descriptions of several goals. Finally, they reviewed a list of potential mitigation actions by considering the status of 2016 Hazard Mitigation Plan actions and 2018 MVP actions as well as potential mitigation actions based on early risk and capability assessment results.

The third Core Team Meeting, October 28, 2021, gave the team the chance to review all the mitigation actions in detail. These included final group discussion about essential details of each action such as lead department, cost, benefits, and potential funding sources. The Core Team agreed on the definition of benefits and priority ranking criteria for each mitigation action. It also provided a chance to review the final risk assessment results and hazard ranking. The Core Team decided to hold a fourth meeting after they individually review the draft plan, to discuss potential edits and to review the prioritization of each mitigation action.

The final Core Team Meeting, November 15, 2021, provided an opportunity to review the final list of mitigation actions and their priority ranking. It also gave the Core Team a chance to discuss how to engage the public with review of the plan. It was decided to post a link to the plan on multiple Town websites including the Fire Department and Community Planning. It was also decided to put a hard copy in the Town Engineer's Office. Comments and feedback were collected by the Consulting Team. A press release announcing the plan's availability for review was distributed. A copy is in the Appendix.

The Core Team also participated in two public meetings, one on September 30, 2021, and one on October 28, 2021. These were also attended via Zoom. Finally, the Core Team reviewed the Draft Hazard Mitigation Plan Update prior to sending it to the Massachusetts Emergency Management Agency (MEMA) for their review.

Public Outreach

Figure 15. Meeting Announcement on Town Website.

The Planning & Conservation Department is the primary department in North Reading responsible for regulating development. They are actively supported by other Town departments and professionals such as the Town Engineer, and the Department of Public Works. The Community Planning Commission is organized as a planning board under Chapter 41 of the Massachusetts General Laws, giving them the authority to review and approve subdivisions. They are also responsible for site plan reviews for commercial sites and multifamily projects and are the Special Permit Granting Authority for certain special permits, including Planned Unit Developments and those requiring Floodplain Special Permits. They are also charged with long-range planning efforts for the Town, including master plans. Town registered voters participate via Open Town Meeting. In addition, the Metropolitan Area Planning Council (MAPC), works with the Town to regulate development in the region and support consistency with state agencies such as the Department of Conservation and Recreation and MassDOT.

The Public Outreach Strategy was designed to involve the public in the mitigation planning process. The purpose of public outreach and stakeholder involvement was to:

- Generate public interest in mitigation planning
- Identify and accommodate special populations
- Solicit public input
- Engage local stakeholders
- Create opportunities for public and local stakeholders to be actively involved in the mitigation planning process

The public outreach strategy included two Public Meetings, and an opportunity for the public to review the draft plan. Both meetings were hosted virtually due to the Covid-19 pandemic. Each meeting included a PowerPoint presentation and plenty of opportunity for questions and discussion. In addition, Mentimeter was used to facilitate input from meeting participants. This has proven to be an effective tool when engaging people who may not be comfortable speaking up in a virtual meeting. The Core Team participated in each meeting. The meetings were advertised by the Town by way of the Town website (see image below), and the Fire Department's Website (shown in the Appendix), the local newspaper the North Reading Transcript and email invitation. A list of participants and copies of outreach materials for each meeting are included in the Appendix A.

The first public meeting occurred on September 30, 2021 and emphasized identification of hazards and critical facilities. Participants gave feedback regarding what they have noticed in terms of climate change and how the Town can address these changes. When asked to list their 4 hazards of greatest concern the responses showed up in the word cloud shown below.

Figure 16. Hazards of Greatest Concern.

When asked to list the three most important assets to protect, the following word cloud was generated.

Figure 17. Assets of Greatest Concern.

The concept of hazard mitigation was introduced to meeting participants and then they were asked "How should North Reading mitigate risk?" Responses to this question included:

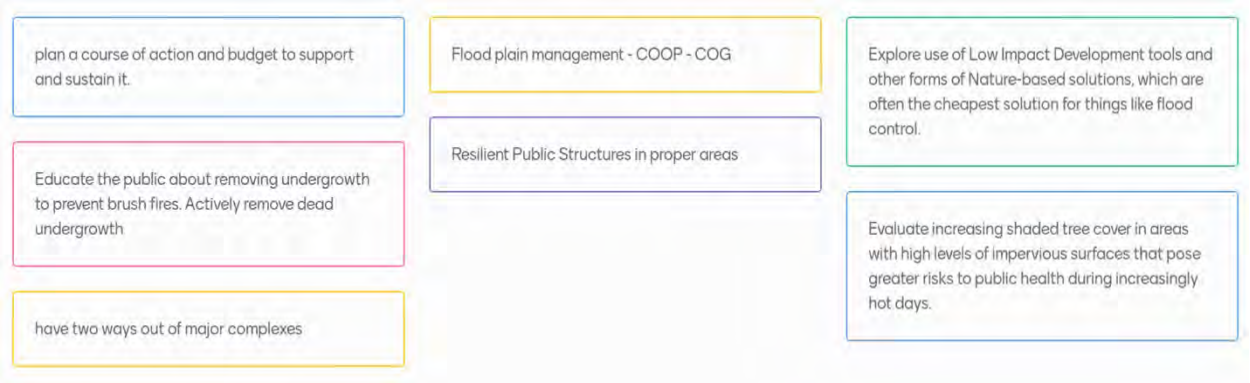


Figure 18. Mitigation Action Recommendations.

The second public meeting occurred on October 28, 2021. The original intent of the meeting was to review the final hazard risk ranking and introduce the list of mitigation actions while seeking feedback and suggestions for these actions. However, only Core Team members attended the meeting. Therefore, the discussion centered around mitigation actions, plan review, and applying for FEMA BRIC funding.

To give neighboring communities and regional agencies an opportunity to participate in the planning process, the Core Team sent personal invitations to their contacts in the Towns of Andover, Middleton, Lynnfield, Reading and Wilmington to participate in each of the public meetings and to review the draft plan. They also personally invited representatives from the Martins Pond Association, the Ipswich River Watershed Association, the Reading Municipal Light Department, and the North Suburban Planning Council of the Metropolitan Area Planning Council (MAPC).

Review of Draft Plan

The Town made the plan available for public review the week of November 15, 2021. A press announcing the availability to review the plan was sent and the announcement was posted to the Town and Fire Department web pages. It was also posted on social media and announced in meetings with stakeholders and the public. Comments from the public were collected by the Fire Chief. Comments included…

Review and Incorporation of Existing Studies

Many sources were used to develop this plan, including web-based resources, reports, and stakeholder engagement. Throughout the plan, these sources are cited within the text as footnotes. The Massachusetts Hazard Mitigation and Climate Adaptation Plan, as well as several Town of North Reading plans, were reviewed for consistency. The goal was to develop a plan that would easily integrate with the key aspects of plans in the Town and State. This section reviews how the content of several key plans and studies influenced the development of this plan. The risk assessment and capability assessment also detail resources used toward development of this mitigation plan update.

Town of North Reading, Hazard Mitigation Plan Update 2016

The Town of North Reading's previous Hazard Mitigation Plan update was reviewed carefully for the development of this updated hazard mitigation plan. Emphasis was placed on review of the risk assessment, critical facilities identified, and the list of mitigation actions. All mitigation actions that were not implemented were considered for inclusion in this plan.

North Reading, Municipal Vulnerability Preparedness (MVP) Plan, 2018

The MVP Plan gives an excellent overview of the Town's challenges in terms of their hazard risks and capabilities. This plan also lists specific areas of concern such as flat roofs on public buildings, culverts and bridges that may be inadequate for future flooding events predicted to increase with climate change, and flooding from Martins Pond. Many of these concerns were listed as recommended mitigation actions in this plan and in the Hazard Mitigation Plan. The Core Team reviewed the priority recommendations for inclusion in the Hazard Mitigation Plan. The Core Team prioritized consistency between the two plans.

Town of North Reading Open Space and Recreation Plan, 2020

The Open Space & Recreation Plan gives terrific background regarding the Town's environment, development patterns, and natural resources which were used to develop the Planning Area Profile chapter of this plan update. This plan details the Floodplain Overlay District and includes hazards such as erosion invasive species. This plan also includes potential funding sources some of which may be used to fund mitigation actions. The plan was reviewed in its entirety for background information.

North Reading Master Plan, 2020-2030

The Master Plan was reviewed for background information regarding the Town and for recommendations and priorities that may be consistent with the updated mitigation strategy. The plan is consistent with and refers to the 2016 Hazard Mitigation Plan throughout in both background descriptions and recommendations for actions. All the recommendations included in the Master Plan were considered toward development of mitigation actions for this 2021 Hazard Mitigation Plan Update.

Massachusetts Hazard Mitigation and Climate Adaptation Plan, 2018

Consistency with the State Plan is not only required, but it also makes sense. The State Plan was used as a starting point for hazard identification and then for hazard analysis; details are included in the Risk Assessment. Of significance is the classification of natural hazards in terms of climate change interactions, changes in precipitation, rising temperatures, extreme weather, and non-climate influenced hazards (http://www.resilientma.org/data/documents).

Hazard Mitigation Plans and MVP plans from surrounding communities were reviewed. The Core Team reviewed these plans for information regarding hazards and their impact as well as for mitigation action ideas. The Core Team looked specifically for actions that they may want to replicate as well as for opportunities to collaborate with other communities. The list of some of the plans reviewed is below:

- North Andover, Multi-Hazard Mitigation and Municipal Vulnerability Plan, 2021

- Town of Lynnfield, Hazard Mitigation Plan 2018 Update
- Town of Middleton, 2020 Hazard Mitigation Plan – Municipal Vulnerability Preparedness Plan
- Town of Reading, Community Resilience Building, Workshop Summary of Findings, June 2020
- Town of Wilmington, Hazard Mitigation Plan Update, 2021

The following list of plans were also reviewed for their data, hazard identification and information regarding potential mitigation actions.

- Emergency Dispensing Site Action Plan, North Reading Health Department, 2019
- North Reading Satellite Shuttle Study, August 12, 2019
- Exploration of Paratransit Options for North Reading, September 2017
- Town of North Reading Main Street (Route 28 at 62) Short Term 2016-2021 Economic Development Strategy, June 2016
- 2020 MA State Model Floodplain Bylaw, DCR Flood Hazard Management Program
- Martins Brook Floodway Operation & Maintenance Plan, North Reading, MA 2014

Based on review of these plans, the Core Team considered the following potential actions to add to their list of previous actions. These actions were initially discussed at the September 23, 2021, Core Team Meeting and then reviewed again at other meetings with key stakeholders and the Core Team.

Figure 19. Mitigation Actions to Consider 1.

Figure 20. Mitigation Actions to Consider 2.

Chapter 4. Risk Assessment

To gain an understanding of the natural disaster risks that the people of Town of North Reading are up against, it is necessary to develop a comprehensive natural hazard risk assessment. This risk assessment examines the vulnerability of current and future populations, and structures (including critical facilities and infrastructure) to various natural hazards. The risk assessment provides a compilation of available information and data sets to the Town for comprehensive planning purposes. The risk assessment answers questions regarding hazard history, probability, frequency, and impact. These answers are then used to inform mitigation actions for the town. The ultimate purpose of this plan is to save lives and reduce property losses in future disasters.

The risk assessment is formatted to meet the Federal Emergency Management Agency's (FEMA's) local-level hazard mitigation planning regulations as found in C.F.R. 44 201.6 (Local Mitigation Plans) in addition to state requirements. FEMA requires the Town to include all possible natural hazard events, to assess vulnerability, and to estimate potential losses. Each hazard must be profiled to include a description of the hazard, historical occurrences, extent (or magnitude), location, and vulnerability. The identified hazards and hazard profile details are described in this chapter.

Gathering information for the risk assessment included historical research, conversations with stakeholders, and available hazard mapping. The 2021 update to the previous (2016) risk assessment also includes information gathered from the Town's 2018 Municipal Vulnerability Preparedness (MVP) Plan and the Massachusetts 2018 State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).[32] Extensive information regarding the Town of North Reading's historic, economic, and population makeup can be found in Chapter 2. It is advisable to review Chapter 2 prior to reading the risk assessment to best understand the geography and unique characteristics of the Town.

Hazard Identification

The first step in the risk assessment was to reaffirm the hazards identified for study and inclusion in the risk assessment based on the Town's previous hazard mitigation plan. This was a key topic of discussion at the Town's first Core Team meeting, along with the consideration of any additional hazards to include in the updated risk assessment. While only natural hazards are required to be addressed by FEMA, other hazards such as technological or man-made hazards can be included in the plan.

All the hazards from the 2016 plan remain included in this updated risk assessment with the exception of one. After further consideration and a review of the findings of the 2016 assessment, the ***Landslide*** hazard was removed. The rationale for excluding landslide from the updated assessment is based on the fact that there are no identified landslide hazard zones in North Reading (the entire Town lies within an

[32] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018.

area of low incidence), there is no recorded history of occurrences, the probability of future of occurrence is unlikely, and the impacts of any such events occurring would be minimal.

The top 4 natural hazards as identified for the Town's MVP Plan are thoroughly covered in this assessment. These hazards include flooding, winter storms/blizzards/nor'easters, wind, and extreme cold/heat and drought. In addition, two new hazards have been identified and incorporated into the assessment, including ***Infectious Disease*** and ***Invasive Species***. Infectious disease was added based on the local impacts of the Covid-19 pandemic as well as the Town's growing concern for vector-borne diseases. Invasive species was added to reflect the Town's concern for this becoming a more prevalent hazard with projected climate changes and so that the risk assessment is consistent and aligned with the SHMCAP. With the addition of invasive species, all relevant hazards identified in the SHMCAP for the planning area were considered and addressed in this risk assessment for North Reading. Due to the Town's inland location, coastal hazards identified in the SHMCAP are not included (such as sea level rise, coastal flooding, coastal erosion, and tsunami).

In addition to reviewing all hazards identified in the Town's previous mitigation plan, the MVP Plan, and the SHMCAP, a list of major presidential disasters was reviewed to recall which hazards have the potential to cause major and widespread impacts that exceed existing Town and State capabilities and resources to respond and recover adequately on their own. This updated list of major disaster declarations for Middlesex County is provided below in Table 34.

Table 6. Major Disaster Declarations for Middlesex County, MA (1953-2021).[33]

Disaster Name (Date of Event)	**Disaster Number (Type of Assistance)**	**Declared Counties**
Hurricane Gloria (September 27, 1985)	FEMA-751 (Public)	Barnstable, Berkshire, Bristol, Dukes, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester.
Severe Storms, Flooding (March 30 – April 13, 1987)	FEMA-790 (Public, Individual)	Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester.
Hurricane Bob (August 19, 1991)	FEMA-914 (Public, Individual)	Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, and Worcester.
December Blizzard (December 1992)	FEMA-975 (Public)	Barnstable, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, and Worcester.
January Blizzard (January 1996)	DR-1090 (Public)	Statewide (All Counties)
Severe Storms/ Flooding (October 20-25, 1996)	DR-1142 (Public, Individual)	Essex, Middlesex, Norfolk, Plymouth, and Suffolk.

[33] FEMA, OpenFEMA Dataset: Disaster Declarations Summaries - v2. Accessed on 9/10/2021 at: https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2

Disaster Name (Date of Event)	Disaster Number (Type of Assistance)	Declared Counties
Heavy Rain and Flooding (June 13 – July 6, 1998)	DR-1224 (Individual)	Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester.
Massachusetts Severe Storms & Flooding (March 5 – April 16, 2001)	DR-3164 (Individual)	Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester.
February Snowstorm (February 17-18, 2003)	FEMA-3175-EM (Public)	Statewide (All Counties)
December Snowstorm (December 5-6, 2003)	FEMA 3191-EM (Public)	Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester
Flooding (April 1-30, 2004)	DR-1512 (Public)	Essex, Middlesex, Norfolk, Suffolk, and Worcester.
Severe Storms and Flooding (October 7-16, 2005)	DR-1614 (Public, Individual)	Berkshire, Bristol, Franklin, Hampden,, Hampshire, Middlesex, Norfolk,, Plymouth, and Worcester.
Severe Storms and Flooding (May 12 -23, 2006)	DR-1642 (Public, Individual)	Essex, Middlesex, and Suffolk.
Massachusetts Severe Winter Storm and Flooding (December 11-18, 2008)	DR-1813 (Public)	Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester.
Severe Storms and Flooding (March 12 – April 26, 2010)	DR-1895 (Public, Individual)	Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester.
Severe Winter Storm and Snowstorm (January 11-12, 2011)	DR-1959 (Public)	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, and Suffolk.
Severe Storm and Snowstorm (October 29-30, 2011)	DR-4051 (Public)	Berkshire, Franklin, Hampden, Hampshire, Middlesex, and Worcester.
Severe Winter Storm, Snowstorm, and Flooding (February 8-10, 2013)	DR-4110 (Public)	Statewide (All Counties)
Severe Winter Storm, Snowstorm, and Flooding (January 26-28, 2015)	DR-4214 (Public)	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, and Worcester.
Severe Winter Storm and Snowstorm (March 13-14, 2018)	DR-4379	Essex, Middlesex, Norfolk, Suffolk, and Worcester.
Covid-19 Pandemic (January 1, 2020 – present)	DR-4496	Statewide (All Counties)

To better reflect the relationship between natural hazards and changing climate and weather patterns, each of the individual hazards identified for the updated risk assessment have been reorganized and categorized according to their primary interaction with climate change. These new categories are consistent with the SHMCAP and include the following:

- Changes in Precipitation
- Rising Temperatures
- Extreme Weather
- Non-Climate Influenced Hazards
- Technological and Human-Caused Hazards

Individual hazards are also grouped within each category according to their primary hazard (for example, all flooding-related hazards are listed under "Flooding" in the Changes in Precipitation category). This new classification for identified hazards was done for the 2021 plan update to consolidate and be consistent with the State's current hazard classification scheme per the SHMCAP. Table 7 provides the complete listing of all specific hazards identified for North Reading, along with the justification for including each in the Town's hazard mitigation plan and whether the hazard is also included in the SHMCAP.

Table 7. Hazard Identification and Rationale for North Reading.

Hazard	Justification for Inclusion	Included in SHMCAP?
CHANGES IN PRECIPITATION		
Flooding	There are several historical floods in the Town and presidential disasters linked to flood in the county. Flooding can result in property damage and loss of lives. Flooding may be caused by heavy rainfall events, beaver dams, ice jams, and other local stormwater drainage issues.	Yes
Drought	Drought typically occurs in the summer months and can result in water restrictions and increased fire hazard.	Yes
RISING TEMPERATURES		
Average/Extreme Temperatures	Extreme temperatures were identified as a top priority hazard for the Town during the MVP planning process. Both cold and heat extremes pose life/safety threats to residents, particularly for vulnerable populations if the power is disrupted or the event lasts several days.	Yes
Infectious Disease	Infectious diseases are present within every community, but the recent impacts of the Covid-19	No

Hazard	Justification for Inclusion	Included in SHMCAP?
	pandemic and increasing concerns for how rising temperatures may exacerbate vector-borne illnesses is of great concern to the Town.	
Invasive Species	North Reading's wetlands are being degraded by invasive plant species, which inhibit or smother native plants that are important to the health of the wetlands system. Such invasive species include purple loosestrife and phragmites. Invasive species are becoming an increasing concern to many communities in Massachusetts, primarily driven by the anticipated long-term effects of climate change, and in 2018 became added as a new hazard to the SHMCAP.	Yes
Wildfires	The Town experiences occasional brush fires but is generally not at risk to major wildfires. Future conditions caused by climate change, including rising temperatures and changing precipitation patterns, may increase the frequency and likelihood of wildfire events across Massachusetts.	Yes
EXTREME WEATHER		
Hurricanes/Tropical Storms	North Reading is susceptible to hurricane-force winds and tropical downpours associated with cyclonic storm events. The hurricane may arrive as a tropical storm or remnants but is still capable of resulting in wind damage, tornadoes, and flooding.	Yes
Severe Winter Storm/Nor'easter	The Town is at high risk to a variety of winter-related storm events including nor'easters, blizzards, ice storms, and other severe winter weather.	Yes
Tornadoes	Tornadoes pose a significant risk because buildings in this part of the country are not built to withstand severe wind damage.	Yes
Other Severe Weather	The Town is at risk to a variety of other severe weather events typically associated with thunderstorms. In Massachusetts, thunderstorms are often accompanied by heavy rainfall (addressed under *Flooding*) and occasionally damaging winds, hail, and lightning as described below.	Yes
NON-CLIMATE INFLUENCED HAZARDS		

Hazard	Justification for Inclusion	Included in SHMCAP?
Earthquake	Earthquakes are possible in this area and may cause damage to structure and injury or death to population. The Town is about 25 miles from Cape Ann, where the state's most intense earthquake event occurred in 1755.	Yes
TECHNOLOGICAL AND HUMAN-CAUSED HAZARDS		
Dam Failure	Dam failures have the potential to flood properties and endanger lives in downstream inundation zones. Dam breaches or overtopping may also result in erosion along stream banks that are inundated.	Yes (addressed under inland flooding but not profiled separately)
HAZMAT	Hazardous material events (HAZMAT) are a concern given nearby Interstate 93 just west of the Town boundary and Interstate 95 to the west. HAZMAT incidents from companies in and near the Town may also pose a threat. HAZMAT may impact the surrounding land, air, or water supply.	No (addressed in other state plans)

Table 8 provides an abbreviated list of the 13 primary hazards included in the update risk assessment.

Table 8. Town of North Reading Hazards.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	Flooding Drought
Rising Temperatures	Average/Extreme Temperatures Infectious Disease Invasive Species Wildfires
Extreme Weather	Hurricanes/Tropical Storms Severe Winter Storm/Nor'easter Tornadoes Other Severe Weather
Non-Climate Influenced Hazards	Earthquake
Technological / Human Caused Hazards	Dam Failure HAZMAT

Hazard Profiles

Detailed profiles have been developed for each identified hazard and organized by primary climate change interaction. Hazard profiles include the following sections: Hazard Description, Location, Previous Occurrences, Extent, Probability of Future Events, and Vulnerability Assessment. A description

of each of these profile sections is provided in Table 9. Data for these sections comes from the following primary sources: the Town's 2016 Hazard Mitigation Plan, 2018 MVP Plan, and 2020 Open Space and Recreation Plan; and the State's 2018 SHMCAP. Supplemental data on previous hazard occurrences from NOAA's Storm Events Database and other official State or Federal datasets as cited throughout this chapter. Lastly, several Town employees and HMP Core Team members gathered and provided best available data in support of the hazard profiles.

Table 9. Categories for Hazard Analysis.

Categories	Definition
Hazard Description	A basic description of each hazard, its characteristics, and potential effects.
Location	Describes the geographic area(s) within the town that are affected by the hazard
Previous Occurrences	Provides information on the history of previous hazard events for the region, including their impacts on people and property.
Extent	Describes the potential strength or magnitude of a hazard. Where possible, extent is described using established scientific scales.
Probability of Future Events	Describes the likelihood of future hazard occurrences in the town based on best available and climate-informed science.
Vulnerability Assessment	Describes the hazard's potential impact on the community, including estimated potential losses and the anticipated effects of climate change.

Changes in Precipitation

Flooding

Hazard Description

Flooding is a very frequent, dangerous, and costly hazard. It is also considered the top priority hazard for the Town of North Reading to address per the Town's recent MVP planning process. Flooding is the most common environmental hazard, due to the widespread geographical distribution of valleys and coastal areas, and the population density in these areas. Nearly 90 percent of all presidential disaster declarations result from natural events where flooding was a major component. The severity of a flooding event is typically determined by a combination of several major factors, including stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surface. There are several types of flooding which are presented below:

- **Flash Flooding**
  Flash floods occur within a few minutes or hours of heavy amounts of rainfall and can destroy buildings, uproot trees, and scour out new drainage channels. Heavy rains that produce flash floods can also trigger mudslides and landslides. Most flash flooding is caused by slow-moving thunderstorms or repeated thunderstorms in a local area, or by heavy rains from hurricanes and

tropical storms. Although flash flooding often occurs in mountainous areas, it is also common in urban centers where much of the ground is covered by impervious surfaces.

- **Riverine Flooding**
  Periodic flooding of lands adjacent to non-tidal rivers and streams (known as the floodplain) is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal watercourse, some of the above-normal stream flows onto adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of a stream or river. The recurrence interval of a flood is defined as the average time interval measured in years, expected to take place between the occurrence of a flood of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

- **Sheet Flooding**
  Sheet flooding is a condition where storm water runoff forms a sheet of water to a depth of six inches or more. Sheet flooding and ponding are often found in areas where there are no clearly defined channels, and the path of flooding is unpredictable. This type of flooding is more common to occur in flat areas. Most floodplains are adjacent to streams or oceans, although almost any area can flood under the right conditions where water may accumulate.

- **Urban Flooding**
  Urban flooding is usually caused by heavy rain over a short period of time. As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Since sidewalks and roads are non-absorbent, water flows down the surface of the streets, and is then dumped directly into sewers. In fact, roads and buildings generate more runoff than tropical forestland. Fixed drainage channels in urban areas may be unable to contain the runoff that is generated by relatively small but intense rainfall events. Urbanization increases runoff two to six times over what would occur on natural terrain. Consequently, high volume of water can turn parking lots into lakes, flooding basements and businesses, and cause lakes to form in roads where drainage is poor or overwhelmed.

  Urban flooding occurs where there has been development within stream floodplains. This is partly a result of the use of waterways for transportation purposes in earlier times. Sites adjacent to rivers and coastal inlets provided convenient places to ship and receive commodities. The price of this accessibility has increased flooding in the ensuing urban areas. Urbanization intensifies the magnitude and frequency of floods by increasing impermeable surfaces, amplifying the speed of drainage collection, reducing the carrying capacity of the land, and occasionally, overwhelming sewer systems.

There are a variety of specific causes of these types of flooding in North Reading, including heavy rainfall, beaver dams, erosion, snowmelt, and ice jams. Each of these specific causes are described in more detail below and have been incorporated as applicable in the hazard profile sections that follow.

Heavy Rainstorms

According to the meteorology glossary, a rainstorm is defined as a storm characterized by the fall of liquid precipitation. A more severe rainstorm that is associated to a storm is considered a thunderstorm. A thunderstorm is defined as a local storm, invariably produced by a cumulonimbus cloud and always accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain, and sometimes with hail.[34] These storms may also bring flash flooding and frequently result in flood watches and warnings. Under this hazard profile, the rain produced by thunderstorms will be considered. Other associated hazards such as wind, hail, and lightning are addressed separately in this chapter (see *Other Severe Weather*).

Beaver Dams

Beavers build dams on nearly any type of water source as a form of protection from predators. It is formed by tree branches, mud, and rocks that beavers scavenge. By flooding the area behind the dam, beavers can easily swim to obtain food (bark and aquatic vegetation) and has a safe habitat to eat, sleep, and bore kits within the beaver lodge. Beavers typically select spots where there is a large flat area to flood with plenty of trees nearby.[35] While this is natural process for beavers, it can often have dramatic consequences on the landscape.

Beavers can impact the flow of water and cause flooding by cutting down trees and creating dams. In fact, beavers have posed a problem in many areas within the state. The Massachusetts Division of Fisheries and Wildlife notes that beavers can dramatically change the environment in which they live. Further, "When this activity is in conflict with human land use practices, it can result in extensive complaints due to damage caused by flooding. Techniques used to mitigate the flooding damage caused by beaver include breaching of beaver dams, protecting road culverts with fences or guards, and controlling water levels with water flow devices. All these techniques require a certain degree of effort and regular maintenance to ensure water levels that can be tolerated (there by preserving the positive aspects of the associated wetland)."[36]

[34] Thunderstorm. (2012). Meteorology Glossary: American Meteorological Society. Retrieved December 11, 2014 from http://glossary.ametsoc.org/wiki/Thunderstorm

[35] Beaver Biology. (2014). Beaver Solution. Retrieved on December 11, 2014 from http://www.beaversolutions.com/about_beaver_biology.asp

[36] Langlois, S.A. and T.A. Decker. (2004). The Use of Water Flow Devices and Flooding Problems Caused by Beaver in Massachusetts (Rev. Ed.). MA Division of Fisheries and Wildlife. Retrieved on December 11, 2014 from http://www.mass.gov/eea/docs/dfg/dfw/wildlife/wildlife-facts-pubs/beaver-water-flow-devices.pdf

Figure 21. A Beaver Dam in Martins Brook.[37]

Erosion

Erosion is the gradual breakdown and movement of land due to both physical and chemical processes of water, wind, and general meteorological conditions. Natural or geologic erosion has occurred since the Earth's formation and continues at a very slow and uniform rate each year. There are two types of soil erosion: wind erosion and water erosion. Wind erosion can cause significant soil loss. Winds blowing across sparsely vegetated or disturbed land can pick up soil particles and carry them through the air, thus displacing them. Water erosion can occur over land or in streams and channels. Water erosion, the type of erosion of concern in this plan, may result from raindrops, shallow sheets of water flowing off the land, or shallow surface flow, which becomes concentrated in low spots. Stream channel erosion may occur as the volume and velocity of water flow increases enough to cause movement of the streambed and bank soils. Erosion is possible on lakes with wave action or still lakes where wind events have caused frequent disruption of water.

Fluvial erosion is the process of natural stream channel adjustments. Fluvial erosion causes erosion of sediment in some areas, while causing aggradation of sediment in other areas. Fluvial erosion processes occur more quickly and severely during flood events. Steeper sloped areas and smaller streams are most prone to fluvial erosion. Fluvial erosion can also undercut river or stream bank, creating a risk of collapse. This creates a hazard for those walking along the bank or structures near the bank.

Snowmelt

The meteorology glossary defines snowmelt as the water resulting from the melting of snow. According to the U.S. Geological Survey (USGS), most run and stream flow in rivers is attributed to snowmelt. The

[37] Image by Travis Dove for The New York times. Retrieved on December 11, 2014 from http://www.nytimes.com/2009/06/09/science/earth/09beaver.html?pagewanted=all

effect of snowmelt on flooding occurs mainly in the spring when temperatures begin to rise. Snowmelt may also occur when rain falls on snow (a rain-on-snow-event). This results in increased run off from the rain event.

Ice Jams

Large chunks of melting ice in rivers can easily become stuck on debris or lodged around bends on rivers and streams. As the flow of the water carries more large chunks into the same spots, a natural, temporary dam can develop. The water will eventually back up behind the dam, and severe flooding can occur. This is known as ice jam flooding.[38]

Ice jams (breakup jams) occur when warm temperatures and heavy rain cause rapid snow melting. The melting snow combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layer into large chunks. These large ice chunks can float downstream and pile up near narrow passages or near obstructions, such as bridges and dams. Cranes with wrecking balls and explosives are sometimes used to break up ice dams. Historically, there have been hundreds of ice jams in New England. The most devastating winter floods have been associated with a combination of heavy rainfall, rapid snowmelt, and ice jams. When river ice piles up at shallow areas, bends, and islands, it blocks the flow of water and may cause flooding of nearby homes and businesses.

Location

The main sources of flooding in North Reading are the Ipswich River and Martins Brook. The Ipswich River has a total drainage area of forty square miles at the downstream corporate limits at Middleton. The river forms the south boundary of the Town with Reading. An old mill dam located on the Bostik Corporation property in Middleton, just downstream of the North Reading corporate limits, controls the elevation of the Ipswich River for a distance upstream of the dam. The Ipswich River begins in Wilmington just southwest of the Concord Street Interchange along I-93 at the confluence of Lubbers Brook and Maple Meadow Brook. The river flows east through Wilmington before entering North Reading.

The Martins Brook watershed, which includes Martins Brook, Martins Pond, and the Skug River, is another significant flooding source in Town. Martins Brook is a tributary to the Ipswich River and has a total drainage are of 13.2 square miles at its confluence with the Ipswich River.

Other sources of flooding in Town include Rapier Brook, Swan Pond, Eisenhaures Pond, and a number of unnamed streams that are tributaries to the Ipswich River. One such unnamed tributary passes under Lindor Road and Elm Street. It has a total drainage area of 2.0 square miles and has been the source of past flooding problems. Because of the relatively flat slope of the Ipswich River in North Reading,

[38] Sagliani, Anothony. (2013). Snowmelt Flood Risk: Worcester, Boston, Hartford. Accuweather. Retrieved December 11, 2014 from http://www.accuweather.com/en/weather-news/snowmelt-flood-risk-worcester/7955795

floodwaters move slowly through the town such that property and structures can be inundated for days after the rainfall has stopped. Several major roadways, including State Route 28, typically have to be closed during flood events.

Beaver dams are typically located in slow flowing currents where the water is relatively shallow, but deep enough to provide habitat under winter ice. In North Reading, all reports of beaver dams are at Martins Pond including Fieldcrest Terrace and Route 62 at Martins Brook, which is in Wilmington but impacts Martins Pond. In summary, beaver dams are possible anywhere with water and nearby trees.

Floodplains

In addition to the above referenced flooding sources, types, and causes, there are several types of floodplains. All the flood types described earlier in this section may occur within a floodplain but can also happen (and frequently do) outside of known floodplain areas.

As noted above, the periodic flooding of lands adjacent to rivers, streams, and shorelines (land known as floodplain) is a natural process that has some chance of occurrence each year. Floodplains are designated by the frequency (and severity) of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. Flood frequencies such as the 100-year flood are determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size occur. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1% chance of occurring in any given year, and the 500-year flood drops to a 0.2% chance of occurring in any given year. Therefore, they are commonly referred to as the 1% annual chance flood and 0.2% annual flood, respectively. It should be noted that flooding is possible every year and even multiple times each year.

FEMA develops Digital Flood Insurance Rate Maps (DFIRMs) to indicate areas in the U.S. where regulatory development standards and flood insurance purchase requirements may apply under the National Flood Insurance Program (NFIP). They are also used for planning purposes to identify areas of varying flood risk. In 2021, updated Preliminary DFIRMs were published by FEMA for Middlesex County (including all jurisdictions) to update the currently effective DFIRMs (adopted in 2010). The Preliminary DFIRMs for North Reading were still undergoing review at the time of this plan update but are anticipated to replace the Town of North Reading's current DFIRMs by the end of 2022. While not officially adopted at this time, the Preliminary DFIRMs and associated flood hazard data provided by FEMA in August 2021 are considered best available information for purposes of hazard mitigation planning, and they are incorporated into this assessment by reference (see below).

Special Flood Hazard Areas

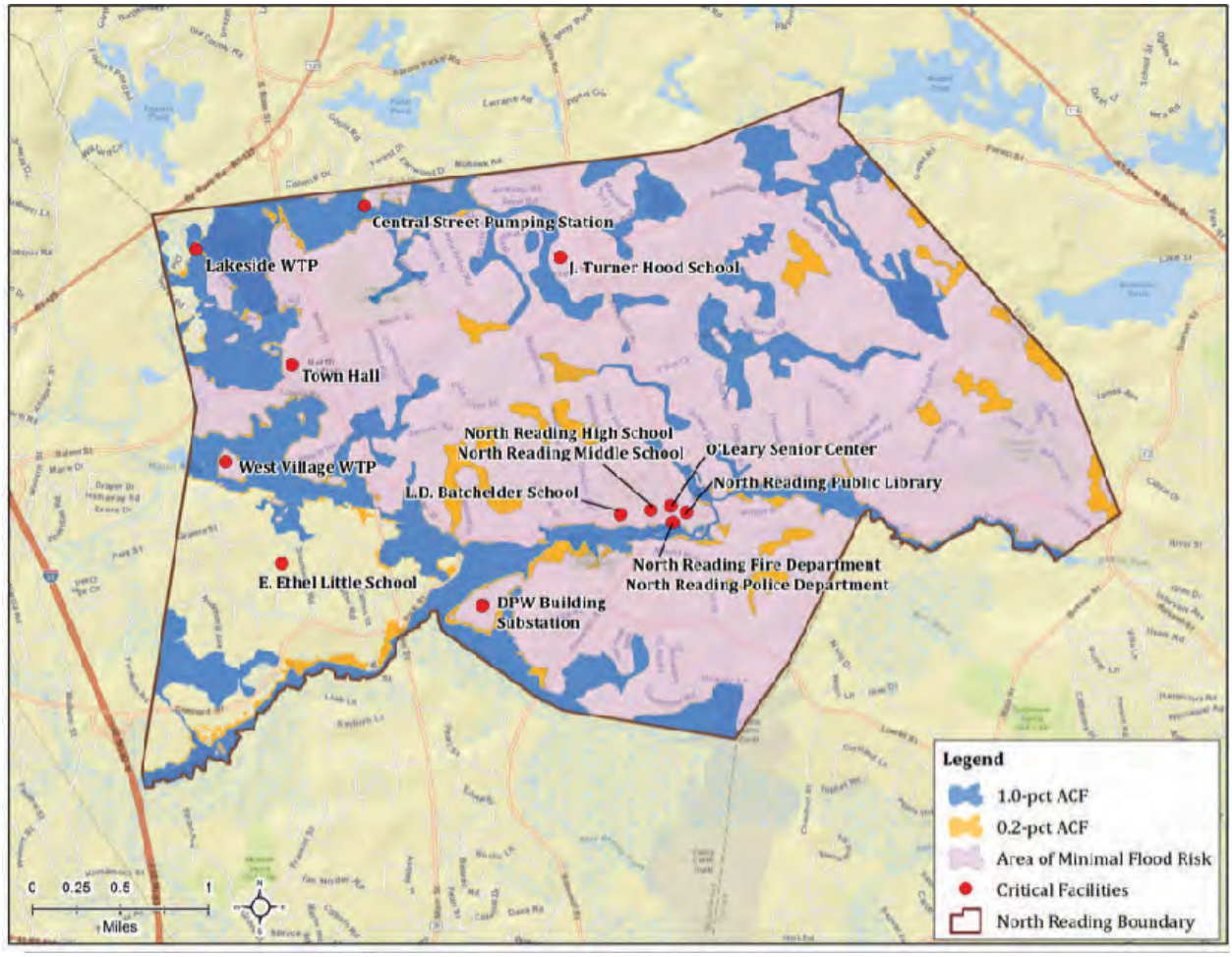
As noted above, FEMA designates a variety of flood hazard zones which are delineated on Digital Flood Insurance Rate Maps. In addition to flood insurance applications, DFIRMs are used by most communities to regulate new construction to specific floodplain management standards as required by the NFIP, in

addition to state-specific standards and/or local bylaws for floodplain management. In North Reading these regulatory standards are enforced through its Floodplain Overlay District requirements as further described in Chapter 5.

As shown on DFIRMs, FEMA's mapped Special Flood Hazard Areas (SFHAs) are subject to flooding by the 1% annual chance flood. The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. The Base Flood Elevation (BFE) is the water surface elevation of the 1% annual chance flood. The Regulatory Floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.
In addition to these SFHAs, FEMA also delineates areas subject to the 0.2% annual chance flood (also known as the 500-year flood) and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile. These are identified as other areas of flood hazard but are not linked to flood insurance or local development regulations. Areas outside of the SFHAs and these other mapped areas are of minimal flood hazard. However, it should still be noted that flooding can occur outside of these locations, particularly due to flash floods and over capacity storm water management systems.

Figure 22 illustrates the location of the current regulatory floodplains in North Reading per the effective DFIRMs (dated June 2010). In August 2021, FEMA released Preliminary DFIRMs along with other updated flood risk products for Middlesex County, including the Town of North Reading. As noted above, these DFIRMs are still undergoing review but are considered best available data for hazard mitigation planning purposes, even though not yet officially adopted by the Town for regulatory purposes. The Preliminary DFIRMs delineate a variety of flood zones for North Reading and are illustrated on a series of DFIRM Panels which are provided in Appendix D.

Figure 22. Regulatory Floodplains in North Reading).



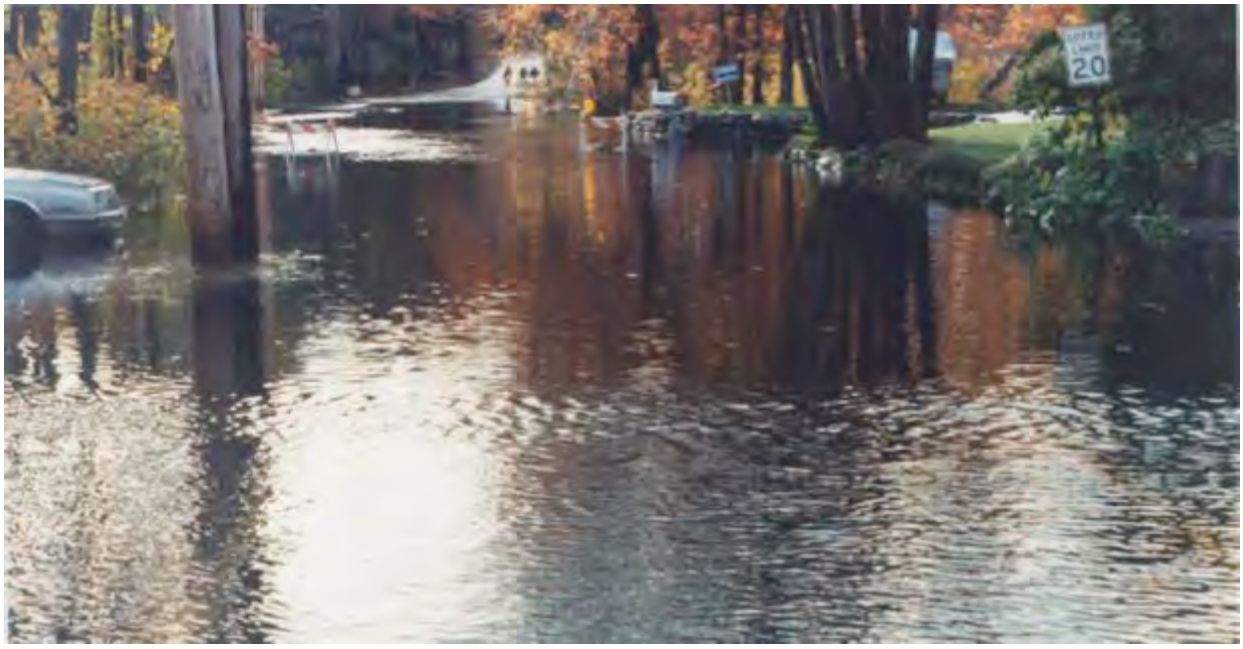
Martins Pond Flooding Issues

Flooding damage in the Martins Pond area of North Reading has been a recurring problem for many years. Most of Martins Pond is surrounded by older private development – former vacation homes that are now year-round residences. Many of these structures were built before the National Flood Insurance Program came into existence and provided Flood Insurance Rate Maps for which to base regulatory development standards. As such, the homes were never built with the current or projected flood risk in mind.

When flooding occurs in Martins Pond that is greater than a 10-year event, floodwaters overtop both Burroughs Road at the outlet structure of the pond and Lakeshore Boulevard in the vicinity of the Town's water pumping station (Lakeside Pumping Station, a critical facility) and inundates the pump station site, causing flood damage and preventing access for work vehicles and safe egress from the Pond area for residents. When this occurs, the only alternate route for many residents utilizes Poplar Terrace. Poplar Terrace is a local road with sight line issues caused by a severe crest vertical curve.

During floods greater than a 10-year event, Burroughs Road becomes impassible, isolating more than 200 homes located along the west side of Martins Pond. An emergency access (Rahnden Terrace Emergency Gate) is now in place to allow emergency vehicles to access the west side of the pond from State Route 125 and to allow residents to leave and return to their homes. Water levels in Martins Pond can take a week or more to recede. Figure 23 shows how portions of Burroughs Road and Lakeside Boulevard become inundated with floodwaters and are closed for safety reasons.

Figure 23. Flooding Near Martins Pond.



For two decades now, The Martins Pond Association (MPA) is a local organization that has been advocating and providing stewardship services that support the Pond. With funding help from DEP, North Reading and the Association have undertaken a shoreline restoration and sediment reduction project and a stormwater reduction project. Members of the MPA have noticed a rise in the normal level of Martins Pond over the years caused by restrictions or obstructions in the pond's outlet, Martins Brook. This increase in the normal pond elevation causes a reduction in the pond water storage capacity and in the Martins Brook watershed, which can increase a flood events depth and duration. Flooding of the homes adjacent to the pond can also cause the backup and overflow of septic systems, causing the pollution of Martins Pond, Martins Brook and ultimately the Ipswich River.[39]

The MPA and the Town's Martins Pond Reclamation Study Committee continues to work with the Town's Department of Public Works regarding alleviating flooding around Martin's Pond. One priority solution identified through the Town's MVP planning process was the Route 62 culvert in Wilmington,

[39] Martins Pond L&P Report. (2014). Martins Pond Association. Retrieved December 11, 2014 from http://www.martin- spond.org/environment/studies_reports/reports/MartinsPond_L&P_Report.pdf

which is considered undersized and controls flood elevations in Martins Pond. The culvert reportedly acts as a dam such that increasing the size of this culvert would allow larger discharges to flow downstream impacting homes in Wilmington that were built lower than they should have been in the floodplain. The culvert is the hydraulic control for Martins Brook and is prone to clogging. Culvert is old and failure would create major transportation problem for North Reading.

Per the 2016 hazard mitigation plan, in February 2013, it was deemed impossible to get permitting to utilize a MEMA grant to enlarge the Route 62 culvert due to downstream impacts. A public meeting was held on February 26, 2013, with DPW and the Town's consultant, Green International, to inform residents that this solution is no longer an option. In June 2013, Town Meeting voted to reallocate the money that was set aside to replace the Route 62 Bridge to examine other options to help mitigate flooding and come up with policies and plans to minimize flooding. A draft report was submitted and commented on by the MPA in July 2013.[40]

After much study relative to the replacement of the Route 62 culvert in Wilmington, it was determined that there is not a cost-effective solution that will lower flood elevations in Martins Pond without causing a slight increase in flood elevations on downstream properties in Wilmington. Furthermore, while the Route 62 culvert controls flood elevations in Martins Pond during large flood events (such as the 100-year, or 1% chance flood), it was also determined that for smaller flood events, the culvert on Benevento's property controls flood elevations up to a certain level in Martins Pond. The MPA has also observed that keeping the channel clear of vegetation and debris helps alleviate flooding conditions in Martins Pond.

Pursuant to these efforts, Green International was retained by the Town to establish guidelines and procedures for inspecting and maintaining the Martins Brook stream channel and ensuring that the existing channel capacity is not compromised by debris, excessive vegetation growth, obstructions, unregulated filling and/or construction activities. This resulted in the Martins Brook Floodway Operation and Maintenance (MBF-O&M) Plan which was completed in October 2014. The purpose of the MBF-O&M Plan is to establish guidelines and procedures for inspecting and maintaining the Martins Brook stream channel and ensuring that the existing channel capacity is not compromised by debris, excessive vegetation growth, obstructions, unregulated filling and/or construction activities.[41]

Previous Occurrences

According to the State Hazard Mitigation and Climate Adaptation Plan, Middlesex County has had 14 federally declared flood-related disasters since 1954.[42] Most of this flooding occurred during severe storms during the fall, winter, and spring months.[43] Many additional flood events have occurred in the region but did not result in a federal disaster declaration.

[40] Town of North Reading Annual Report. December 31, 2013 p.129
[41] Martins Brook Floodway Operation & Maintenance Plan, North Reading, MA. October 2014. P. 4.
[42] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-9.
[43] Flood Insurance Study for Middlesex County. Federal Emergency Management Agency. July 2016. P. 29.

Local data for previous flooding occurrences are not collected by the Town of North Reading. The best available local data is for Middlesex County through the NOAA's Storm Events Database. Per NOAA's database records, Middlesex County experienced a total of 205 flood events which have caused an estimated $57 million in property damages since 1996.[44] Notable events for the area include flooding from severe storms in October 1996, June 1998, April 2001, April 2004, October 2005, May 2006, and March 2010. The May 2006 "Mother's Day Flood" damaged 14,000 homes in 44 communities, including Middlesex County.

Looking further back in time there have been numerous other flood events recorded for the region, though little data on impacts specific to North Reading exist. The flood of August 1955 resulted from two hurricanes that arrived almost concurrently-Hurricane Connie, occurring between August 11 and 15; and Hurricane Diane occurring between August 17 and 20. As a result of these two storms, roads and bridges were overtopped, and residences and businesses were flooded. Further, significant recorded floods were those occurring in May 1850, December 1878, July 1891, July 1897, February and March 1900, November 1927, March 1936, July and September 1938, October 1942, October 1955, April 1960, March 1968, and January 1979.[45] More recent flooding occurrences as cited in the previous hazard mitigation plan included events for North Reading in April 1987, 1993, October 1996, June 1998, March 2001, April 2004, November 2005, May 2006, January 2009, and March 2010. The March 2010 flood event was one the most severe in recent memory for the planning area, after a total of nearly 15 inches of rainfall accumulation was recorded by the National Weather Service.

According an earlier (2002) Flood Hazard Mitigation Plan for North Reading, the community "is being adversely affected by floods every few years on average. Recent flooding events have disrupted transportation within the Town, damaged critical facilities vital to the public's health and safety, damaged roadways, and utilities, and have caused damage to private homes, property and businesses. In recent years, the frequency of flood events has increased."

Residences adjacent to Martins Pond annually experience basement flooding resulting from a combination of high groundwater and surface flooding. Based on information obtained from the Martins Pond Association, the May flood of 2006 was the worst flood on record and caused flooding in the Martins Pond neighborhood such that several families had to be evacuated from their homes. Some people suffered thousands of dollars in damage to first floor living space, loss of mechanical/heating equipment, and loss of basement furnishings. During the 2006 flood, Burroughs Road was impassable, along with the intersection of Lakeside Boulevard and Burroughs Road, and the section of Lakeside Boulevard near the Town's Pumping Station.[46]

[44] NOAA's Storm Events Database: https://www.ncdc.noaa.gov/stormevents/
[45] Flood Insurance Study for Middlesex County. Federal Emergency Management Agency. July 2016. P. 24-25.
[46] Martins Brook Floodway Operation & Maintenance Plan, North Reading, MA. October 2014. P. 4.

Additional information on the previous occurrences of other local causes for flooding events include the following:

- All reported occurrences caused by beaver dams were reported are near Martins Pond. Although these reported beaver dams are considered a threat, there has been limited actual damage and flooding that occurs. This is due largely in part to the diligent monitoring completed by the MPA. The MPA have removed large beaver dams on several occasions in the past (2005, 2009) and trap and remove beavers as necessary.
- No specific previous occurrences were reported for erosion, however, given that erosion is a continuous natural process, it is undoubtedly occurring. Erosion may result from floods, heavy rain, winds, wildfire/brush fires, or hurricane events.
- The Ice Jam Database maintained by the US Corps of Army Engineers, Cold Region Research, and Engineering Lab, is a searchable database of historic ice jam events.[47] However, no events were reported for North Reading. A total of 233 ice jam events were reported for Massachusetts, but only one of these occurred on the Ipswich River (in Ipswich, MA), and six occurred in Middlesex County on other rivers.
- Snowmelt is a natural occurrence and will inevitably continue to occur. No specific examples of snowmelt-induced flood events were identified for the planning area. However, based on local knowledge and reports from the USGS, it is certain that snowmelt has contributed to previous flood occurrences in combination with intense rainfall.

NFIP Information

The Town of North Reading has actively participated in the National Flood Insurance Program (NFIP) since 1978, when the first FEMA FIRMS became effective. As of September 2, 2021, 43 NFIP policies exist in North Reading with total annual premiums of $59,368 for a total of $11,192,900 coverage in force.

Since joining the NFIP, a total of 122 insured flood losses have been reported, totaling $790,590 in claims payments. The average claim amount is $6,480. It should be emphasized that these numbers include only those losses to structures that were insured through the NFIP policies, and for losses in which claims were sought and received. It is likely that many additional instances of flood losses in the Town were either uninsured, denied claims payment, or not reported.

Repetitive loss properties are defined by FEMA as “any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. A repetitive loss property may or may not be currently insured by the NFIP. Currently there are over 150,000 repetitive loss properties nationwide. Severe repetitive loss properties are those which are residential and have at least four NFIP claim payments over $5,000 totaling over $20,000; have at least two separate claim payments exceeding the market value of the buildings; and at least two of the above must have occurred within a ten-year period.

[47] Ice Jam Database, Bulletins & Surveys. (2014). US Army Corps of Engineers. Retrieved December 11, 2014 from http://rsgisias.crrel.usace.army.mil/apex/f?p=273:2:9514583758394

According to FEMA's latest data records[48], there are 24 repetitive loss properties located in the Town of North Reading. All these properties are residential, with 23 classified as single-family structures and one as multi-family. These 24 repetitive loss structures in North Reading have accounted for 56 reported flood losses and nearly $549,031 in claims payments, for an average claim amount of $9,804. This data indicates that nearly half (46%) of the reported NFIP claims and the majority (70%) of claims payments in the Town have come from repetitive loss properties. Without mitigation, these properties will likely continue to experience flood losses.

Table 10 provides a summary of repetitive loss data by occupancy and payment type as provided by FEMA for North Reading. There are no severe repetitive loss properties in the Town.

Table 10. Repetitive Loss (RL) Property Data for North Reading.

Occupancy Type	# of RL Properties	# of RL Losses	Building Payments	Contents Payments	Total Payments	Average Payment
Single-Family	23	54	$502,432	$35,857	$538,289	$9,968
2-4 Family	1	2	$10,743	-	$10,743	$5,372
TOTAL	24	56	$513,175	$35,857	$549,032	$9,804

Extent

It is often thought the 0.2% annual chance flood is the greatest extent (or severity of flooding). However, flooding may exceed the boundaries and anticipated depth of this hazard, a particular concern when it comes to the consideration of potential changing future conditions related to development patterns, changing precipitation patterns, and other climate-related factors such as more extreme weather events. As noted above, the March 2010 flood event was one the most severe in recent memory for the planning area, after a total of nearly 15 inches of rainfall accumulation was recorded by the National Weather Service. One indication of the extent of flooding is the gage height at the nearest USGS streamflow gauging station, which is on the Ipswich River in South Middleton. The USGS gage height exceeded 8 feet on March 16, 2010 and exceeded 7 feet on March 31, 2010. Normal gage height in March is about 4 feet.[49]

Additional information on the extent of other local causes for flooding events include the following:

- In terms of heavy rainstorms, historic occurrences above indicate a rate of 6- 12 inches of rain over two days in 1998.
- In terms of beaver dams, in the most severe cases, dams will be expansive enough to cause flooding behind the dam. Beaver dams have been reported as up to seven feet high and 1,000 yards wide. The greatest severity would be extensive flooding resulting in damage to structures.

[48] Provided by Garrett Fish, FEMA Emergency Management Specialist, by email on September 23, 2021.
[49] Town of Wilmington, Hazard Mitigation Plan Update. 2015. P. 25.

There are several previous events that have resulted in roads and structures being flooded due to beaver dams in Massachusetts.

- In terms of erosion, data was not available to show the exact erosion rate, such as feet per year (a measure of extent), that is occurring in the planning area. Erosion typically happens slowly over time but may be accelerated by fast moving and/or high-water levels in rivers or creeks. In the most severe situations, erosion will result in the bank of a stream of river receding or collapsing.
- In terms of ice jams, there was no specific information on ice jam extent in North Reading (as defined by amount of flooding or thickness of ice, for example). However, per the 2013 Massachusetts State Hazard Mitigation Plan, chunks of ice in Miller's River in 2008 was 1-2 feet thick and approximately 1,500 feet long. It is possible that this size could be exceeded in future events. Further, the size of the ice jam can be relative based on the width of the river or stream on which they are located. The most severe situation is when the ice jam is large enough to block water flow and result in flooding.
- In terms of snowmelt, extent will depend on the amount of snow, the rise in temperature, and current water level. For example, a late spring snow followed but fast warming temperatures could easily result in flooding on already saturated ground and swollen rivers. Snowmelt can result in a rise of several extra inches (or even feet) in the water level. Snowmelt will also impact the discharge rate along rivers, such as that described for Martins Brook above.

Probability of Future Events

There have been at least 17 major flood events based on previous reports and associated disaster declarations since 1938 (21% estimated annual chance). However, it is likely that less severe events also impact the planning area more frequently. Therefore, the probability is higher for these events. An estimated probability of likely was assigned.

In addition to a changing climate which has already increased the frequency of heavy rainfall events, aging infrastructure—specifically antiquated pipes, storm drains and undersized or failing culverts—will continue to increase the probability and magnitude of flooding events. As precipitation events become more intense and less predictable, the Town's older and undersized stormwater systems are expected to pose a greater threat of failure and flooding.

Additional information on the probability of other local causes for flooding events include the following:

- The probability of future rainstorm events is highly likely.
- The probability of future beaver dams and associated impacts is certain. While the exact number of beavers in North Reading is unknown, the population is sizable enough to cause continued impacts. While only two major events were reported, articles citing these occurrences suggest a regular event. Given the tenacity and industrious nature of beavers, it is likely that beavers dams are occurring annually though may not require annual attention. Regular maintenance is needed to prevent significant damage, such as flooding, from occurring. Beaver trapping continues as needed under emergency permitting and in-season trapping is done when beaver dams are causing flooding upstream. In addition, volunteers regularly kayak down Martin's Brook to search for beaver activity.

- Given the natural process of erosion, some occurrence is inevitable. However, it will likely continue to be a slow recurring event in the Town.
- While there is no history of ice jam events recorded in North Reading, they are possible in the area as demonstrated by previous occurrences.
- The probability of future snowmelt-induced flooding events is possible. It is recognized that snowmelt occurs annually, though may not always result in flooding. Such events will most likely occur in the spring months, mostly commonly in March.

Vulnerability Assessment

While flooding does have some designated areas, flash floods and urban flooding put all current and future buildings and populations at risk. Impacts of flood include business interruption, mold issues, and damaged contents and equipment, to name a few. Just a few inches of water in a building could cause damage to floors, walls, and foundation structures that cost thousands of dollars to repair. If the water rises more than a few inches in a structure, damaged electrical systems, appliances, and other building contents may need to be replaced.

During the initial preparation of this plan, flood vulnerability was investigated further in terms of population at risk, number of parcels at risk, value of parcels, and estimated losses from Hazus-MH. Since the basic underlying data and methods haven't markedly changed since that time, the same flood vulnerability information has been provided below for this plan update. As new data inputs and methods become available for further analysis by the Town's GIS staff, including but not limited to new Census data and floodplain mapping products from FEMA that suggest community vulnerability has significantly changed, the Core Team will consider updating this vulnerability assessment.

The 2010 Census block data indicates a population of 14,904 in the planning area. A GIS intersection analysis was used to estimate potential population at risk. To reduce double counting in the small planning area, the analysis counted census blocks when their centroid was with the floodplain layer. While the data is not exact, it provides a reference to the potential population at risk (Table 11).

Table 11. Population Potentially at Risk to Flooding.

Flood Hazard Area	Estimated Population at Risk	Estimated % of Population at Risk
1% annual chance floodplain	1,979	13%
0.2% annual chance floodplain	1,262	8%
TOTAL	3,241	21%

A GIS analysis was also conducted to determine the potential number of parcels (and thus buildings at risk). In addition, a GIS analysis was conducted to determine potential risk to critical facilities. However, it should be noted that this analysis does not include elevation of buildings (and assumes all building are at ground level). Therefore, some buildings captured in the GIS analysis may not actually be at risk. Results are shown in Table 12.

Table 12. Parcels and Associated Building Value Potentially at Risk to Flooding.

Flood Hazard Area	Estimated Number of Parcels at Risk	% of Parcels	Estimated Building Value on At Risk Parcels	% of Building Value
1% annual chance floodplain	1,275	21%	$435,339,700	26%
0.2% annual chance floodplain	961	15%	$305,318,300	18%
TOTAL	2,236	36%	$740,658,000	44%

Based on the GIS analysis, four critical facilities were found to be potentially located in the floodplain. The Lakeside Water Treatment Plant and Central Street Pumping Station reside in the 1% annual chance floodplain. The North Reading Police and Fire Department properties (Public Safety Building) were found to reside in the 0.2% annual chance floodplain. However, these buildings are protected by a floodwall that was constructed in 2001. The floodwall was then capped with 18 inches of additional protection in 2010. Since its installation, no losses have occurred. However, Town officials noted that a major storm has not tested it, and this facility along with access issues for the DPW garage were identified as major concerns by the MVP Core Team. All other properties, except for E. Ethel Little School, have some risk to flooding (as demonstrated by the Area of Minimal Flood Risk area).

Hazus-MH 2.1 Potential Losses

Hazus-MH 2.1 was used to estimate potential riverine flood losses in the Town of North Reading. A Digital Elevation Model (DEM) of 1/3 arc second was obtained from the USGS for the study area. Hazus-MH was utilized to estimate floodplain boundaries, potential exposure for each event frequency based on probabilistic scenarios for the 10-, 25-, 50-, 100-, and 500-year flood events using a Level 1 analysis. A drainage area of 10 square miles was used, meaning large water sources are included (and some small tributaries). Hazus-MH losses are based on a Hazus-MH modeled floodplain boundary, depth grid and methodology. When the floodplain boundary intersects a census block, the buildings within that block are incorporated into the loss estimate. Further, the damages are associated with the depth of water. Higher damages result in greater losses based on the model's depth damage functions. The Hazus-MH model assumes that all buildings are evenly distributed throughout the assessment area. This can lead to an over- or underestimation of actual losses to structures. (For example, if the model indicates 25 percent of a census block has two feet of water, then 25 percent of buildings have damages associated with 2 feet of water.)

Table 13 highlights the total exposure in the Town (total replacement value of buildings as reported in the Hazus-MH inventory). In other words, this information helps to understand the dollar value of assets at risk based on the Hazus-MH model inventory. It should be noted that data is not from the Town and may be different that the assessed value of property within North Reading. Building data is drawn from Dunn and Bradstreet and RS Means.

Table 14 includes potential losses to buildings and total losses because of flood. Total losses include building loss, content loss, inventory loss, relocation costs, income loss, rental income loss, and wage loss. Lastly,

Table 15 shows losses based on total exposure (as shown in Table 13). The percentage of potential damage based on total exposure is a way to present overall risk within the community. These results were used to estimate the average annualized loss by multiplying the estimated building losses by the respective frequency. An estimate of approximately $42,000 was derived for average annualized loss for building only losses.

It should be noted that the Hazus-MH calculated floodplain does not reflect (or supersede) the regulatory or Preliminary FEMA DFIRMs discussed earlier in this chapter. However, the model does present a general picture of losses due to various flood scenarios. Losses are concentrated in the southern portion of the Town along the Ipswich River and Martins Brook.

Table 13. Hazus-MH Building Exposure to Flooding.

Building Type	Building (only) Exposure	Contents Exposure	Total Exposure
Residential	$956,940,000	$478,613,000	$1,435,553,000
Commercial	$269,976,000	$278,336,000	$548,312,000
Industrial	$46,714,000	$58,368,000	$105,082,000
Government	$5,618,000	$6,748,000	$12,366,000
Education	$11,960,000	$11,960,000	$23,920,000
Religious	$10,528,000	$10,528,000	$21,056,000
Agricultural	$3,417,000	$3,417,000	$6,834,000
TOTAL	$1,305,153,000	$847,970,000	$2,153,123,000

Table 14. Hazus-MH Losses for 100-Year and 500-Year Flood.

Building Type	100-Year Losses			500-Year Losses		
	Building (only) Losses	Other	Total	Building (only) Losses	Other	Total
Residential	$7,541,000	$3,990,000	$11,531,000	$12,893,000	$6,641,000	$19,534,000
Commercial	$5,943,000	$14,984,000	$20,927,000	$8,134,000	$19,656,000	$27,790,000
Industrial	$2,214,000	$4,193,000	$6,407,000	$2,538,000	$4,787,000	$7,325,000
Government	$282,000	$1,981,000	$2,263,000	$325,000	$2,186,000	$2,511,000
Education	$7,000	$59,000	$66,000	$8,000	$74,000	$82,000
Religious	$175,000	$1,234,000	$1,409,000	$213,000	$1,335,000	$1,548,000
Agricultural	$113,000	$335,000	$448,000	$135,000	$375,000	$510,000

TOTAL	$16,275,000	$26,776,000	$43,051,000	$24,246,000	$35,054,000	$59,300,000

Table 15. Losses Reported as a Percent of Building Exposure.

Building Type	100-Year Losses		500-Year Losses	
	Building (only) Losses	% Building Exposure Impacted by Flooding	Building (only) Losses	% Building Exposure Impacted by Flooding
Residential	$7,541,000	1%	$12,893,000	1%
Commercial	$5,943,000	2%	$8,134,000	3%
Industrial	$2,214,000	5%	$2,538,000	5%
Government	$282,000	5%	$325,000	6%
Education	$7,000	0%	$8,000	0%
Religious	$175,000	2%	$213,000	2%
Agricultural	$113,000	3%	$135,000	4%
TOTAL	$16,275,000	1%	$24,246,000	2%

Additional information on the unique vulnerabilities posed by local causes for flooding events include the following:

- The major threat associated with beaver dams is flooding. The dams alter the course of the water and flood areas that are typically not at risk to flooding during normal conditions. Flooding of septic tanks is also common and has been reported near Martins Pond. All structures near Martins Pond are at risk to flooding from beaver dams. (The exact number of structures is unknown.) It should also be noted that dismantling (or breaching) a beaver dam can result in flooding on adjacent properties and downstream.
- In severe cases, erosion can compromise the stability of a stream bank and, eventually, a structure's foundation. Erosion can also result in scouring of the stream bottom, which can be problematic around bridge piers and abutments. This puts current and future structures and populations residing near steep embankments at risk. Erosion can also undercut streambeds and pose a risk to those walking along the bank.
- While ice jams are categorized as a winter hazard, their impacts and vulnerability are best aligned with flood impacts. However, all current and future structures and populations located along river and stream corridors should be considered at risk to the flooding caused by this hazard. Ice jams may also cause damage to bridges, culverts, and other structures as they float down swollen rivers.
- The greatest vulnerability of snowmelt to North Reading is increased runoff. This can overwhelm storm water management systems and result in flooding. Snowmelt also weakens slopes by saturating landscapes (often combined with heavy rain). A secondary impact of snowmelt is ice jam flooding (discussed separately). As snowmelt occurs and rivers begin to rise, the rivers may be jammed with ice, resulting in flooding.

Anticipated Effects of Climate Change

In terms of climate change, multiple studies cite that the Northeast region of the US will continue experience more very heavy rainfall events which are often associated with severe thunderstorms and other extreme weather events. The Northeast has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, and this trend is expected to continue."[50] According to the Massachusetts Climate Change Projections Report released by the Commonwealth in 2018, the Ipswich Basin is expected to see nearly 3 additional days with precipitation over 1 inch by the 2050s.[51]

Climate change will also impact flooding due to increased hazard frequency or severity. For example, increased hazard occurrence in the form of snow could results in greater impacts from snowmelt. Research suggests that due to climate change, the Northeast should expect wetter winters. Climate change may also result in more severe rain events that bring several extra inches of rain. This is also true for hurricane and nor'easter.

Other cyclical climate conditions, such as El Niño, can also impact flooding through increased or decreased events. El Niño can be generally described as a warmer than normal sea temperatures in the equatorial Pacific. However, its impact can be felt around the globe. Southern Oscillation is defined as a "seesaw of atmospheric pressure between the eastern equatorial Pacific and Indo–Australian areas." The two are closely linked and together called El Niño–Southern Oscillation (ENSO) events. During El Niño is the sea temperature component while Southern Oscillation is the atmospheric pressure component. The systems can impact weather patterns throughout the globe when in effect. While it is known that El Niño can cause weather changes, and NOAA data suggests increased winter (November through January) precipitation during strong El Niño events and decreased precipitation in weak El Niño events. Beyond these months, trends were for normal to drier conditions during El Niño events.

Climate change may impact the potential for ice jams due to greater extremes, as in winters may be more severe. This may result in thicker ice on the river, which is more damaging if ice jam conditions arise during warming temperatures. Secondly, as opposed to gradual temperature rises, temperatures may rise rapidly following winter events, which could result in favorable conditions for ice jams.

Drought

Hazard Description

Drought is conceptually defined by the national Drought Mitigation Center as "a protracted period of deficient precipitation resulting in extensive damage to crops, resulting in loss of yield." Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, yet its characteristics vary significantly from one region to another.

[50] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-254.
[51] Massachusetts Climate Change Projections. Northeast Climate Adaptation Science Center at UMass-Amherst. Published by Massachusetts Executive Office of Energy and Environmental Affairs. March 2018. P. 109.

Drought is a temporary aberration and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. Droughts are slow-onset hazards, but over time can have very damaging affects to crops, municipal water supplies, recreational uses, and wildlife. If droughts extend over a number of years, the direct and indirect economic impact can be significant.

Drought should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration in a particular area, a condition often perceived as "normal." It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness of the rains (i.e., rainfall intensity, number of rainfall events). Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate its severity.

The beginning of a drought is difficult to determine. Several weeks, months, or even year may pass before people know that a drought is occurring. The first evidence of drought usually is seen in rainfall records. Within a short period of time, the amount of moisture in soils can begin to decrease. The effects of a drought found in stream and river flows or on water levels in lakes and reservoirs may not be noticed for several weeks or months. Water levels in wells may not reflect a shortage of rainfall for a year or more after a drought begins.

The end of a drought can occur as gradually as it began. Dry periods can last for 10 years or more. During the 1930s, most of the United States was much drier than normal. In California, the drought extended from 1928 to 1937. In Missouri, the drought lasted from 1930 to 1941. Missouri's extended dry period produced 1930s' "Dust Bowl", which refers to crops and farms that were destroyed by dust storms.

Drought is a normal part of virtually all-climatic regimes, including areas with high and low average rainfall. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period, usually a season or more in length. Drought can be defined according to meteorological, hydrological, or agricultural criteria. Drought is typically categorized in three types as shown in Table 16.

Table 16. Drought Types.

Drought Type	Description
Meteorological Drought	Meteorological drought is usually based on long-term precipitation departures from normal, but there is no consensus regarding the threshold of the deficit or the minimum duration of the lack of precipitation that makes a dry spell an official drought.
Hydrological Drought	Hydrological drought refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow, and as lake, reservoir, and ground water levels.

Agricultural Drought	Agricultural drought occurs when there is insufficient soil moisture to meet the needs of a particular crop at a particular time. A deficit of rainfall over cropped areas during critical periods of the growth cycle can result in

Location

A drought is a regional event that is not confined to geographic or political boundaries; it can affect several areas at once. However, it can range in severity across those areas. All of North Reading is at risk to drought occurrence.

Previous Occurrences

Massachusetts is often considered a "water-rich" state. Under normal conditions, regions across the state receive between 40 to 50 inches of precipitation annually. The precipitation occurs nearly evenly throughout the year. However, Massachusetts can experience extended periods of dry weather, from single season events to multi-year events, such as the drought event experienced in the mid-1960s. Historically, most droughts in Massachusetts have started with dry winters, rather than a dry summer.

Massachusetts has experienced multi-year drought periods in 1879-83, 1908-12, 1929-32, 1939-44, 1961-69, 1980-83, and 2016-2017. Several less-severe droughts occurred in 1999, 2001, 2002, 2007, 2008, 2010, and 2014. As recently as October 2020, most of Massachusetts was experiencing mild drought conditions due to over six months of below normal rainfall and above normal temperatures.

The most severe drought on record in the northeastern United States was during 1961-69. Water supplies and agriculture were affected because of the severity and long duration of the drought. Precipitation was less than average beginning in 1960 in western Massachusetts and beginning in 1962 in eastern Massachusetts. During this drought, several communities declared water supply emergencies. As a point of reference, Quabbin Reservoir, the major water source for the metropolitan Boston area, reached 45% of capacity in 1967.

More recently, notable times of water stress in eastern Massachusetts (including North Reading) include 1999-2000, 2002, 2012, 2016-17, and 2020. During these events rivers, streams, lakes, and ponds were most affected as many ran at record low levels during the spring run-off season, and there were periods of very high fire danger. While soil moisture was well below normal, little to no monetary losses to the agricultural sector were recorded for the region. The 2016-2017 drought was the most significant drought in Massachusetts since the 1960s. In many parts of the state, USGS data for streamflow and groundwater reached new record low levels for several consecutive months. In total, between 2001 and 2017, the Town of North Reading experienced between 15-21 weeks in Extreme Drought (D3) conditions.[52]

[52] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-43 – 4-45.

The magnitude and complexity of drought hazards have increased in association with growing population, the shift of population to drier regions of the country, urbanization, and changes in land and water use. Climate change impacts may also be impacting the frequency of drought conditions.

There have been no major disaster declarations related to drought for Middlesex County.

Extent

The extent and severity of impacts caused by drought will vary greatly among different land uses, and for residents is largely based on where they get their water supply. Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event and the demand people place on water supply. Human activities often exacerbate the impact of drought. For example, water use can deplete ground water supply.

In terms of classifying the severity of drought conditions, the U.S. Drought Monitor categorizes drought on a D0-D4 scale as shown in Table 17.

Table 17. U.S. Drought Monitor.

D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water- use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water

In addition to the U.S. Drought Monitor, the State of Massachusetts assesses and determines the severity of drought conditions based on a series of indices linked to observed impacts to various resources and forecasts. These drought conditions levels dictate the key actions or responses for various regions across the state. Massachusetts drought condition levels include those listed and briefly described below. These levels were selected to provide distinction between different levels of drought severity and for adequate warning of worsening drought conditions.[53]

- Level 0 – Normal (i.e., No Drought)
- Level 1 – Mild Drought (formerly Advisory)

[53] Massachusetts Drought Management Plan. September 2019. P. 14.

At Drought Level 1, the emphasis is on conservation through education, communication, and planning. The objective is to act under the precautionary assumption that conditions may deteriorate further.

- Level 2 – Significant Drought (formerly Watch)
  At Drought Level 2, conditions are becoming significantly dry. Emphasis continues to be on conservation, and more stringent watering restrictions may be imposed by water service providers.

- Level 3 – Critical Drought (formerly Warning)
  At Drought Level 3, many sectors, community functions, and environmental resources are facing critical strain. At this stage, there is an increased reliance on mandatory conservation measures to augment voluntary measures. Coordination efforts are expanded to include neighboring states, and preparations begin for emergency conditions.

- Level 4 – Emergency Drought (formerly Emergency)
  At Drought Level 4, the state may face failure of local or regional drinking water supplies, impairment, or loss of supply for firefighting, major agricultural and business losses, and impairment or loss of critical natural resources. In this situation, the objective becomes to implement emergency response actions to protect public health and safety and critical environmental resources, and to minimize losses and damages resulting from drought.

Probability of Future Events

Massachusetts has and will continue to experience extended periods of dry weather, from single-season events to multi-year events. Based on the data summarized above on previous occurrences, significant long-term drought events will continue to be considered a possible occurrence in the planning area (between 1-10 percent probability in the next year, or at least one occurrence in the next 10 years). This probability determination is also consistent with statewide data on drought occurrences.

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in all climatic zones across the northeast, but each drought will affect subregions differently. Historically, most droughts in Massachusetts have started with dry winters rather than dry summers. However, based on recent climate projections this trend may shift the probability of future events to summer and fall seasons, particularly for what are anticipated to be more frequent, short-term drought occurrences.

Vulnerability Assessment

Drought is an atmospheric hazard, so it has the potential to impact all existing and future assets, essential facilities, and populations. As previously noted, drought tends to have greater economic, environment, and social impacts than the built environment.

Drought remains a threat to North Reading in terms of both water quantity and water quality issues. Severe droughts could create challenges for the Town's local water supply by reducing surface water storage and the recharge of groundwater supplies. At Martins Pond, increased bacteria/algae and other water quality issues have already occurred during past dry weather or drought periods. These conditions are expected to worsen in the future based on climate change projections.

Droughts can also lead to cascading hazard impacts. For example, more frequent droughts could potentially exacerbate the impacts of localized flood events by damaging vegetation that could otherwise help mitigate flooding and the impacts of streambank erosion. Droughts may also weaken tree root systems, making them more susceptible to toppling during high wind events. Lastly, droughts may increase the likelihood, frequency, and intensity of brush fire events.

Anticipated Effects of Climate Change

It is anticipated that the effects of climate change will result in an increase in the frequency, duration, and intensity of short-term droughts. According to the 2011 Massachusetts Climate Change Adaptation Report, by the end of the century and under the high emissions scenario, the occurrence of droughts lasting one to three months could go up by as much as 75 percent over existing conditions. Also, per the downscaled climate projections for the Ipswich Basin as made available by the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) in 2018, both summer and fall seasons are expected to continue to experience the highest number of consecutive dry days. Annually the region is expected to experience an increase of up to 3 days in consecutive dry days by the end of the century.[54]

Rising Temperatures

Average/Extreme Temperatures

Hazard Description

There is no universal definition for extreme temperatures. The term is relative to the usual weather in the region based on climatic averages. Extreme heat for Massachusetts is usually defined as a period of three or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region.[55] Further descriptions of each temperature extreme is provided below.

Extreme Cold

What constitutes extreme cold, and its effects can vary across different areas of the country. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Whenever temperatures drop decidedly below normal and as wind speed increases, heat can leave your body more rapidly. These weather-related conditions may lead to serious health problems. Extreme cold

[54] Massachusetts Climate Change Projections. Northeast Climate Adaptation Science Center at UMass-Amherst. Published by Massachusetts Executive Office of Energy and Environmental Affairs. March 2018. P. 110.
[55] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-143-144.

is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter or who are stranded, or who live in a home that is poorly insulated or without heat. Extreme cold can last for several days or more in Massachusetts putting people at risk of exposure and stressing heating systems. Extreme cold increases the risk of secondary hazards such as carbon monoxide poisoning and building fires. In addition, water pipes that freeze or break may cause flooding.

Extreme Heat

Extreme heat is defined as excessively dry and hot conditions where temperatures hover 10 degrees or more above the region's average high temperature that last for several weeks. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. As a result, both drought and dust storms could occur.

Location

Extreme temperatures are atmospheric hazards and can impact the entire North Reading planning area.

Previous Occurrences

According to the State Hazard Mitigation and Climate Adaptation Plan, there have been 33 extreme cold weather events in Massachusetts since 1994. Extreme cold/wind chill events were reported in February 2016 in many climate zones across the state, including Middlesex County where many locations reported wind chills between 25 and 35 degrees below zero. There have been 43 warm weather events since 1995. In 2012, Massachusetts temperatures broke 27 heat records in June. According to NOAA's Storm Events Database, Middlesex County most recently experienced excessive heat events in July 2010 and July 2013 (including heat index values above 105 degrees). The 2013 heat wave lasted four days resulted in one casualty in Middlesex County (City of Medford) when a 45-year-old postal worked died because of heat illness. North Reading's MVP Core Team noted that the Town has experienced problems with extreme cold temperatures and has had issues with heat and drought in the past.

The coldest temperature on record in Massachusetts was on January 22, 1984, when the temperature reached -22 degrees Fahrenheit. The highest recorded temperature in North Reading was 102°F on August 3, 1975. However more extreme temperatures are possible, and it should be noted that as described below the effects of wind chill and heat index can greatly impact the severity of these hazards.

There have been no major disaster declarations related to extreme temperatures in Middlesex County.

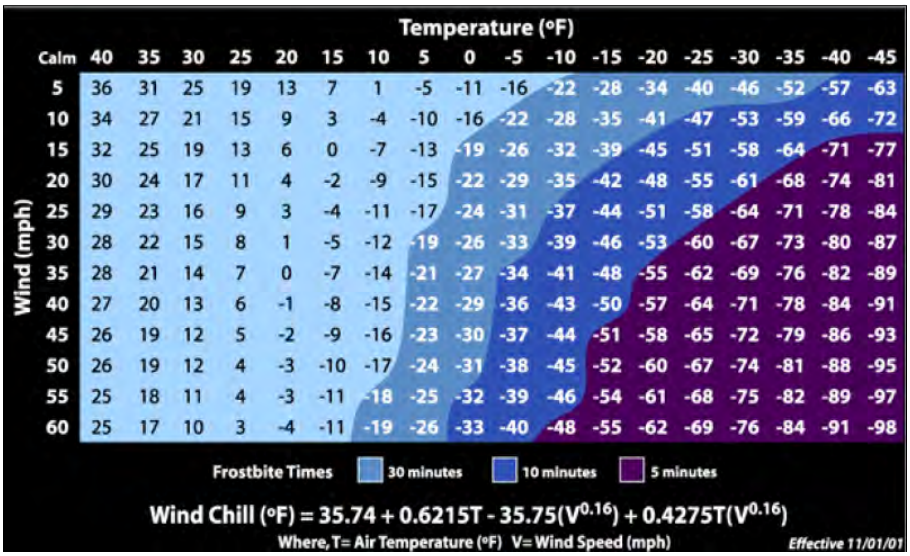
Extent

According to the State Hazard Mitigation and Climate Adaptation Plan, extreme temperatures are relative to the region being studied. For Massachusetts, extreme heat is considered three or more consecutive days of temperatures above 90 degrees. Extreme cold is less well defined and relative to

wind chill. On average, Massachusetts experiences the highest consecutive days of heat in July, and the lowest consecutive days of cold in January.

Wind chill temperature is the temperature people and animals feel when outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. Figure 24 shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops. In Massachusetts, a wind chill warning is issued by the National Weather Service (NWS) when the Wind Chill Temperature Index, based on sustained wind, is –25°F or lower for at least three hours.

Figure 24. Wind Chill Temperature Index.[56]



For extremely hot temperatures, the Heat Index Scale is used, which combines relative humidity with actual air temperature to determine risk to humans. The NWS issues a Heat Advisory when the Heat Index is forecast to reach 100-104 °F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105+ °F for two or more hours. Figure 25 indicates the relationship between heat index and relative humidity.

[56] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-146.

Figure 25. Heat Index.[57]

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Probability of Future Events

Extreme temperatures are considered a likely future occurrence for North Reading (between 10 and 90 percent annual probability). It is anticipated that the effects of climate change will result in an increase in the frequency, duration and intensity of extreme heat events, and a decrease in the frequency of extreme cold events. Heat waves are projected to become much more commonplace in a warmer future with potentially major implications for human health, particularly as it relates it more vulnerable populations such as children, seniors, lower income residents, and those already dealing with respiratory or other health problems.

Vulnerability Assessment

Extreme temperatures place vulnerable populations at increased risk, such as children, seniors, lower income residents, and those already dealing with respiratory or other health problems. North Reading's elderly residents along with those people residing in group homes were cited as a particular concern for the Town to consider by the MVP Core Team. Fortunately, North Reading's Department of Elder Affairs and Council on Aging are committed to continuously advocating, promoting, and providing services to elderly residents. These services contribute to the well-being of seniors in many ways including and beyond extreme temperature events and other local emergencies. The Town also operates multiple facilities that can open as emergency heating or cooling shelters when needed. More details on the vulnerabilities posed by each type of extreme temperature are provided below.

Extreme cold is unlikely to damage structures though may result in broken water pipes. It also poses a health threat in terms of hypothermia and frostbite. Vulnerable populations, including the elderly and babies, have an increased risk and lower tolerance for such events. During extreme cold events,

[57] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-147.

motorists should use caution when crossing bridges and traveling secondary roads, which may be icy. In addition, sidewalks and driveways may become slippery. Lastly, death and injury risk from improperly using heating devices is also a concern for fire and carbon monoxide poisoning. No losses were reported with this hazard and expected future losses are expected to be minimal. They would be negligible if annualized over time. Climate change may impact this hazard through increased occurrence and severity. However, some trends indicate a warming northeast (by a few degrees), which could reduce the severity of this hazard.

Extreme heat is unlikely to damage structures though occasionally buildings buckle due to prolonged high heat exposure. It also poses a health risk in terms of heat stroke and heat exhaustion. Those working or exercising outdoors should exercise caution. Vulnerable populations, including the elderly and babies, have an increased risk and lower tolerance for such events. North Reading's electrical grid was cited as a particular vulnerability during the MVP planning process in 2018, which noted that future electric demand during extreme heat situations may exceed the capacity of existing systems if they are not upgraded. No losses were reported with extreme heat and expected future losses are expected to be minimal. They would be negligible if annualized over time. Climate change may impact this hazard through increased occurrence and severity.

Anticipated Effects of Climate Change

Climate change is known to increase incidences of extreme temperatures. Table 18 is taken from the Massachusetts Climate Change Projections Report released by EOEEA in 2018. The table shows that for the Ipswich Basin (where North Reading is located) not only are the average temperatures increasing, but the total number of high heat days is increasing.[58] It was also concluded by the Town's MVP Core Team in 2018 that with climate change, extreme temperatures for North Reading in both directions will become more common.

Table 18. Average/Extreme Temperature Figures.

Merrimack Basin	Observed Baseline 1971-2000	Projected Change in 2030s	Projected Change in 2050s	Projected Change in 2070s	Projected Change in 2090s
Average Annual Temperature (°F)	49.5	+2.1 to +4.3	+2.7 to +6.2	+3.3 to +8.9	+3.6 to +10.8
Annual Days with Maximum	7	+6	+8	+10	+12

[58] Massachusetts Climate Change Projections. Northeast Climate Adaptation Science Center at UMass-Amherst. Published by Massachusetts Executive Office of Energy and Environmental Affairs. March 2018. P. 105-107.

Merrimack Basin	Observed Baseline 1971-2000	Projected Change in 2030s	Projected Change in 2050s	Projected Change in 2070s	Projected Change in 2090s
Temperature over 90°F (Days)		to +17	to +31	to +50	to +69
Annual Days with Minimum Temperature below 32°F (Days)	130	-12 to -28	-18 to -42	-21 to -55	-23 to -66

Infectious Disease

Hazard Description

Public health risks, such as those presented by infectious diseases and vector-borne illnesses, are present within every community. An infectious disease is one that is caused by micro-organisms, such as bacteria, viruses, and parasites. A vector-borne illness is an infectious disease that is transmitted to humans by blood-feeding arthropods, including ticks, mosquitoes, and fleas, or in some cases by mammals (e.g., rabies). Infectious diseases cause illness, suffering and even death, and place an enormous financial burden on society.

Most infectious diseases are caused by pathogens that can be spread, directly or indirectly, from person to person. Such diseases may be seasonal (seasonal influenza) or result, in the case of new diseases, result in a global pandemic. Infectious disease dynamics depend on a range of factors, including land use, human behavior, climate, efficacy of healthcare services, population dynamics of vectors, population dynamics of intermediate hosts and the evolution of the pathogens themselves. Many of these diseases require continuous monitoring, as they present seasonal threats to the general population.

In Massachusetts, state public health officials rely on local boards of health, healthcare providers, laboratories, and other public health personnel to report the occurrence of notifiable diseases as required by law. An epidemic emerges when an infectious disease occurs suddenly in numbers that are more than normal expectancy. Infectious disease outbreaks put a strain on the healthcare system and may cause continuity issues for local businesses. These outbreak incidents are a danger to emergency responders, healthcare providers, schools, and the public. This can include influenza (e.g., H1N1), pertussis, West Nile virus, and many other diseases. A pandemic is an epidemic that has spread over a large area, that is, it is prevalent throughout an entire country, continent, or the whole world. On March 11, 2020, the World Health Organization (WHO) officially declared the Coronavirus disease 2019 (COVID-

19) outbreak a pandemic due to the global spread and severity of the disease. COVID-19 is a respiratory illness that can spread rapidly from person to person and is further described below under *Previous Occurrences*.

While major disease outbreaks are uncommon, public health emergencies can become stand-alone disasters that compound the threat of other natural hazards and exceed local and state capacity. There is precedent for federal assistance due to public health emergencies including West Nile Virus (2000), a mosquito-borne disease, for which a federal emergency declaration was made in New York and New Jersey, and the COVID-19 pandemic, which resulted in a major disaster declaration in all states, territories, and the District of Columbia.

Location

Most of North Reading is uniformly exposed to various types of infectious diseases with the most significant impacts felt by people (depending on specific characteristics of the disease), and potentially followed by direct or indirect impacts to the economy. People who spend more time outdoors during mosquito and tick seasons are more susceptible to vector activity, which is more likely in or adjacent to heavily wooded and wetland areas.

Previous Occurrences

The most significant occurrence of infectious disease for North Reading (and currently most of the United States and the world) is that of COVID-19. COVID-19 is a highly contagious, viral upper-respiratory illness that was first detected in China in late 2019. The virus quickly spread throughout the world and has resulted in a global pandemic ongoing at the time of this plan. COVID-19 symptoms include cough, difficulty breathing, fever, muscle pain, and loss of taste or smell. Severe cases may result in death, especially in individuals over the age of 65 or with underlying medical conditions, such as diabetes, lung disease, asthma, obesity, or those who are immunocompromised. COVID-19 spreads from person to person through respiratory droplets in the air or on surfaces.[59]

As of October 1, 2021, there have been over 43 million cases of COVID-19 reported in the US, resulting in nearly 700,000 deaths.[60] In Massachusetts there have been over 750,000 confirmed cases reported with more than 18,000 deaths, and a total of 1,648 cases reported in North Reading.[61] Data on confirmed or probable deaths for North Reading residents is not available but the state has reported a total of 3,866 confirmed or probable deaths for Middlesex County.[62] As further described in the next

[59] Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/faq.html
[60] Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html
[61] Massachusetts Department of Public Health, COVID-19 Interactive Data Dashboard. Accessed on March 19, 2021: https://www.mass.gov/info-details/covid-19-response-reporting#covid-19-interactive-data-dashboard-
[62] Ibid.

section, the COVID-19 pandemic has the potential to continue to some degree over the next several years.

Pandemic influenza, considered to be a global outbreak, spread quickly around the world, and was observed in 1918, 1957, 1968, and in 2009 with the novel H1N1 strain. The 2009 H1N1 outbreak, though not considered a serious threat, still affected some residents in Massachusetts with nearly 2,000 confirmed cases and 33 deaths.[63] The great influenza epidemic of 1918 killed millions worldwide and would likely cause hundreds to thousands of deaths in Massachusetts should a similar outbreak occur today. It is anticipated that a more serious strain of the usual flu will occur some year and that vaccines might not be ready in time to combat rapid spread.

Vector-borne diseases continue to pose a significant threat to communities across Massachusetts. Black-legged (deer) ticks and dog ticks are found throughout Massachusetts and may spread different disease-causing germs when they bite people. The most common tick-borne diseases in Massachusetts are Lyme Disease, Babesiosis, and Anaplasmosis. Other diseases that are rare, but still occur, are Tularemia, Rocky Mountain spotted fever, Borrelia miyamotoi, and Powassan virus.[64] Mosquito-borne diseases are also a seasonal threat. West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE or "Triple E") are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. There are other diseases spread by mosquitoes that people may be exposed to when traveling in other regions of the world. These include Zika virus, Dengue fever, and Chikungunya.[65]

Massachusetts is typically not vulnerable to diseases such as HIV/AIDS, SARS, cholera, malaria, and resistant tuberculosis, though they are considered to be major disasters in some parts of the world. However, an incident that causes water supplies to become contaminated or result in people eating spoiled food could have significant health implications.

Extent

The severity and extent of infectious disease is dependent on many various types and therefore difficult to classify given the range of potential impacts. COVID-19 has had the most significant impact on the community in recent history in terms of societal impacts and disruptions, however the severity and extent of infectious diseases will continue to vary widely.

Probability of Future Events

Probability of infectious disease in the planning area is extremely variable. Many public health risks occur seasonally and are ongoing, such as the common cold and influenza. Major disease outbreaks,

[63] Mass Public Health Blog: http://blog.mass.gov/publichealth/
[64] Massachusetts Department of Public Health, Tick-borne diseases: www.mass.gov/tick-borne-diseases
[65] Massachusetts Department of Public Health, Mosquito-borne diseases: www.mass.gov/mosquito-borne-diseases

such as the current COVID-19 pandemic, are much less common but can last for long periods. Based on the information available regarding occurrences of greatest concern, the infectious disease hazard has been assigned a probability of likely (10-90 percent annual chance) for North Reading.

The COVID-19 pandemic has the potential to continue to some degree over the next several years, even as vaccines continue to be developed are distributed. To prevent the continued spread of COVID-19, many communities (including North Reading) have used stay-at-home orders, in which residents must remain home except to utilize essential services, such as grocery stores and health care services. Many schools have closed, and workers have switched to teleworking. Business closures have also caused major economic losses in states and communities. The Town of North Reading is continually updating community mitigation measures and guidance in close consultation with Massachusetts Department of Public Health and based on new information from the Centers for Disease Control (CDC).

It is anticipated that the effects of climate change will result in an increase in the probability and/or frequency of some infectious diseases. Those infectious diseases that are currently present in Massachusetts and which may be exacerbated by climate change are already exhibiting increased prevalence in New England. For example, with both temperature and precipitation expected to increase in Massachusetts, West Nile Virus mosquito vector activity will likely increase, as well as the vector's period of activity. Similarly, between 1964 and 2010, counts of Eastern Equine Encephalitis (EEE) have continued to rise in New England, though they remain constant in the southeastern states.

The United States is already seeing a significant increase in vector-borne infectious diseases. According to the CDC, the number of reported disease cases from mosquito, tick, and flea bites tripled from 2004 to 2016, and mosquito-borne disease epidemics are happening more frequently. Annual cases of Lyme disease have increased over the last decade, and with shrinking winters, the potential for infection through tick bite continues to grow.

Given increasing trends for global travel, several other diseases not typically observed in Massachusetts could continue to make their way back to the state through infected travelers. COVID-19 is the most recent and severe example of this threat. Another example is the Zika virus, transmitted from infected mosquitoes to humans, which received international attention during an outbreak in 2015 and persists today.

Vulnerability Assessment

All current and future populations in the planning area are considered at risk to infectious disease, though individual vulnerabilities will vary based on the type of disease as well as underlying health or exposure issues. For example, outdoor laborers and recreationalists are especially vulnerable to Lyme disease, as exposure to ticks is greater. Buildings and infrastructure assets are not typically impacted by disease outbreaks but may need to be sterilized or decontaminated in some cases. Economic impacts will also vary widely depending on the specific type of infectious disease. For example, as most recently demonstrated by COVID-19, health risks associated with epidemics or pandemics may result in

quarantining, stay-at-home orders, mandatory closures, or social distancing measures that cause business interruptions, lost tourism, job losses, and a variety of other social or economic impacts.

The degree to which communities are susceptible to or actively experience infectious diseases can also impact a community's vulnerability to natural hazards, as well as its ability to respond to disasters. For example, an infectious disease outbreak may complicate evacuations or/and mass sheltering required due to a natural hazard. Similarly, high incidents of chronic diseases may decrease mobility within a community, and natural hazards may reduce access to vital healthcare services needed by the ill or those with special medical needs.

As it relates to vector-borne diseases, North Reading is part of the East Middlesex Mosquito Control Project (EMMCP) which serves to reduce mosquito populations through surveillance, water management, biological and chemical controls. The EMMCP provides mosquito control services to 26 participating communities located west and northwest of Boston, with funding comprised entirely of voluntary appropriations that originate from the municipal budgets of participating communities. The EMMCP has an Integrated Pest Management plan that includes mosquito and wetland surveillance, larval and adult mosquito control, ditch maintenance, and public education. Each municipality, through its funding, determines the type and level of services to be offered in their community. During risk periods of West Nile virus and Eastern Equine Encephalitis, EMMCP may provide surveillance and mosquito control services under the direction of State and local health authorities, as specified by the Massachusetts Surveillance and Response Plan for Mosquito-Borne Disease.

Anticipated Effects of Climate Change

Climate change is expected to have complex effects on infectious diseases, causing some to increase, others to decrease, and many to shift their distributions. According to the World Health Organization (WHO), changes in infectious disease transmission patterns are a likely major consequence of climate change but we need to learn more about the underlying complex causal relationships and apply this information to the prediction of future impacts, using more complete, better validated, integrated, models.[66]

Among infectious diseases, water- and foodborne infectious diseases and vector-borne infectious diseases are among those likely to be most affected. As the Massachusetts climate begins to look more like the climate of the mid-Atlantic and southern states, it is seeing higher incidents of vector-borne diseases. 2018 marked the Commonwealth's highest ever incidence of West Nile Virus diagnosis, and 2019 marked the highest number of EEE cases in recent history (a time when many communities near North Reading were classified by the State as having a "moderate" risk for EEE). Also, a recent Centers for Disease Control (CDC) report showed that vector-borne diseases tripled between 2004 and 2016, with approximately 75% of cases being related to tick-borne disease. According to the Massachusetts Department of Public Health, projected impacts from climate change will mean that ticks will show

[66] World Health Organization, Climate Change and Infectious Diseases: https://www.who.int/globalchange/climate/en/chapter6.pdf

earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme and disease-causing bacteria. These changes present a major public and animal health challenge in terms of education, prevention, and treatment.

Invasive Species

Hazard Description

Invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC 2006).[67] The Massachusetts Department of Agricultural Resources (DAR) recognizes sixty-nine (69) invasive species that are of particular concern in the Commonwealth. Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Town of North Reading also recognizes invasive species as one of the greatest threats to the integrity of natural communities, representing a direct threat to the survival of many indigenous species. For most species, eradication is possible only in the earliest stages of invasion.

Location

Like many communities statewide, North Reading is home to a number of invasive plant species. These become a problem when they overgrow or outnumber native species, creating a monoculture and decreasing the diversity of species present. Invasive vegetation tends to spread quickly and thrive in disturbed conditions, outcompeting and displacing native species. Among the more prevalent invasive plant species in North Reading include the following: Barberry, Multiflora Rose, Burning Bush Euonymous, Norway Maple, Japanese Honeysuckle, Oriental Bittersweet, Buckthorn, Purple Loosestrife, Phragmites, Autumn Olive, and Russian Olive.

In terms of specific locations of concern, Martins Pond continues to be a problem area for aquatic invasives. Current invasive species being watched in the area include the Eurasian Milfoil (including weed treatment in 2021), Variable Milfoil, Fanwort, Water Chestnut, and Curly Leaf Pondweed.

More generally speaking, North Reading's wetlands are being degraded by invasive plant species, which inhibit or smother native plants that are important to the health of the wetlands system. Such invasive species include Purple Loosestrife, Phragmites, and Milfoil. The woodlands and curbsides in Town have also begun to suffer from invasive non-native plants, those which obliterate entirely the native vegetation and interrupt natural succession when they escape into natural areas and reproduce.

Previous Occurrences

Invasive species do not represent a singular event but rather an ongoing or emerging problem, so it is difficult to measure the frequency of occurrences. The Town of North Reading has supported invasive weed treatment programs in the past, including most recently in 2021 through the provision of $25,000

[67] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-188.

to control a severe infestation of Eurasian Milfoil at Martins Pond, but the growth and spread of invasive species remain a recurring issue.

Extent

Invasive species are a widespread problem throughout the state and may be monitored by observation. The State conducts surveillance to monitor the incidence of invasive species and has a variety of laws and regulations in place that attempt to mitigate their impacts. These impacts can range widely from general nuisance to causing severe harm and long-term ecological, economic, and social consequences if not properly managed or mitigated.

Probability of Future Events

Invasive species were not considered in the previous hazard mitigation plan or the Town's MVP planning process; however, they are expected to be an increasing problem in North Reading and throughout the State due to a changing climate and projected increases in non-native plant and animal infestations. For this reason and based on the fact invasive species are already an ongoing issue for the Town, this hazard has been assigned a probability of highly likely (90-100 percent annual probability).

Vulnerability Assessment

Non-native invasive plants, those that grow rapidly and are difficult to remove or control once established, are often threats to forests and wetland areas, particularly in urban and suburban areas. Warmer temperatures due to climate change can also contribute to the proliferation of invasive species. When invasive species take over large areas of habitat, ecological processes are changed. Often invasives force out the native species that provide food and habitat for local species.

Anticipated Effects of Climate Change

Climate change is affecting flora and fauna as well as pests and disease vectors both through changing precipitation conditions and changing temperature conditions. Warmer, wetter conditions lead to increased mosquito populations, while the absence of sufficient periods of cold means that pest populations that would historically have been killed off or reduced are able to survive the winter and emerge in greater numbers the following season.

Wildfires

Hazard Description

A wildfire is an uncontrolled fire spreading through vegetative fuels, potentially consuming structures. They often begin unnoticed, spread quickly, and are finally detected by the dense smoke that fills the area from miles away. Wildfires can be caused through human acts like arson or careless accidents, or through natural occurrences of lightning. Wildfire danger can vary greatly season to season and is exacerbated by dry weather conditions. In North Reading, major wildfires are very unlikely, so the Town

addresses wildfires mostly in terms of brush fires (a type of wildfire). The U.S. Fire Service defines brush fire as "a fire burning in vegetation that is predominantly shrubs, brush, and scrub growth."[68]

Three principal factors influence the behavior of wildfires, including brush fires: topography, fuel type, and weather. Steep slopes, fuel types like dry grasses and soft woods, and dry or windy weather conditions all spur the spread of wildfires.

Fires that burn forest plants can be classified in three ways: 1) ground fires, 2) surface fires, and 3) crown fires. Ground fires burn the humus layer of the forest floor. Surface fires burn forest undergrowth and surface litter. Finally, crown fires advance through the tops of trees. Atmospheric factors such as temperature, humidity, and rainfall are important factors in determining the combustibility of a given forest. As noted above, the principal type of fire that may impact North Reading is brush fires, which includes ground and surface fires. Wildfires, including brushfires are often a result of human activity. Humans, either through negligence, accident, or intentional arson, have caused approximately 90% of all wildfires in the last decade. Accidental and negligent acts include unattended campfires, sparks, burning debris, and irresponsibly discarded cigarettes. The remaining 10% of fires are mostly caused by lightning but may also be caused by other acts-of- nature such as volcanic eruptions or earthquakes.

Wildfires, including brush fires, are also a natural process. Its suppression is now recognized to have created a larger fire hazard, as live and dead vegetation (fuel) accumulates in areas where fire has been excluded. In addition, the absence of fire has altered or disrupted the cycle of natural plant succession and wildlife habitat in many areas. Consequently, federal, state, and local agencies are committed to finding ways, such as prescribed burning to reintroduce fire into natural ecosystems, while recognizing that firefighting and suppression are still important. In addition, wildfires leave problems behind them, such as debris flows and damage to water supply systems.

During an intense wildfire, all vegetation may be destroyed; also, the organic material in the soil may be burned away or may decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall may result in unusual erosion or flooding from a burned area. Water supplies are also affected by wildfires: the loss of ground surface cover, such as needles and small branches, and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms. For example, the U.S. Forest Service (USFS) uses greenness maps to generate national maps of selected fire weather and fire danger components of their Wildland Fire Assessment System.[69] Although North Reading is likely to be subjected to smaller brush fires as opposed to large wildfire, these impacts are possible in the planning area.

[68] Fire Terminology. U.S Forest Service. Retrieved January 20, 2013 from http://www.fs.fed.us/nwacfire/home/terminol- ogy.html#B

[69] Wildland Fire Assessment System. (2014). US Forest Service. Retrieved December 11, 2014 from http://www.fs.fed.us/ land/wfas/welcome.html

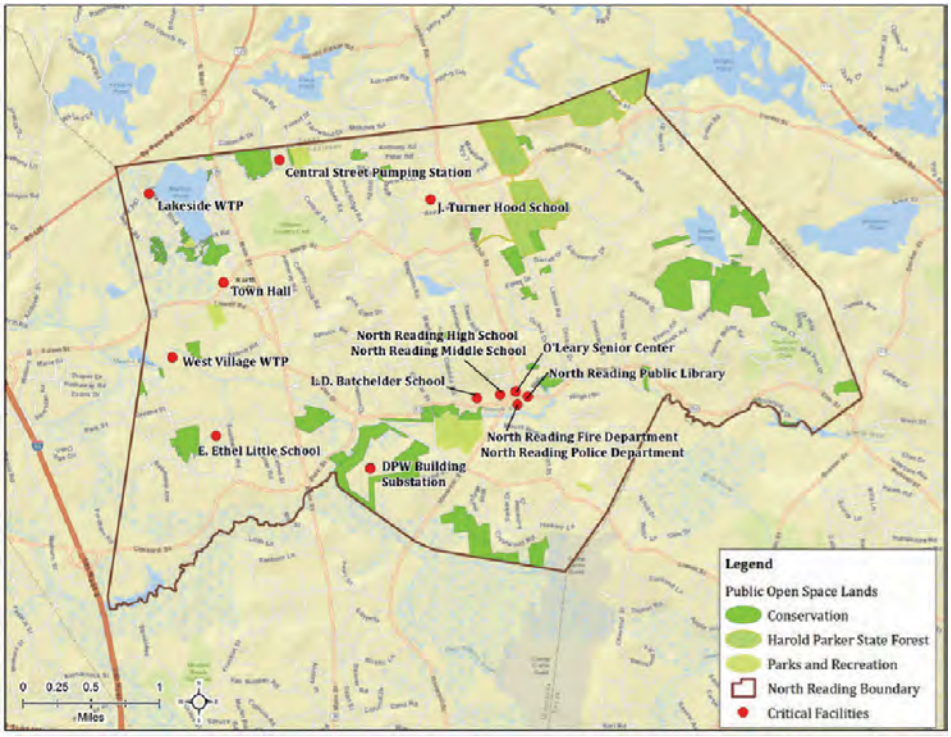
The wildfire season in Massachusetts usually begins in late March and culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. Drought, snowpack level, and local weather conditions impact the length of the fire season.[70]

Location

Wildfires are a natural part of the Massachusetts ecosystem. Increasingly, however, development is encroaching into isolated areas and wildfires present a danger to human life and manmade facilities. This trend is further validated by current wildfire hazard mapping data which show a large and increasing amount of wildfire hazard areas across the state.

Massachusetts has approximately 350,000 acres of forested public lands. An additional 2.65 million acres of forested acres resides in private ownership. North Reading, however, is much more developed than the state, which reduces the wildfire and brush fire risk. There are approximately 860 acres of publicly owned open space within the Town as shown in Figure 26. In addition, there are two golf courses including Hillview in northwest North Reading and Thompson in southeast North Reading. Brush fires are more common in these parts of the planning area but still quite limited. The area of Town-owned Eisenhaures Pond Park was another area of concern identified during the plan update process.

Figure 26. Public Open Space Lands.



[70] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-171.

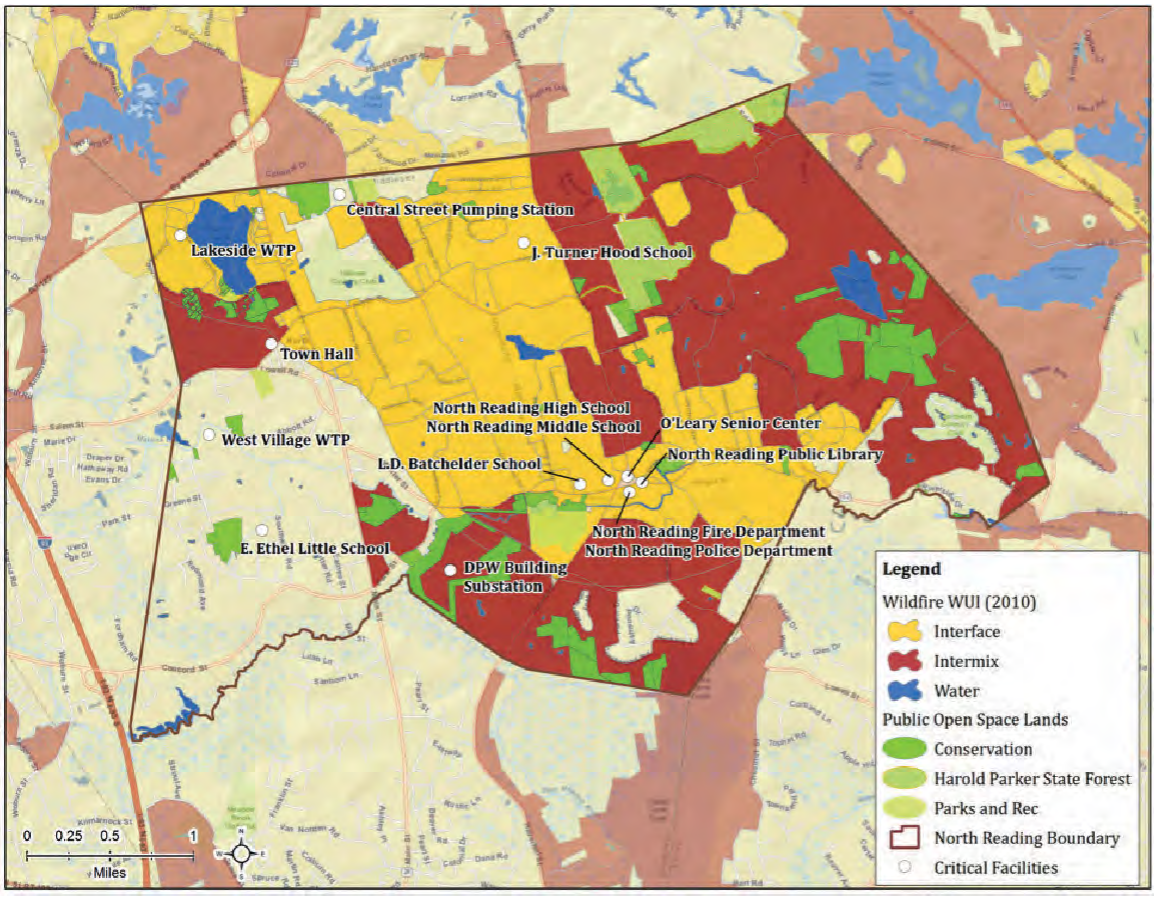
In addition, brush fire location in North Reading may be determined by investigating areas where development is near undeveloped areas. The area where urban development meets vegetated, wildfire prone lands is known as the Wildland Urban Interface (WUI). There are several areas in the planning area where this exists. The Silvis Lab (University of Wisconsin) produces wildland urban interface data. This data was used to map WUI areas in the Town of North Reading.

Silvis defines interface areas and intermix areas as follows:

- Interface areas: Housing density between 6.2 and 742 structures/census block combined with Wildland vegetation less than or equal to 50% AND within 2.4 kilometers of areas with at least 75% Wildland vegetation.
- Intermix areas: Housing density between 6.2 and 741 structures/census block and Wildland vegetation is greater than 50%.

Figure 27 shows the location of these mapped wildfire hazard areas for the Town of North Reading.

Figure 27. Wildfire Hazard Areas.



Previous Occurrences

Several notable wildfires have occurred in Massachusetts history, although none has ever resulted in a

FEMA disaster declaration. According to the previous plan and NOAA's Storm Events Database, there is no recorded history of damaging wildfire events in Middlesex County. However, according to the State Hazard Mitigation and Climate Adaptation Plan, wildfire risk for Middlesex County is considered high in many areas. Nearly 30% of the population in the county is considered to be in wildfire hazard areas.[71]

Although North Reading has not experienced major wildfire events (or significant brush fires) in recent years, the Fire Department responds to approximately 15 brush fires annually (based on incident reports from 2010-2021). The average area burned is under one acre and these incidents very rarely result in any significant property losses. Typical causes include natural occurrences (lightning), careless disposal of smoking materials, permit burns that go out of control, unauthorized burning (campfires out of control), or recreational vehicles.

Several sources were investigated to determine brush fires that have impacted North Reading. Limited information was available and only two events were found in North Reading, as described below:

- April 21, 2021: A brush fire burned just over one acre in the area near Locust Street. Mutual aid was called in from surrounding towns (Wilmington and Middleton FD) due to the location.
- May 13, 2014: 1-2 acres caught on fire and spread near Kings Row. Fire units from neighboring Towns of Middleton and Wilmington were included. Firefighters were able to quickly contain the fire. (Note this event occurred following drought conditions, which ended in early 2014.)[72]

There have been no major disaster declarations related to wildfire in Middlesex County.

Extent

Wildfires can cause widespread damage to the areas they affect, so their severity is often determined by fire size. They can spread very rapidly, depending on local wind speeds and be very difficult to get under control. Fires can last for several hours up to several days. While there is limited information, using data from the State Hazard Mitigation and Climate Adaptation Plan, it can be inferred that wildfires in North Reading are categorized as small (up to a few acres in size).

Probability of Future Events

Wildfire season (including brush fires) in Massachusetts usually begins in late March and runs through June. April is historically the month in which wildfire danger is the highest. However, wildfires and brush fires can occur every month of the year. Drought, snowpack, and local weather conditions can expand the length of the fire season.

[71] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-181.
[72] Masterson, Les. (2014). Firefighters From Multiple Towns Extinguish Brush Fire. North Reading Patch. Retrieved December 11, 2014 from http://patch.com/massachusetts/northreading/firefighters-from-multiple-towns-extinguish- brush-fire

Wildfires (brush fires) will continue to be a highly likely occurrence in North Reading, though the magnitude and impact of most events will be contained due to early detection and fire suppression. The probability of future wildfire events is predicted to increase as the average numbers of dry days and those with extreme heat are projected to increase. The magnitude of future events will largely depend on weather, fuel conditions, and existing fire detection, control, and suppression capabilities.

Vulnerability Assessment

North Reading has several areas that have been delineated as having the highest risk of wildfires (shown as low density intermix in Figure 27), though the wildfire hazard presents a fairly uniform risk throughout the community due to many developed areas abutting woodlands and other vegetated areas with a healthy tree canopy. Fortunately, the magnitude and impact of most wildfire events will be contained due to early detection and fire suppression. However, the potential for larger, destructive fires does exist for North Reading due to several factors including the availability of fuel, large concentrations of wood frame structures, and development within or alongside some heavily wooded areas of Town.

Small wildfires (a few acres in size) are expected in the planning area. Typically, fire incidents are very random and can't be modeled accurately. All current and future buildings and populations are considered at risk to wildfire. However, WUI data permits further GIS intersection analysis to indicate the risk in this area. The results indicate risk in Table 19.

Table 19. Buildings and Populations Potentially at Risk to Wildfire.

Exposure Type	Interface Areas	Intermix Areas
Number of Parcels	3,034	1,799
Building Value on Parcels	$711,477,000	$488,084,100
Population at Risk	11,101	1,262

Critical facilities at risk have a combined value of nearly $163 million (97% of total exposure). Based on the wildfire hazard areas (WUI) the following critical facilities are potentially at risk to wildfire:

Located in an interface area:

- Lakeside WTP
- J. Turner Hood School
- L.D. Batchelder School
- North Reading High School
- North Reading Middle School
- North Reading Public Library
- O'Leary Senior Center
- North Reading Fire Department
- North Reading Police Department

Located in an intermix area:

- DPW Building
- Substation
- Town Hall

Anticipated Effects of Climate Change

It is anticipated that the effects of climate change, including more frequent and prolonged drought conditions, will increase the frequency and intensity of wildfire events. Another related factor that is expected to increase the probability of future wildfire events is the introduction of disease, pests, and invasive plants that result in the dieback of mature tree species thus creating increased vegetative fuel loads in forested areas. In addition, lightning strikes may increase with climate change and can be responsible for igniting more wildfires.

Extreme Weather

Hurricanes/Tropical Storms

Hazard Description

Hurricanes and tropical storms are classified as cyclones and defined as any closed circulation developing around a low-pressure center. In the Northern Hemisphere, winds rotate counterclockwise (or clockwise in the Southern Hemisphere) and measure on average 10 to 30 miles in diameter. A tropical cyclone refers to any such circulation that develops over tropical waters. Tropical cyclones act as a "safety-valve," limiting the continued build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornadoes.

The key energy source for a tropical cyclone is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, warm sea surface temperature, rotational force from the spinning of the earth, and the absence of wind shear in the lowest 50,000 feet of the atmosphere. Most hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which encompasses the months of June through November. The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in the Atlantic basin is about six (6).

As an incipient hurricane develops, barometric pressure (measured in milliards or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Hurricane Wind Scale (Table 20), which rates hurricane wind intensity on a scale of 1 to 5, with 5 being the most intense.

Table 20. Saffir-Simpson Scale.

Category	Maximum Sustained Wind Speed (MPH)
1	74–95
2	96–110
3	111–129
4	130–156
5	157+

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, which is used to estimate potential damage. Hurricanes of categories 3, 4, and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States.

Table 21 describes the damage that could be expected for each category of hurricane. Damage during hurricanes may also result from spawned tornadoes, storm surge and inland flooding associated with heavy rainfall that usually accompanies these storms.

Table 21. Hurricane Damage Classification.[73]

Storm Category (Saffir-Simpson Scale)	Damage Level	Description of Damages
1	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage. An example of a Category 1 hurricane is
	Very dangerous winds will produce some damage	
2	MODERATE	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings. An example of a Category 2 hurricane is Hurricane Francis in
	Extremely dangerous winds will cause extensive damage	
3	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of

[73] National Hurricane Center. Retrieved February 4, 2015. Available at: http://www.nhc.noaa.gov/aboutsshws.php

Storm Category (Saffir-Simpson Scale)	Damage Level	Description of Damages
	Devastating damage will occur	curtain wall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain may be
4	EXTREME	More extensive curtain wall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland. An example of a Category 4 hurricane is
	Catastrophic damage will occur	
5	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required. An example of a Category 5 hurricane is
	Catastrophic damage will occur	

Location

Hurricane and tropical storms will impact the entire planning area.

Previous Occurrences

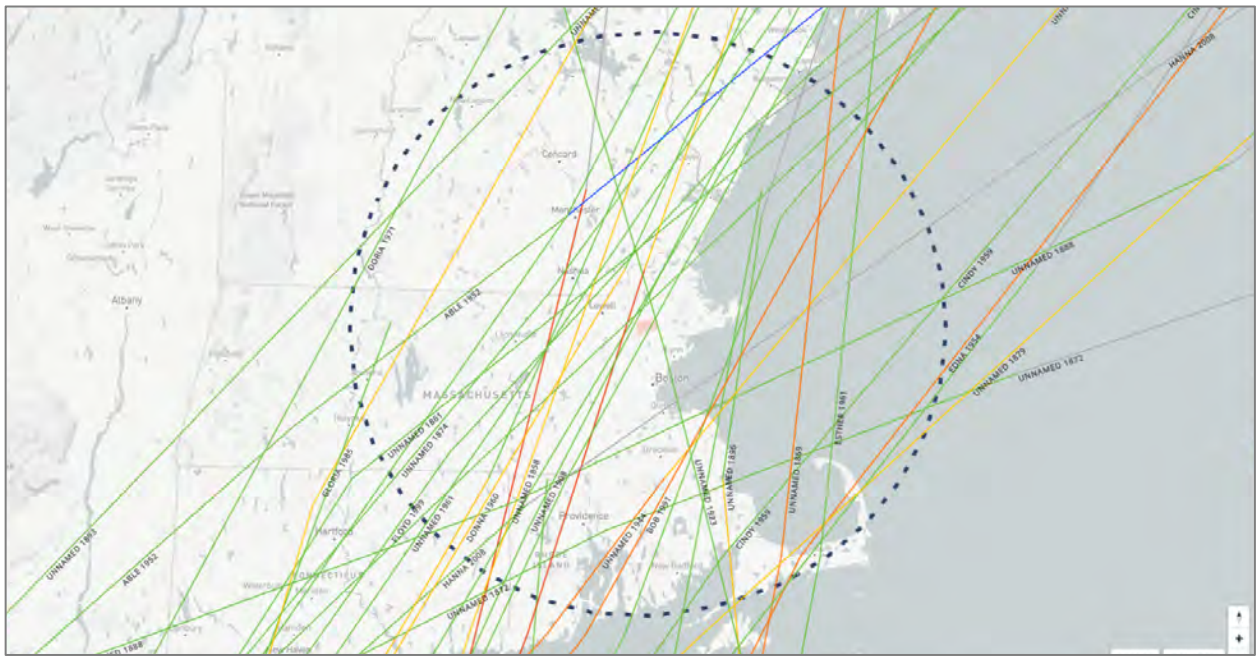
Since 1900, thirty-nine tropical systems have impacted New England. Twenty-five were hurricanes and 14 were tropical storms. Any tropical storm or hurricane can bring a combination of high winds, large storm surges and severe inland flooding along rivers and streams. Of the 24 hurricanes, nine made landfall along the southern New England coast. Of those nine hurricanes, seven of them were either of category 2 or 3 intensity based on the Saffir-Simpson hurricane scale. Though the primary threat to New England is during August and September, the region has been affected as early as June and as late as mid-October.[74]

NOAA has kept records of hurricanes since 1851. From 1851 through 2021, 35 hurricane and tropical storm tracks have come within 75 miles of North Reading. These storm events have included two (2) category 3 hurricanes; four (4) category 2 hurricanes; seven (7) category 1 hurricanes; and 22 tropical

[74] http://nesec.org/hurricanes/

storms. Figure 28 displays these historic tracks across the region.[75] NOAA's database indicates that two tropical storms have traversed directly through North Reading in 1861 and in 1923. The tropical storm that occurred in 1861 marked wind speeds of 67 miles per hour when it impacted the planning. The storm that occurred in 1923 marked wind speeds of 52 miles per hour. The most damaging storms for Massachusetts made landfall and tracked to the west of North Reading, including the Great Hurricane of 1938 and Hurricane Carol in 1954. The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region.

Figure 28. Historical Hurricane Tracks within 75 Miles of North Reading.



Both Hurricane Gloria and Hurricane Bob resulted in major disaster declarations for Middlesex County. Information on these and other major hurricanes is presented below.

The Hurricane that occurred on September 21st of 1938 was a Category 3 storm and is considered one of the strongest hurricanes to impact New England and made landfall in Suffolk County, Long Island and onto Milford, Connecticut. From here, the track goes nearly straight up into Canada, tracking through western Massachusetts. Forecasting was still limited and often miscalculated. In fact, this storm was not anticipated to strike New England that led to very little warning time for the population.[76] The storm moved across land very quickly with a forward speed of 70 miles per hour. In Massachusetts, sections of New Bedford were less than 8 feet of water, and there was substantial river flooding across the state

[75] https://coast.noaa.gov/hurricanes/

[76] Freeman, Stan. (2012). New England hurricane history shows path of deadly strikes from Hurricane of 1938 through Hurricane Bob in 1991. Masslive. Retrieved December 11, 2014 from http://www.masslive.com/news/index.ssf/2012/10/new_england_hurricane_history.html

due to rain.[77] A 186-mile per hour wind gust was reported at the Blue Hill Observatory (Milton, MA), and till this day, still one of the strongest gusts on record in the U.S. Further impacts from the storm included fires from downed power lines, especially in Connecticut. In all, the storm left over 550 people dead, 1,700 injuries, 9,000 homes and buildings destroyed 15,000 buildings damages, and 250 million downed trees. In 2012 dollars, nearly $5 billion in damages lay in its wake.

Hurricane Gloria formed on September 18, 1985.[78] The hurricane topped out at 145 miles per hour (Category 4) near the Bahamas. Gloria made landfall three times including the Outer Banks, North Carolina (on September 26th, 1985), Long Island, New York, and Connecticut. The storm caused impacts from South Carolina to Maine including 14 fatalities (6 related to fallen trees) and extensive power outages. In Massachusetts, category 1-hurricane winds were felt, power outages affected over 500,000 people statewide, and tree damages were extensive. A small F1 tornado was reported in Middlesex County. Damage across the state was estimated a total of $61 million. The stronger quadrants of the storm were to the east, which impacted North Reading.

Hurricane Bob was the first hurricane of the 1991's Atlantic Hurricane season. Bob peaked as a Category 3 hurricane but weakened to a Category 2 before making landfall in Rhode Island on August 20th. Damage throughout New England totaled over $1.5 billion. The storm resulted in six separate tornadoes. The storm left substantial damage in Massachusetts, including extensive damage to agricultural crops. Sustained winds peaked at 100 miles per hour (Category 2 force).

Extent

The Saffir-Simpson Scale can be used to define extent as shown in Table 20. The strongest event to directly traverse the Town was a 67-mile per hour tropical storm. However, a major category 3 hurricane passed just a few miles outside of the planning area. Stronger events are possible but unlikely. To date, the Commonwealth (including North Reading) has not experienced a Category 4 or 5 hurricane. The colder water and air temperatures of New England typically cause storms to dissipate before they make landfall. In fact, it is rare for hurricanes to reach Category 3 strength in New England. However, with changing weather patterns due to climate change may make such event more frequent in the future.

Probability of Future Events

Based on past hurricane and tropical storm landfalls, the frequency of hurricanes to hit the Massachusetts coastline is an average of once every six years. Conducting a GIS buffer analysis indicates that approximately 35 tropical storms or hurricanes have passed within 75 miles of the planning area between 1851 and 2021. This is an approximate probably of 21 percent for experiencing impacts or approximately 1 percent for experiencing a direct impact. Therefore, a probability of likely was assigned.

[77] The Great Hurricane of 1938. (2014). National Weather Service. Retrieved December 11, 2014 from http://www.weather.gov/box/1938hurricane

[78] Collins, Chris. (2014). Hurricane Gloria September 27, 1985. National Weather Service. Retrieved December 11, 2014 from http://www.weather.gov/mhx/Sep271985EventReview

For North Reading, these events are generally limited to the months of August, September, and October, with some storms arriving in May, June, July, or November.

Vulnerability Assessment

Hurricane and tropical storms had varying impacts on the planning area based on track location and storm characteristics. Since storms are atmospheric in nature, all existing and future buildings and populations are at risk to the hurricane and tropical storm hazard (including critical facilities). Hurricanes and wind events have a large spatial extent and would affect many buildings in the community. There is typically adequate warning with this hazard that allows for evacuation helping to reduce the impact on the population. The event itself would likely last less than 24 hours. Widespread power outages during and following a major storm event is a key concern across multiple sectors in town. Additionally, high winds could down trees, which could damage or indirectly affect many structures across town due to the area's dense tree canopy. Additional impacts include water damage in buildings from building envelope failure, business interruption, and loss of communications. Utility disruption is a serious threat for areas with above ground electrical wiring. Flooding is also a major concern. Slow moving hurricanes (or ones that stall over an area) can dump tremendous amounts of rain on an area.

Hazus-MH 2.1 Potential Losses

Potential losses due to hurricane are investigated further below using Hazus-MH.

The Hurricane of 1938, described in detail above, likely impacted the planning area as a Tropical Storm or weak Category 1 hurricane in September 1938. According to the Hazus-MH results, if this hurricane were to impact the planning area today, it would result in approximately $7.7 million in total damages (Table 22). (Note that total loss includes building damage, content damage, relocation losses, and income losses, wage losses, and rental losses.) $5 million of the total losses reported are attributed to building losses. While this is a significant loss figure, it is estimated to be small in terms of total exposure based on Hazus- MH inventory results (approximately 0.5 percent of total exposure).

Table 22. Hazus-MH Hurricane Losses.

Building Type	Building Losses	Content Losses	Other	Total
Residential	$5,024,000	$2,264,000	$176,000	$7,464,000
Commercial	$196,000	$16,400	$5,600	$218,000
Industrial	$21,000	$1,200	$800	$23,000
Government	$2,000	$0	$0	$2,000
Education	$5,000	$0	$0	$5,000
Religious	$8,000	$0	$0	$8,000
Agricultural	$2,400	400	$200	$3,000
TOTAL	$5,258,400	$2,282,000	$182,600	$7,723,000

The probabilistic scenario runs a variety of scenarios, both catastrophic and minor, to determine potential losses on an annual basis. It is intended to be a value to help the communities plan. The potential annualized hurricane losses for North Reading at $756,000 (in total losses). Ninety-three percent of these losses (approximately $700,000) are attributable to building and content loss estimates.

Anticipated Effects of Climate Change

According to the State Hazard Mitigation and Climate Adaptation Plan, climate change is increasing extreme weather and rising temperatures, which produce warmer oceans and more energy for coastal storms. In addition, warmer air may hold more moisture, increasing the rate of rainfall. However, climate change impacts on hurricanes and tropical storms are difficult to predict but likely will after storm behavior in the Northeast. A National Geographic article cited a National Aeronautics and Space Administration (NASA) study that indicates Atlantic winds may "blow more directly from west to east during hurricane season, pushing storms away from the United States."[79] However, this same article notes conflicting data, and that rising sea temperature could lengthen the hurricane season and fuel stronger hurricane events. The National Climate Assessment report (2014) notes that hurricane "intensity, frequency, and duration have all increased since the early 1980s. This source predicts continuing intensity and associated rainfall with raising temperatures.[80] This would result in greater losses due to increased flooding, associated building damages and business interruption impacts.

Severe Winter Storm/Nor'easter

Hazard Description

Severe winter storms are the most common and most familiar Massachusetts hazards which affect large geographical areas. Most winter storms in the Commonwealth cause more massive inconvenience than they do serious property damage, injuries, or deaths. However, periodically, a storm will occur which is a true disaster, necessitating intense, large-scale emergency response.

Severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, ice, freezing rain, sleet, and extreme wind and cold. As defined by the National Weather Service, a severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four-hour period. The leading cause of death during severe winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. North Reading, like the rest of the region, is at high risk for winter storms.

[79] Drye, Willie. (2013). Scientists: Climate Change May Offer Hurricane Help. National Geographic News. Retrieved December 11, 2014 from http://news.nationalgeographic.com/news/2013/09/130902-hurricanes-climate-change-superstorm-sandy-global-warming-storms-science-weather/

[80] Walsh, John and Donald Wuebbles. (2014). Changes in Hurricanes. National Climate Assessment – U.S. Global Change Research Program. Retrieved December 11, 2014 from http://nca2014.globalchange.gov/report/our-changing- climate/changes-hurricanes

Nor'easters are low pressure, severe storm systems that affect the Mid-Atlantic and New England states primarily during winter months. They can form over land or water and are notorious for producing heavy snow, rain, and tremendous waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. Wind gusts associated with these storms can exceed hurricane force in intensity, and when combined with snow result in blizzard conditions that form deep drifts capable of paralyzing a region. A nor'easter gets its name from the continuously strong northeasterly winds blowing in from the ocean ahead of the storm. A blizzard is the most severe form of winter storm. It combines low temperatures, heavy snow, and winds of 35 miles per hour or more. Heavy snow and winds at that speed reduces visibility to a quarter mile or less for at least three hours.

During the Town's MVP planning process, winter storms were determined to be the second most troublesome natural hazard (after flooding). This decision was based on problems that occurred in recent years with heavy wet snow taking down trees and utility wires, and it was determined that warmer temperatures and increased precipitation would likely lead to even more similar type events.

Location

The entire Town of North Reading is equally at risk to severe winter storms. However, winter storms impact vulnerable populations more significantly, including seniors, lower-income residents, and the homeless.

Extent

NOAA's National Centers for Environmental Information (NCEI) recently developed the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the U.S. The RSI ranks snowstorm impacts on a scale from 1 to 5, as shown in Table 23. RSI values are based on the spatial extent of the storm, the amount of snowfall, and the association of these elements with population and societal impacts. For mitigation planning purposes the maximum probable extent of a severe winter storm in North Reading is a Category 5 on the RSI. The climate report from Best Places shows that North Reading has an average of 48 inches of snowfall each year, nearly double the national average of 28 inches.[81]

Table 23. Regional Snowfall Index (RSI).

Category	RSI Value	Description
1	1–3	Notable
2	3–6	Significant
3	6–10	Major
4	10–18	Crippling
5	18.0+	Extreme

[81] https://www.bestplaces.net/climate/city/massachusetts/north_reading

There is no widely used scale to classify nor'easters. However, the classification scheme developed by Gregory A. Zielinski and presented in Table 24 is a useful index to categorize nor'easters (and other severe winter storms) by intensity.[82] It consists of a five-level hierarchy similar to the Saffir-Simpson Hurricane Wind Scale, with a category 1 storm being the least severe in terms of its intensity and a category 5 storm being the most severe. For mitigation planning purposes, the maximum probable extent of a nor'easter for North Reading is an Intensity Index Category 4.

Table 24. Classification Scheme for Nor'easters.

Intensity Index Category	Maximum Snowfall Amounts	Maximum Snowfall Rate	Potential Wind Speeds	Maximum Drifting Potential	Closings/Delays on Communities, Schools, and Travel	Impact on Coastal and Maritime Interests	Nature of Disruption
1	< 10 in.	Very low < 1 in./hr	Weak	Minor < 20 in.	Maybe minor (hours)	Minor	Minimal-nuisance
2	10-20+ in.	Moderate 1+ in./hr	Strong	Moderate 3 ft.	Maybe moderate (hours to a day common)	Minor to moderate	Nuisance-inconvenience
3	20-30+ in.	High 2+ in./hr	Gale force	High 4-6+ ft.	Possibly extensive/ lengthy (several days possible)	Moderate to severe	Inconvenience-crippling
4	30-40+ in.	Very High 2-3 in./hr	Gale force hurricane	Very High 6-10+ ft.	Probably extensive/ lengthy (up to a week may be common)	Severe	Crippling-paralyzing
5	40-50+ in.	Overwhelming > 3+ in.hr	Gale force hurricane	Exceptional 10-15 ft.	Extensive/ lengthy (up to a week common)	Extreme	Paralyzing

Previous Occurrences

Severe winter storms are a very frequent occurrence in North Reading and the surrounding region. According to NOAA's Storm Events Database, Middlesex County experienced a total of 312 winter storm events since 1996 which have caused an estimated $12.5 million in property damages, 2 fatalities, and 5 injuries. These events include those recorded as blizzard, ice storm, heavy snow, winter storm, and

[82] Gregory A. Zielinski, Institute for Quaternary and Climate Studies, University of Maine.

winter weather. Many additional municipal expenses are spent on snow removal and treatment of local roadways, sidewalks, and other rights of way. Of the 34 federally declared disasters or emergencies that have affected Middlesex County since 1953, 15 have been associated with severe winter storms.[83]

Countless additional snowfall events have impacted the planning area and such events occur several times annually. These events typically result in a few inches of snow, which can be quickly cleared. Given their frequency, the planning area is well equipped to handle most snow events. More severe snow events, such as blizzards, nor'easters, and ice storms can cause serious disruptions and are reported in the aforementioned winter weather hazard sections.

The most severe winter storm to ever strike New England was the Blizzard of 1888. The storm that occurred from March 11-14, 1888, deposited up to 50 inches of snow. The Blizzard of 1978, a classic nor'easter, dumped 24-36 inches of snow on the eastern part of the state and paralyzed the area for several days. The region experienced another major nor'easter in March 2001, when more than two feet of snow fell over a three-day period. Wind gusts to 64 miles per hour were reported in some areas, and the combination of heavy wet snow and high winds resulted in broken tree limbs that blocked roadways and downed power lines.

The winter of 2010-2011 produced some of the largest snowfall totals in the region and state's history, and included two blizzards, both occurring in January 2011. According to the National Weather Service, Boston received 80.1 inches of snow that winter, while the Northern Middlesex region received 79.6 inches. Less than a year later, an early season snowstorm in October 2011 (known as the Halloween Nor'easter) left 640,000 Massachusetts homes and residents without power. The storm produced a snow fall more than 30 inches in some parts of the state, and, due to the amount of foliage still on the trees, resulted in widespread power outages for up to seven days.

Since 1983, the most significant winter snowfall accumulations for the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in North Reading were similar, however the Town does not maintain its own records. The most recent ice storm in the region occurred in December 2008. The storm resulted in one fatality and left over one million people without power, some for as long as two weeks. Damage from the storm was measured in millions of dollars in property damage, lost business, and cleanup costs.

Probability of Future Events

Severe winter storms will continue to be a highly likely occurrence in North Reading (90-100 percent annual probability). Using history as a guide for the probability of future events, it can be assumed that North Reading will be affected by numerous severe winter weather events each year (up to 10 or more). The highest risk of these storms occurs in January, with significant risk also occurring in December through March.

[83] FEMA Disaster Declarations Summary: https://www.fema.gov/media-library/assets/documents/28318

Vulnerability Assessment

North Reading's location in Middlesex County places it at a high risk for winter storms, including damaging Nor'easters that typically track up the East Coast with severe winds, heavy snow, and blizzard conditions. Severe winter storms and nor'easters pose multiple threats and impacts to North Reading. Heavy snow or ice conditions can disrupt transportation and may impede the passage of emergency vehicles, and may also bring down trees and power lines, leading to large-scale power outages. Other impacts related to downed trees include those more thoroughly described for impacts associated with the Hurricane/Tropical Storms hazard. Heavy accumulations of seasonal snowfall can also lead to roof collapses across the community. Although collapsed roofs are possible on residential structures, large flat roofs on commercial, retail, and school buildings are at highest risk to this occurrence.

As expected, several public safety issues can arise during severe winter storms. Impassible streets are a challenge for emergency vehicles but also will affect residents and employers. For example, the Fire Department representatives noted a snowbank normally blocks the access from Route 125 near Martin's Pond. Snow-covered sidewalks force people to walk in streets, which are already less safe due to snow, slush, puddles, and ice. Large piles of snow can block sight lines for drivers, particularly at intersections. Not all residents are able to clear their properties (including roofs), especially the elderly. In addition, when that snow melts, the potential for flooding increases and the refreezing of melting snow can cause dangerous roadway and sidewalk conditions.

Recovery from a severe winter storm poses several challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events.

<u>Anticipated Effects of Climate Change</u>

It is anticipated that the effects of climate change will result in winters that are much shorter with fewer cold days and more precipitation, but less precipitation falling as snow and more as rain. This will result in reduced snowpack, earlier breakup of winter ice on lakes and rivers, and earlier spring snowmelt resulting in earlier peak river flows. Climate change is also expected to increase the amount of severe winter storms. This is due to "increased sea surface temperature in the Atlantic Ocean will cause air moving north over the ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall in Massachusetts."[84]

[84] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-224.

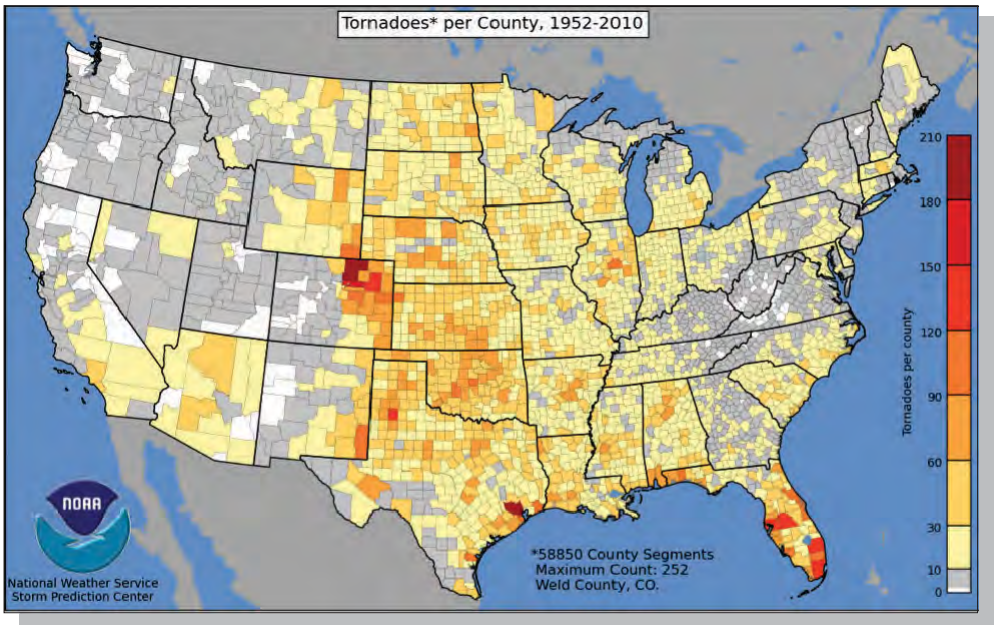
Tornadoes

Hazard Description

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity (but sometimes form from hurricanes and other tropical storms) when cool and dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 miles per hour to more than 300 miles per hour. The most violent tornadoes have rotating winds of 250 miles per hour or more and can cause extreme destruction and turning harmless ordinary objects into deadly missiles.

Each year, an average of over 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries. According to the NOAA Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in Oklahoma, Texas, Kansas, and Florida respectively. Although the Great Plains region of the Central United States does favor the development of the largest and most dangerous tornadoes (earning the designation of "tornado alley"), Florida experiences the greatest number of tornadoes per square mile of all U.S. states (SPC, 2002). Figure 29 shows tornado activity in the United States based on the number of recorded tornadoes per 3,700 square miles.

Figure 29. Tornado Activity.



Tornadoes are most likely to form in the late afternoon and early evening. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. The average

forward speed is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. Most tornadoes are a few dozen yards wide and touchdown briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several miles long.

Location

A tornado is an atmospheric hazard that can strike anywhere, so all areas in the planning area are considered at risk. Worcester County and areas just to its west have been dubbed the "tornado alley" of the state, as most significant tornadoes in Massachusetts history have occurred in that region. Most tornadoes are a few dozen yards wide and touch down only briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several miles long.

Previous Occurrences

Although North Reading hasn't experienced a confirmed tornado event, historical records indicate there have been numerous incidents across the surrounding region. According to NOAA's Storm Events Database, Middlesex County experienced a total of 18 tornado events since 1950 which have caused 1 fatality, 6 injuries, and an estimated $4.9 million in property damages. Prior to 2007, tornados were based on the Fujita Tornado Scale. During this period Middlesex County had 17 tornadoes classified as two (2) F0 events, nine (9) F1 events, four (4) F2 events, and (2) two F3 events. Beginning in 2007, tornados were rated based on the Enhanced Fujita Tornado Scale as described below (under *Extent*). Since then, Middlesex County has had 3 recorded tornado events, each of which was classified as an EF-1 tornado.

Although not yet recorded in NOAA's Storm Events Database, the National Weather Service reported two isolated tornadoes in Middlesex County on August 23rd as remnants of Tropical Storm Henri traveled through the state. These events occurred in the towns of Stow and Marlborough, with estimated wind gusts of 65 miles per hour and which reportedly caused minor damage, including downed trees on vehicles.

One of the most significant historical tornado events in proximity to North Reading occurred on September 29, 1974, when an F3 tornado struck nearby Tewksbury. The storm resulted in no fatalities but caused 1 injury and an estimated $250,000 in property damage.

Extent

The Enhanced Fujita Scale (EF-scale), shown in Table 25, is used to categorize the strength and magnitude of tornado events based on estimated wind speeds and related damage. This represents an update to the original Fujita Scale (F-scale) and has been widely used since February 2007. For mitigation planning purposes the maximum probable extent of a tornado in North Reading is an EF-3.

Table 25. Enhanced Fujita Scale.

Rating	Wind Speed (3 second gust)	Potential Damage
EF-0	65–85 mph	Light – Causes some damage to siding and shingles.
EF-1	86–110 mph	Moderate – Considerable roof damage. Winds can uproot trees and overturn singlewide mobile homes. Flagpoles bend.
EF-2	111–135 mph	Considerable – Most singlewide mobile homes destroyed. Permanent homes can shift off foundations.
EF-3	136–165 mph	Severe – Hardwood trees debarked. All but small portions of houses destroyed.
EF-4	166–200 mph	Devastating – Complete destruction of well - built residences, large sections of school buildings.
EF-5	Over 200 mph	Incredible – Significant structural deformation of mid- and high-rise buildings.

Probability of Future Events

The Tornado Index and historical events were also consulted to investigate probability. The tornado index indicates that North Reading has an index of 99, compared to an index of 88 for the state and 136 for the nation. The tornado index value is calculated based on historical tornado events data using USA.com algorithms. It is an indicator of the tornado level in a region. A higher tornado index value means a higher chance of tornado events.

While no events were specifically reported in North Reading, tornadoes are possible in the planning area. Therefore, the broader scale of Middlesex County was used to determine probability. According to available records, 18 tornado events over nearly 71 years were reported in Middlesex County. This results in an approximate annual probability of 25 percent which correlates to a probability of possible on the PRI probability scale. However, probability is likely lower for the Town, given a smaller study area.

Vulnerability Assessment

All current and future buildings and populations should be considered at risk to tornadoes. Estimating accurate losses is difficult since is it impossible to predict where a tornado will strike, and there have been no direct losses reported in the Town. Tornadoes can cause catastrophic damage, injuries, and deaths. Additional impacts include power failure, loss of communications, downed trees, and wind-blown debris. Tornadoes often develop so rapidly that little, if any, advance warning is possible making them a significant life/safety threat to people. This fact, coupled with how a major event could severely impact the Town's ability to quickly respond (for example, due to downed trees or debris across roadways), makes tornadoes a significant low-probability / high-consequence hazard for North Reading.

Anticipated Effects of Climate Change

Climate change could impact the frequency and severity of this hazard. Tornadoes occur due to unstable air. Warmer and moister air due to climate change could increase the frequency of favorable conditions for tornadoes to occur.[85] Also, according to the State Hazard Mitigation and Climate Adaptation Plan, "future environmental changes may result in an increase in the frequency and intensity of severe thunderstorms, which can include tornadoes."[86] However, some evidence suggests that wind shear, which organizes a storm, may actually decrease due to lower temperatures contrasts from pole to pole.[87] This would limit increases in severity. Research from Florida State University (using NOAA Storm Prediction Center data) does predict more frequent tornadoes. The data indicates that larger numbers of tornadoes are occurring in a single day. Since 2001, there has been at least one day per year when 32 or more tornadoes occurred on a single day.[88]

Other Severe Weather

Hazard Description

Several frequent natural hazards in Massachusetts—particularly strong winds and extreme precipitation events—occur outside of notable storm events. This section discusses the nature and impacts of these and other severe weather hazards, including hail, lightning, and microbursts, and the ways in which severe weather occurrences are likely to respond to a changing climate.[89]

Hail

Hailstorms are a potentially damaging outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere, followed by cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until they develop to a sufficient weight and fall as precipitation. Hail typically takes the form of spheres or irregularly shaped masses greater than 0.75 inches in diameter. The size of hailstones is a direct function of the scale and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstone size can range a great deal in size from 5 millimeters (mm) (approximately pea-sized) to greater than 100mm (approximately melon-sized).

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[85] Biello, David. (2013). What Role Does Climate Change Play in Tornadoes? Scientific American. Retrieved December 11, 2014 from http://www.scientificamerican.com/article/kevin-trenberth-on-climate-change-and-tornadoes/

[86] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-243.

[87] Is Climate Change Causing More Powerful Tornadoes? (2014). Accuweather. Retrieved December 11, 2014 from http://www.accuweather.com/en/weather-news/severe-weather-and-climate-change/62715

[88] Haughney, Kathleen. (2014). New research links tornado strength, frequency to climate change. Florida State Uni- versity News. Retrieved December 11, 2014 from http://news.fsu.edu/More-FSU-News/New-research-links-tornado- strength-frequency-to-climate-change

[89] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-253.

Lightning

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a "bolt" when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000°F. Lightning rapidly heats the sky as it flashes but the surrounding cool air follows the bolt. This rapid heating and cooling of the surrounding air causes thunder, which is often accompanied by lightning strikes. While most often affiliated with severe thunderstorms, lightning may also strike outside of heavy rain and might occur as far as 10 miles away from any rainfall.

According to FEMA, lightning injures an average of 300 people and kills 80 people each year in the United States. NOAA's National Weather Service reported 42 deaths and 58 injuries from lightning for the ten-year average between 2000 and 2009. Direct lightning strikes also have the ability to cause significant damage to buildings, critical facilities, infrastructure, and inventory largely by fire ignition. Lightning is also responsible for igniting wildfires that can result in widespread damages to property. Of particular concern is electrical equipment within the buildings.

Microburst

A microburst is a type of downburst that is often associated with tornado or thunderstorm wind events. It is defined as less than 2.5 miles wide; duration of less than 5 minutes, and wind speeds up to 168 miles per hour. Downbursts that are measured wider than 2.5 miles are known as microbursts. As opposed to tornadoes, where wind flows inward, downburst wind flows outward, often resulting in straight-line winds. They are caused by down drafts from the base of a convective thunderstorm cloud. It occurs when rain-cooled air within the cloud becomes heavier than its surroundings. Thus, air rushes towards the ground in a destructive yet isolated manner. In the past, microbursts have downed airplanes and capsized small sailboats by sudden-shifting and strong winds.

Location

All North Reading is at equal risk of being impacted by severe weather, and while major impacts are typically associated with smaller localized areas, and it is not possible to predict where damage from such an event might occur. Severe weather events have been a recurring threat to North Reading throughout its history, from severe thunderstorms bringing wind, intense precipitation, and localized flooding to damaging hail and lightning events. More recently, the Town has experienced increasing regular storms (severe thunderstorms and other high wind or heavy rainfall events) with greater intensity. As discussed under the hazard profile for *Flooding*, more intense storms delivering higher volumes of precipitation in a single event are expected to put significant pressure on dams, culverts, and other drainage infrastructure, which were all designed to handle smaller storms with more consistent distributions of precipitation.

Previous Occurrences

According to NOAA's Storm Events Database, Middlesex County experienced a total of 1,179 severe weather events since 1950 which have caused 2 fatalities, 62 injuries, and an estimated $11.3 million in property damage. These events include those recorded as high or strong wind, thunderstorm wind, heavy rain, or lightning as shown in Table 26.[90] Most of the wind-related casualties and recorded property damages were caused by downed trees or falling limbs and typical event impacts included power outages, road closures, and other relatively short-term disruptions. Lightning has been recorded as the cause for 1 fatality and 31 injuries across the county since 1996, in addition to nearly $3 million in property damages. Although events classified as heavy rain resulted in no damages, these are separate from events classified by the NWS as "flood" or "flash flood" events which are more likely to have caused property damages (and are covered in this chapter under "Flooding").

Table 26. Other Severe Weather Events for Middlesex County, 1950 – October 2020.

Event Type	# of Events	Fatalities	Injuries	Property Damage
High / Strong Wind	315	1	7	$3,957,000
Thunderstorm Wind	507	0	24	$4,356,650
Heavy Rain	112	0	0	$0
Lightning	58	1	31	2,901,600
Hail	187	0	0	$75,250
Total	**1,179**	**2**	**62**	**$11,290,500**

Extent

The National Weather Service considers a thunderstorm to be severe if it produces hail at least ¾ inch in diameter, has winds of 58 mph or higher, or has the potential to produce a tornado. Lightning accompanies all thunderstorms and can cause death, injury, and property damage. Straight-line winds can exceed 100 mph and are responsible for most thunderstorm wind damage. A microburst can reach speeds equal to that of a strong tornado. In addition, hail can cause substantial damage to property and crops. Large hailstones can fall faster than 100 miles per hour and can be very costly in terms of economic losses.

An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms. The amount of precipitation from a 100-year 24-hour storm event has increased from approximately 7 inches to 9 inches for Boston. Based on this fact, North Reading may expect a similar increase. According to NOAA's Storm Events Database, very large hailstones are possible in the planning area but the largest recorded to date is 0.75 inches (2.25 inches for Middlesex County). Microbursts with maximum wind speeds of 100 miles per hour have also been recorded in proximity to the planning area.

[90] NOAA's Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Probability of Future Events

Severe storms comprising of thunderstorms, high winds, hail, and lightning will continue to be a highly likely occurrence for North Reading (1-10 percent annual probability) with the potential to affect all areas of Town with increasing frequency and intensity. While these events may occur during any month, they are most likely to occur between May and August. In recent years there has been an observed shift in the type and timing of storms. Many storm events now encompass a mixture of rain, ice, and snow, making it more difficult to maintain safe, accessible roadways. Early season storms of wet, heavy snow when leaves were still on the trees have caused extensive damage to electrical infrastructure, leading to extended power outages.

Vulnerability Assessment

As mentioned above, one of the greatest local impacts resulting from severe weather in North Reading is electrical power outages. During severe storms with strong winds, trees and tree branches often fall and break electric lines, causing widespread power outages for local residents. Other direct and indirect impacts related to downed trees include those more thoroughly described for impacts associated with the Hurricane/Tropical Storms hazard (for example, closing roadways or blocking ingress/egress to developments or facilities with only one way in and out). In addition, storms that come with extreme precipitation are expected to put significant pressure on North Reading's culverts, and other drainage infrastructure that were designed to handle smaller storms with more consistent distributions of precipitation. This problem manifests at points across the Town and is acute where the local drainage systems concentrate and discharge, and especially in those problem areas of concern as described in the Flooding section of this assessment.

In terms of other severe weather impacts to North Reading, hail is capable of damage, particularly to roofs, vehicles, and exposed metal and glass. In addition to the life/safety threat, losses due to lightning include impacts from structural fires, debris cleanup from downed trees and power lines, and electronic equipment damage. Microbursts can cause catastrophic damage, injuries, and deaths. Additional impacts include power failure, loss of communications, and widespread areas of downed trees and debris.

Anticipated Effects of Climate Change

According to NOAA, the effects of climate change on future severe weather events cannot be determined at the present time due to insufficient scientific evidence. However, multiple studies cite that the Northeast region of the US will continue experience more very heavy rainfall events which are often associated with severe thunderstorms and other extreme weather events.

Non-Climate Influenced Hazards

Earthquake

Hazard Description

An earthquake is a combination of different phenomena. An earthquake initiates with the sudden slip of rock on either side of a crack in the earth, called a fault. The sliding of the rock on the fault due to the rock slip radiates seismic waves in all directions. The seismic waves vibrate the ground surface and are experienced as earthquake ground shaking. Different kinds of seismic waves travel with different speeds and have different amplitudes or strengths. For this reason, even though the rock slip that initiates an earthquake might be over in a few or several seconds, the ground shaking radiated by a large earthquake slip on a fault can last many tens of seconds.[91]

Location

Because of the regional nature of the hazard, the entire community of North Reading is equally susceptible to earthquakes. Unlike other areas of the country where earthquakes occur along known fault lines, earthquakes in the Northeast do not correlate with the many known faults that exist in the region. They occur in the middle of plates, far from the plate boundaries. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult.

Previous Occurrences

Earthquakes occur on a regular basis in the Northeast US. According to the Weston Observatory Northeast Earthquake Catalog, more than 5,000 earthquakes have occurred in the region since 1638, including more than 1,500 earthquakes in New England and more than 350 with epicenters in Massachusetts. Generally, most earthquakes that occur in the Northeast US are small in magnitude and cause little to no damage, though ground shaking is felt across large areas due to the geologic composition and rock structure of the region. In terms of potential impacts, this makes the specific location of the epicenter in the Northeast less relevant than in other regions of the US.

Between 1924 and 2016, there were 105 earthquakes in the Northeast measuring a magnitude 4.5 or greater on the Richter scale. Out of these 104 earthquakes, 10 were centered within New England and the other 94 occurred within New York State and the Province of Quebec. Historically, moderately damaging earthquakes strike somewhere in the region every few decades, and smaller earthquakes are felt approximately twice per year. The largest known New England earthquakes occurred in 1638 (magnitude 6.5) in New Hampshire, and in 1755 (magnitude 5.8) offshore from Cape Ann northeast of Boston. The most recent New England earthquake to cause moderate damage occurred in 1940 (magnitude 5.6) in central New Hampshire. Reported damages included toppled chimneys, cracked walls, broken water pipes, fallen plaster, and broken furniture.

Based on past records, the maximum experienced earthquake intensities on the Mercalli Scale in Northern Middlesex County have been in the range of VI (where there is damage to objects indoors, the tremor is felt by all people indoors and outdoors, movement is unsteady, moderately heavy furniture moves, and pictures fall off walls) to VII (where there is damage to architecture, the tremors are

[91] http://nesec.org/earthquakes-hazards/

frightening, it is difficult to stand, cracks occur in chimneys and plaster, bricks may fall, and stream banks may cave in).

Extent

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 (shown in Table 27) measures the amount of seismic energy released by an earthquake, while the Modified Mercalli Intensity Scale (shown in
Table 28) describes the intensity of an earthquake based on its observed effects at a site where earthquake shaking is felt.[92] For mitigation planning purposes the maximum probable extent of an earthquake in North Reading is a 6.5 on Richter Scale and Intensity VII on Modified Mercalli Intensity Scale.

Table 27. Richter Scale.

Magnitude	Effects
< 3.5	Generally, not felt, but recorded.
3.5 - 5.4	Often felt, but rarely causes damage.
5.4 - 6.0	At most, slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1 - 6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0 - 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or >	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Table 28. Modified Mercalli Intensity Scale.

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	Moderate	Felt by people walking.	
V	Slightly Strong	Sleepers awake; church bells ring.	< 4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves.	< 5.4

[92] http://nesec.org/earthquakes-hazards/

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
VII	Very Strong	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	Destructive	Moving cars become uncontrollable; masonry fractures, poorly constructed buildings damaged.	
IX	Ruinous	Some houses collapse; the ground cracks; pipes break open.	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes, and cables destroyed; general triggering of other hazards.	< 8.1
XII	Catastrophic	Total destruction: trees fall; ground rises and falls in waves.	> 8.1

Probability of Future Events

Although New England has not experienced a damaging earthquake since 1755, seismologists state that a serious earthquake occurrence is possible. Based on the historic occurrences, which have been few and of limited severity, North Reading should be at a moderate risk for earthquake damage in the future. Because the region's geologic faults zones do not correlate strongly to earthquake locations or aid in predication of occurrence, it is difficult to determine level of probability. However, North Reading falls within a seismic zone with a peak ground acceleration value of 14-16%g, which is considered a moderate risk zone in terms of potential ground shaking and damage from such an event. This zone generally indicates that there is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

Earthquakes with a magnitude of 3.0 and greater will remain a possible occurrence for being felt in North Reading, though based on historical data and existing seismic hazard maps, the Town is considered susceptible to only minor ground shaking and light damages (if any). Moderately damaging earthquakes are only expected to strike somewhere in the New England region every few decades.

Vulnerability Assessment

The entire population of Massachusetts is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure depends on many factors, including the age and construction type of the structures where people live, work, and go to school, and the soil type these buildings are constructed on. Ground movement during an earthquake is seldom the direct cause of injury or death. Collapsing walls, falling objects, and flying glass cause most casualties. Buildings with foundations resting on unconsolidated landfill, old waterways, or other unstable soils are most at risk.

Most buildings and infrastructures in Massachusetts were constructed without specific earthquake-resistant design features. Massachusetts introduced earthquake design requirements into their building code in 1975 and improved building code for seismic reasons in the 1980s. However, these specifications apply only to new buildings or to extensively modified existing buildings. Buildings, bridges, water supply lines, electrical power lines and facilities built before the 1980s may not have been designed to withstand the forces of an earthquake. Seismic standards were upgraded in the 1997 revision of the State Building Code. Older buildings, including some historic properties, are most vulnerable to earthquakes. If bridges or other key infrastructure assets were damaged by an earthquake, that could lead to travel challenges. Underground infrastructure, such as water, gas or electric, may also be negatively impacted by an earthquake.

The greatest damage in the Middlesex County region from an earthquake event is likely to occur where structures were designed prior to seismic standards being incorporated into the State Building Code. Such structures are scattered throughout the region. In addition, older structures in the region such as schools, hospitals, and fire stations, which are built of un-reinforced masonry and are particularly vulnerable to damage or collapse in the event of an earthquake.

Lastly, due to their potential widespread damage and disruption, earthquakes can greatly impact the region's economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. According to the State Hazard Mitigation and Climate Adaptation Plan, in terms of vulnerabilities, residents may be displaced by earthquakes and some of those residents may require sheltering. Vulnerable populations tend to be the most susceptible to displacement; this may include those living at or below the poverty line and the elderly.

Anticipated Effects of Climate Change

The effects of climate change will have no relation to the probability or magnitude of future earthquake events.

Technological and Human Caused Hazards

Dam Failure

Hazard Description

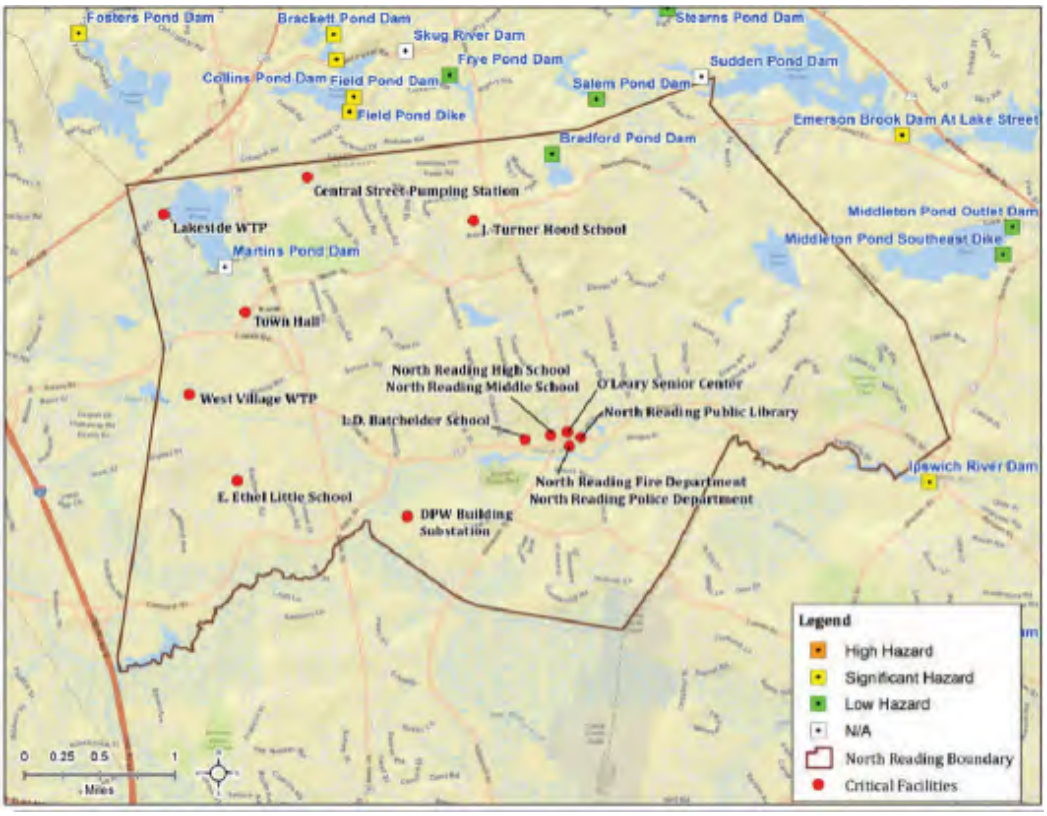
A dam failure is the structural collapse of a dam that releases the water being detained or stored behind it. Dam failures are usually the result of the age of the structure, inadequate spillway capacity, or structural damage caused by an earthquake or flood. Failures due to prolonged periods of rainfall can result in overtopping (the most common cause), and total failure occurs if internal erosion, overtopping, or damage results in a complete structural breach. Overtopping occurs when a dam's spillway capacity is exceeded and portions of the dam that are not designed to convey flow begin to pass water, erode, and

ultimately fail. Other potential causes of dam failure include design flaws, foundation failure, internal soil erosion, inadequate maintenance, or mis-operation.

Location

According to dam information from the Massachusetts Office of Dam Safety, there are two dams in North Reading. One is Bradford Pond Dam, which is a low hazard dam. The other is the Martin's Pond Dam, which is not classified, because it is a municipal dam. The dam locations are shown in Figure 30. In addition to dams, there are several detention areas associated with storm water mitigation in new subdivisions. Some of these, if breached would cause significant damage to public infrastructure and private property.

Figure 30. Dam Locations in North Reading.



Previous Occurrences

Upon a review of data available from the Massachusetts Office of Dam Safety, the National Performance of Dams Program (NPDP) at Stanford University, the Association of State Dam Safety Officials, and NOAA's Storm Events Database, there have been no recorded dam failures causing impacts in North Reading.

Extent

Dam breaches often lead to catastrophic consequences as the water ultimately rushes in a torrent downstream, flooding an area engineers refer to as an "inundation area." The number of casualties and the amount of property damage depends on the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Dams in Massachusetts are assessed according to their risk to life and property. The State has three hazard classifications for dams:

- *High Hazard*: Dams located where failure or improper operation is likely to cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads.
- *Significant Hazard*: Dams located where failure or improper operation may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads, or cause interruption of use or service of relatively important facilities.
- *Low Hazard*: Dams located where failure or improper operation may cause minimal property damage to others. Loss of life is not expected.

Probability of Future Events

Due to the lack of any dams classified as Significant or High Hazard in proximity to the planning area, in addition to current state regulations for dam safety (inspection and maintenance) programs, dam failure is considered an unlikely event for North Reading (less than 1% annual probability).

While a rare and unlikely occurrence, High Hazard dams do represent a potentially disastrous hazard. The likelihood of dam failure increases if dams are not maintained. In Massachusetts, all jurisdictional-dam owners are responsible for inspecting and maintaining their dams in safe operating condition. This includes hiring a qualified engineer to inspect and report results every 2 years for High Hazard dams, every 5 years for Significant Hazard dams, and every 10 years for Low Hazard dams. Owners of High or Significant Hazard dams are also required to develop and annually update Emergency Action Plans (EAPs). For this reason, the probability of failure for state-regulated dams remains low.

Vulnerability Assessment

As noted above, there are no high hazard dams in the planning area, so loss of life or property damages in North Reading due to a dam failure is unlikely. A breach may result in erosion on the rivers and stream banks that are inundated.

In the Town of North Reading, there is only one classified dam, which is a low hazard dam. Low hazard dams are expected to result in minimal property damage if breached. In addition, there several large retention ponds in the Town that may pose a risk to property if breached. However, determining the

exact value is beyond the scope of this plan. Martin's Pond Dam is not classified. There appears to be one structure potentially at risk to breach (which is south of Burroughs Road). However, there are also several wetland areas which would likely buffer a breach. There are no critical facilities at risk.

It is anticipated that the effects of climate change will not increase the probability of dam failure events, though projected increases in the frequency of extreme precipitation events (as described in previous sections) should continue to be considered in the regulation, construction, operation, and maintenance or repair of dam structures. As further explained in the State Hazard Mitigation and Climate Adaptation Plan, there are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was initially designed to handle. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.[93]

Anticipated Effects of Climate Change

It is anticipated that the effects of climate change will not increase the probability of dam failure events, though projected increases in the frequency of extreme precipitation events (as described in previous sections) should continue to be considered in the regulation, construction, operation, and maintenance or repair of dam structures. As further explained in the State Hazard Mitigation and Climate Adaptation Plan, there are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was initially designed to handle. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.[94]

HAZMAT

Hazard Description

Hazardous materials or toxic releases can cause deaths and injuries, shut down facilities, contaminate the natural environment (including surface and groundwater supplies), and cause affected properties to be destroyed or suffer major damage. In a hazardous materials incident, solid, liquid and/or gaseous contaminants may be released from fixed or mobile containers. Weather conditions directly affect how the hazard develops. The micro-meteorological effects of the buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering-in-place can protect people and property from harmful effects. Non-compliance with fire and building codes, as well as failure to maintain existing fire and containment features can substantially increase the damage from a hazardous materials release. The duration of a hazardous materials incident can range from hours to days. Warning time for hazardous materials incidents is minimal to none.

[93] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-5.
[94] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 4-5.

According to the Town of North Reading's Hazardous Materials bylaw (Chapter 80), hazardous materials are defined as "any substance or combination of substances which, because of quantity, concentration, or physical, chemical, or infectious characteristics, poses a significant present or potential hazard to water supplies or to human health if disposed into or on any land or water in the Town of North Reading."

Location

HAZMAT spills can occur via roads, air, water travel, rail, and from fixed sites that use or produce hazardous materials. Therefore, all locations in the planning area are considered at risk.

The EPA's Toxic Release Inventory TRI program is one measure to determine fixed HAZMAT sites. The Emergency Planning and Community Right to Know Act (EPCRA) created the TRI to inform the public about potentially hazardous materials in the community. According to EPA's TRI Inventory, no TRI sites were identified within North Reading. However, three TRI sites were identified in the Town's general proximity in neighboring Towns, including the Bostik Manufacturing Plant (Middleton), Fraen Corp (Reading), and Benevento Sand & Stone Corp (Wilmington).[95]

There are no major freight railroads traversing through or near the planning area, however there are numerous roadways on which mobile hazardous materials are transported. Based on a review of previously reported HAZMAT incidents for North Reading as described below, most incidents occurred along Concord Street.

Previous Occurrences

There have been no major disaster declarations related to HAZMAT in Middlesex County. The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration was consulted to determine previous occurrence information. The HAZMAT Incident Database was searched, and the data indicates that 401 incidents have occurred in North Reading between 1972 and October 2021.[96] All incidents were highway transport incidents (spillage and/or vapor dispersion). However, none of these incidents were classified as serious or resulted in fatalities, and there were only two reported injuries. Total damages were reported as $177,549.

EPA's National Priorities List (NPL) was also reviewed to investigate site-specific previous releases. The list of national priorities lists the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is primarily intended to guide the EPA in determining which sites warrant further investigation. No sites are in North Reading.

[95] EPA TRI Inventory. Accessed October 4, 2021 from https://www.epa.gov/toxics-release-inventory-tri-program
[96] Incident Statistics. (2021). U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. Retrieved October 4, 2021 from https://www.phmsa.dot.gov/hazmat-program-management-data-and-statistics/data-operations/incident-statistics

Extent

HAZMAT extent can be defined in terms of amount of material released. According to the data on previous occurrences described above, the greatest amount released was 180 liquid gallons of cleaning compound on August 21, 2008.

Probability of Future Events

Based on 401 events between 1972 and 2021, the probability is highly likely. However, these events are generally contained quickly with no threats to human life and safety. A more serious, widespread event, such as one impacting air or water, is less likely and has not occurred. Therefore, a probability of likely was assigned.

Vulnerability Assessment

If released, hazardous materials may cause harm to people, the environment, critical infrastructure, and property. Their potential for harm exists regardless of whether hazardous materials are released by accident, malicious actor, fire, or weather-related event. Hazardous materials vary greatly in the types of health risks they pose to humans. Those who are most vulnerable to the impacts of hazardous materials include workers in facilities who regularly use or handle hazardous materials, transportation carriers, and first responders.

It cannot be predicted where a hazardous materials incident may occur all existing and future buildings, facilities and populations in North Reading are equally exposed to this hazard and could potentially be impacted. North Reading does not have any major interstates, but I-93 is just to the west and I-95 is a few miles south and east of the planning area. All these corridors in addition to some local roadways have the potential for an incident that could impact the planning area.

Anticipated Effects of Climate Change

The effects of climate change will have no relation to the probability or magnitude of future HAZMAT events.

Critical Facilities

Critical facilities are considered structures or institutions necessary for the Town of North Reading in terms of emergency response and recovery. These facilities must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery. Critical facilities typically include airports, emergency operation centers (EOCs), fire stations, hospitals, police stations, schools, government buildings, and railroad stations.

Table 29 lists critical facilities as identified for the Town of North Reading.

Figure 31

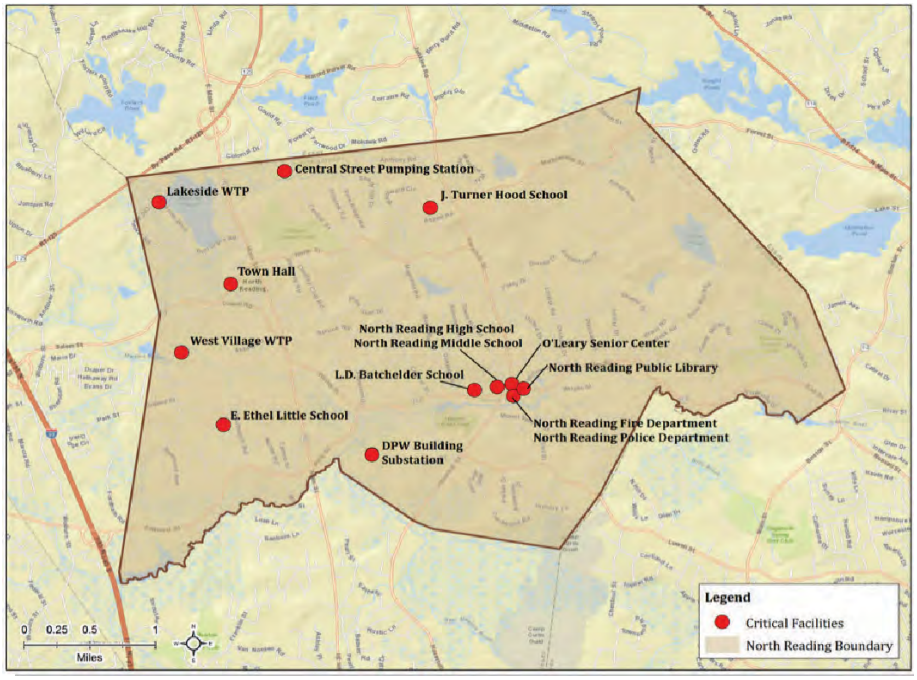
Table 29shows the location of each critical facility. There are no known losses to critical facilities that have occurred in the last fifteen years (though future losses are possible). Further, no additional data on previous losses were available. These facilities have a combined building exposure value of nearly $168 million. In terms of their location in specifically identified areas of concern, the Central Street Pumping Station and Lakeside Water Treatment Plant are in the 1 percent annual chance (100-year) flood zone. The North Reading Fire and Police Stations are in the 0.2 percent annual chance (500-year) flood zone, however, as described in the profile for flooding these buildings are protected by a floodwall.

Table 29. Critical Facilities.

Critical Facility	Justification for Inclusion
O'Leary Senior Center @ 157 Park Street	The Edith A. O'Leary Senior Center is a senior assistance facility located on the first floor of the Third Meeting House on the Town Common. It is open to all residents 60 years of age and older and currently serves more than 26% of the Town's population.
North Reading Fire and Police Departments @ 150-152 Park Street	These facilities are deemed critical because of their emergency response function.
L.D. Batchelder School @ 2 Peabody Street	Houses vulnerable populations and identified as critical.
J. Turner Hood School @ 298 Haverhill Street	Houses vulnerable populations and identified as critical.
E. Ethel Little School @ 7 Barberry Road	Houses vulnerable populations and identified as critical.
North Reading High/Middle School 189 Park Street	Houses vulnerable populations and identified as critical.
Flint Memorial Library @147 Park Street	The Flint Memorial Library located at 174 Park Street, North Reading does not currently have a generator and is not formally part of a disaster response plan. However, if power is not interrupted residents frequent the library as a place to meet and charge electrical devices during and after a disaster. The Town Administrator requested the library be considered a critical facility for this reason.
Town Hall @ 235 North Street	This structure contains Town records and data and houses all Town offices, for this reason it was identified as critical.
DPW Building @ 166 Chestnut Street	This structure contains Town equipment necessary for disaster preparedness, response, and recovery.
Central Street Pumping Station	This structure ensures wastewater is transported to proper site and was identified as critical.

Lakeside Water Treatment Plant	This structure purifies and sanitizes wastewater and was identified as critical.
Substation	This is the only substation in Town and is deemed critical. It owned by Reading Municipal Light Dept. and adjacent to the DPW yard.

Figure 31. North Reading Critical Facilities.



Other Community Assets and Key Resources

In addition to the above listed critical facilities, there are many other community assets and key resources throughout the Town. These include those infrastructure elements and other public facilities described in Chapter 2 such as the local transportation network, utilities, water supply systems, stormwater infrastructure, and other facilities that provide important services to residents and businesses across the community. These also include North Reading's natural, cultural, and historic resources that contribute to the Town's character and are important to continue preserving and protecting against the threat of natural hazards or other potential adverse impacts.

Summary of Vulnerability

The Risk and Vulnerability Assessment completed for the Town of North Reading includes both quantitative and qualitative information to help determine the potential impact of each identified

hazard on community assets. This information provides significant findings that allow the MVP/HMP Core Team to prioritize hazard risks and proposed hazard mitigation strategies and actions.

To assist in this process, the Core Team applied a "Priority Risk Index" (PRI). The PRI is a tool designed to (1) summarize relevant hazard profile information as included in this section; and (2) measure the degree of relative risk each hazard poses to the Town based on that information. The PRI was used to assist the MVP/HMP Core Team in ranking and prioritizing hazards based on a variety of characteristics including location, probability, potential impact, warning time, and duration.

The PRI results in numerical values that allow identified hazards to be ranked against one another – the higher the PRI value, the greater the hazard risk. PRI values are obtained by assigning varying degrees of risk to each of the five characteristics, or categories. Each degree of risk has been assigned an index value (1 to 4) and an agreed upon weighting factor, as summarized in Table 30.

To calculate the PRI value for a given hazard, the assigned index value for each category is multiplied by the weighting factor. The sum of all five categories equals the final PRI value, as demonstrated in the below equation:

PRI VALUE =

(LOCATION x .20) + (PROBABILITY x .30) + (POTENTIAL IMPACT x .30) + (WARNING TIME x .10) + (DURATION x .10)

According to the weighting scheme applied by the Core Team, the highest possible PRI value is 4.0. Prior to being finalized, PRI values for each hazard were reviewed and accepted by the Core Team.

Table 30. Priority Risk Index (PRI).

PRI Category	Degree of Risk			Assigned Weighting Factor
	Level	Criteria	Index Value	
Location	Negligible	Less than 1% of planning area affected	1	20%
	Small	1-10% of planning area affected	2	
	Moderate	10-50% of planning area affected	3	
	Large	50-100% of planning area affected	4	
Probability	Unlikely	Less than 1% annual probability	1	30%
	Possible	1-10% annual probability	2	
	Likely	10-90% annual probability	3	
	Highly Likely	90-100% annual probability	4	
Potential Impact *	Minor	Very few injuries, if any. Only minor property damage and minimal disruption to quality of life. Partial or complete shutdown of critical facilities for less than one day.	1	30%
	Limited	Minor injuries only. 10-25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one day.	2	
	Critical	Multiple fatalities/injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one week.	3	
	Catastrophic	High number of fatalities/injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one month.	4	
Warning Time	More than 24 hours		1	10%
	12 to 24 hours		2	
	6 to 12 hours		3	
	Less than 6 hours		4	
Duration	Less than 6 hours		1	10%
	6 to 24 hours		2	
	1 to 7 days		3	
	More than 1 week		4	

** Potential impact is based upon the estimated maximum probable extent (magnitude/severity) for each hazard based on historic events or future probability data, as shown in Table 31.*

Table 31. Maximum Probable Extent.

Hazard	Maximum Probable Extent
Flooding	1% Annual Chance Flood for all FEMA Special Flood Hazard Areas
Drought	Drought Category D3 (Extreme Drought) as classified by the US Drought Monitor

Hazard	Maximum Probable Extent
Average/Extreme Temperatures	Cold: Wind Chill Temperature Index of –25°F or lower for at least three hours Heat: Heat Index of 105+°F for two or more hours; or 3 consecutive days with a heat index exceeding 100°F"
Wildfires	100+ acres burned along wildland-urban interface
Infectious Disease	Pandemic (major disease outbreak with severe and life-threatening consequences) with confirmed cases in the North Reading region
Invasive Species	Chronic, uncontrolled invasives with consistent threats to ecosystems and/or human health
Hurricanes/Tropical Storms	Category 3 hurricane on Saffir-Simpson Hurricane Wind Scale
Severe Winter Storm/Nor'easter	Category 5 on Regional Snowfall Index (RSI); or Intensity Index Category 4 on Classification Scheme for Nor'easters
Tornadoes	EF-3 on the Enhanced Fujita Scale
Other Severe Weather	Winds gusts in excess of 70 miles per hour, hail measuring at least three-quarters of an inch in diameter, or rainfall exceeding the 10-year design storm event
Earthquake	Intensity VII on Modified Mercalli Intensity Scale
Dam Failure	Complete failure of a high hazard dam
HAZMAT	A major, widespread hazmat event that threatens human safety and/or the community's air and water resources.

Table 32 summarizes the degree of risk assigned for all identified hazards in the planning area based on the application of the PRI tool, along with the calculated PRI values. Please note that more detailed information on the specific locations, probabilities, vulnerabilities, and potential impacts for each hazard in the planning area are provided in each hazard-specific profile in this section. This detailed information was the basis for determining the overall summary of hazards as provided in Table 32.

Table 32. Summary of Priority Risk Index (PRI) Results.

Hazard	Category/Degree of Risk					PRI Value
	Location	Probability	Potential Impact	Warning Time	Duration	
Flooding	Moderate	Likely	Critical	12 to 24 hours	1 to 7 days	2.9
Drought	Large	Possible	Limited	More than 24 hours	More than 1 week	2.5
Average/Extreme Temperatures	Large	Likely	Limited	More than 24 hours	1 to 7 days	2.7
Infectious Disease	Small	Likely	Critical	More than 24 hours	More than 1 week	2.7
Invasive Species	Small	Highly Likely	Minor	More than 24 hours	More than 1 week	2.4
Wildfires	Small	Highly Likely	Minor	Less than 6 hours	6 to 24 hours	2.5
Hurricanes/Tropical Storms	Large	Likely	Critical	More than 24 hours	1 to 7 days	3.0
Severe Winter Storm/Nor'easter	Large	Highly Likely	Critical	More than 24 hours	1 to 7 days	3.3
Tornadoes	Small	Possible	Catastrophic	Less than 6 hours	Less than 6 hours	2.7
Other Severe Weather	Moderate	Highly Likely	Limited	6 to 12 hours	6 to 24 hours	2.9
Earthquake	Large	Possible	Minor	Less than 6 hours	Less than 6 hours	2.2
Dam Failure	Small	Unlikely	Minor	Less than 6 hours	Less than 6 hours	1.5
HAZMAT	Moderate	Likely	Limited	Less than 6 hours	6 to 24 hours	2.7

The calculated PRI values were used by the Core Team to classify and rank each hazard according to three defined risk levels (Low, Moderate, or High) as shown in Table 33.

Table 33. Hazard Rankings Based on Priority Risk Index (PRI).

Hazard Ranking	Hazards
High	Severe Winter Storm/Nor'easter Hurricanes/Tropical Storms Flooding Other Severe Weather
Moderate	Average/Extreme Temperatures Tornadoes HAZMAT Infectious Disease
Low	Drought Wildfires Invasive Species Earthquake Dam Failure

The Town's previous hazard mitigation plan identified very similar hazard rankings for North Reading. The community remains at greatest risk to flooding, severe winter storms, hurricanes and tropical storms, and other severe weather. The only notable differences in the updated rankings are reclassifying extreme heat from a low to moderate risk hazard, drought and earthquake from moderate to low-risk hazards, and the addition of infectious disease and invasive species to the list of hazards assessed. It should be noted that although some hazards are classified as posing "low" risk, their occurrence of varying or unprecedented magnitudes is still possible and they will continue to be evaluated by the Core Team during future updates to this plan.

Chapter 5. Capability Assessment

The purpose of conducting the capability assessment is to identify the strengths and weaknesses of the Town in terms of mitigating risks. This analysis will point to shortfalls and weaknesses as well positive measures already in place, which should continue to be supported.

The capability assessment serves as the foundation for designing an effective hazard mitigation strategy. It not only helps establish the goals and objectives for the Town of North Reading's hazard mitigation plan, but it ensures that those goals and objectives are realistically achievable under given local conditions.

The capability assessment must answer two key questions:

1. Does the Plan document each jurisdiction's existing authorities, policies, programs and resources, and its ability to expand on and improve these existing policies and programs?1
2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate?

The capability assessment includes a comprehensive examination of the following capabilities as summarized in Table 34.

Table 34. Capability Assessment Components.

Components	Description
Planning and Regulatory Capabilities	Does the Town have plans in place that include natural hazards? Do the plans identify mitigation projects? Can the plan be used to implement mitigation actions?
Administrative and Technical Capabilities	What skills does the Town have and can they be used for mitigation planning?
Financial Capabilities	Is the Town eligible for or have access to funding sources for hazard mitigation?
Education and Outreach Capabilities	What education and outreach programs are currently in place to communicate hazard-related information?
National Flood Insurance Program (NFIP)	How does the Town participate in the NFIP?
Capability Assessment Conclusions	A summary of capability findings.

Existing Plans Reviewed

The first step in the capability assessment was to gather and review existing plans to gain an understanding of the region's ability to mitigate risk. A summary of the most relevant plans is provided below.

State Hazard Mitigation and Climate Adaptation Plan (2018)

The Commonwealth's 2018 State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) is an innovative, first-of-its-kind statewide plan that fully integrates a traditional hazard mitigation plan with a climate change adaptation plan. The SHMCAP fulfills two important requirements, including (1) updating the 2013 State Hazard Mitigation Plan as required by Federal regulations (44 CFR Part 201.4); and (2) fulfilling requirements for a state climate adaptation plan per Massachusetts Executive Order 569. The SHMCAP has five goals as shown below:[97]

1. Enhance the Commonwealth's resiliency to natural hazards and climate change by integrating programs and building institutional capacity.
2. Reduce the impacts of natural hazards and climate change with forward-looking policies, plans, and regulations.
3. Understand our vulnerabilities and risks and develop immediate and long-term risk reduction strategies for current and future conditions using the best available science.
4. Increase the resilience of State and local government, people, natural systems, the built environment, and the economy by investing in performance-based solutions.
5. Support implementation of this plan through increased education, awareness, and incentives for action for state agencies, local governments, private industry, non-profits, and the general public.

The Town of North Reading's Hazard Mitigation Plan is consistent and aligned with the SHMCAP. The goals in the following chapter include several of the themes shown in the State plan, including the integration of hazard mitigation and climate adaptation strategies in local policies, plans, and regulations; improving public education and awareness; building local capacity; and reducing risk to people, property, and infrastructure to natural hazards and climate change. In addition, as seen in Chapter 4, the risk assessment has been updated to be organized using the same hazard classification scheme as used for the SHMCAP.

North Reading Municipal Vulnerability Preparedness Plan (2018)

The Commonwealth's Municipal Vulnerability Preparedness (MVP) program provides support for cities and towns in Massachusetts to plan for resiliency and implement key climate change adaptation actions for resiliency. In 2017, North Reading was awarded an MVP Planning Grant to assess its vulnerability to and prepare for climate change impacts, build community resilience, and receive designation from the Executive Office of Energy and Environmental Affairs (EEA) as an MVP Community. Communities with this designation become eligible for MVP Action Grant funding and other opportunities to support the implementation of priority climate adaptation actions.

For the development of North Reading's MVP Plan, the Town followed the Community Resilience Building (CRB) Framework and assembled an MVP Core Team. The Core Team established the MVP Plan

[97] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 7-2.

goals, and following the CRB Guidelines, held two half-day, 4-hour workshops in March 2018. The final MVP plan was released in May 2018 and included the following three goals:[98]

1. Identify Climate Change Vulnerabilities, considering Infrastructural, Societal and Environmental factors and Develop Action Steps to make the Town more Resilient and Sustainable to extreme weather-related conditions in the future based on EOEA climate change projections.
2. Develop an MVP Plan that compliments and builds upon the Town's previous mitigation efforts over the past two decades and the 2016 Hazard Mitigation Plan
3. Develop and MVP Plan that satisfies the requirements of the MA EOEA, such that it receives approval and makes the Town Eligible for Future MVP Grants.

The Town's MVP Plan and supporting materials served as a primary source of information and community-based inputs for the update to this Hazard Mitigation Plan. These inputs include the identification of top climate-influenced hazards and vulnerable areas or community assets (infrastructural, societal, and environmental), current community concerns and challenges presented by these hazards, and specific recommendations to improve North Reading's resilience to hazards. Continuity between the two plans was also strengthened through the involvement of representatives from the MVP Core Team on the Core Team overseeing the update process for the Hazard Mitigation Plan.

North Reading Master Plan (2020-2030)

The Town of North Reading Master Plan for 2020-2030 is intended to provide a roadmap based on community consensus ideas that when implemented throughout the years can set the groundwork for the Town achieving its long-term quality-of-life goals. In addition to serving as a reference document to inform decision-making at local boards, committees, and Town Meeting, the Master Plan also provides a certain sense of mutual certainty for existing and prospective residents and businesses about what type of community North Reading would like to be in the future. Ideally, future zoning amendments, Town policies, and/or investments will be in harmony with the goals and recommendations and create conditions that will get the Town closer to its long-term vision.

As stated in the Master Plan, North Reading's vision for the future encompasses working toward steady progress on five main fronts, including the following (not in any prioritizing order):[99]

- Protecting and celebrating its natural areas
- Improving and expanding its walking and biking trail system
- Improving the aesthetics of the built environment
- Strengthening the Town's community and economic development
- Leaving a legacy for future generations

[98] Municipal Vulnerability Preparedness (MVP) Plan for North Reading. May 2018. P. 1.
[99] North Reading Master Plan, 2020-2030, MAPC, p. 1.

The 2016 Hazard Mitigation Plan is referenced within the Master Plan, and similarly, the Master Plan served as a key source of information in the update to the Hazard Mitigation Plan. More information on the relevance and relationship between these two plans is provided in Table 35.

Town of North Reading Open Space and Recreation Plan (2020)

Building on the 2013 version of the plan and many positive achievements, the 2020 Open Space and Recreation Plan (OSRP) provides a framework for Town officials and residents to make informed decisions impacting open space and recreation. The primary purposes of the plan are to (1) assess and provide information on the state of the Town's open space and recreational resources and programs and identify trends that may affect these existing conditions, (2) assess community needs and desires as they relate to open space and recreation, and (3) provide targeted recommendations that will help the Town of North Reading continue its mission to conserve natural resources, preserve and develop community open spaces, and provide sufficient recreation opportunities for its residents.[100]

The 2016 Hazard Mitigation Plan is referenced within the OSRP, and similarly, the OSRP served as a key source of information in the update to the Hazard Mitigation Plan. Both plans effectively describe and address natural hazards and climate change through similar methods and recommendations, and they are mutually supportive. For example, they both recommend the Town pursue Low Impact Development strategies, green infrastructure, and similar nature-based solutions to address the impacts of development as it relates to flooding, erosion, sedimentation, and stormwater. The control of invasive species is also a community need that is specifically addressed in the OSRP. More information on the relevance and relationship between these two plans is provided in Table 35.

Town of North Reading Annual Report (2020)

The Town's 2020 Annual Report was reviewed for information regarding current mitigation actions and a current list of capabilities. Summary reports from each Town Department is included in the Annual Report. Many reports provided information on the Town's response to the Covid-19 pandemic, which had tremendous impacts to routine Town operations. Relevant updates from the Public Works Department included drainage system upgrades which were completed as part of the Town's annual paving program, and the design and permitting for the reconstruction of drainage on Elm Street from Haverhill Street to Rte. 62 (also completed in 2020). The Community Planning Commission's report included a series of updates related to implementation of the Master Plan, completion of the Open Space and Recreation Plan, and other projects for 2020. It also included a review of permitting activity and subdivision control projects, including the notation that no Floodplain Special Permits were issued in 2020. The Annual Report also included a detailed report from Martins Pond Reclamation Study Committee and the Martins Pond Association, including helpful information regarding localized flooding issues as well as invasive species at Martins Pond.

Emergency Dispensing Site Action Plan for North Reading (2019)

[100] Town of North Reading Open Space and Recreation Plan. 2020. P. 2.

The purpose of this plan, developed and maintained by the Health Department. is to lay out the steps for opening, operating, and closing an emergency dispensing site (EDS) in response to a public health emergency. Distribution and dispensing of medical countermeasures (MCM) are a critical response capability for public health and emergency management officials. MCM, such as antibiotics and vaccines, are used to prevent against, protect from, and as treatment for public health threats. Since many of the details for any emergency dispensing operation can be determined only after the details of the emergency are known, the action steps and resources described in this plan are designed to be modified as needed. The plan has been activated and relied upon by the Health Department in responding to the COVID 19 pandemic through the management and distribution of vaccines.

Town of North Reading Housing Production Plan (2018)

The purpose of North Reading's Housing Production Plan (HPP) is to promote strategic planning for future residential development that will fit its own needs for more diversity in housing types and affordability while still largely complementing North Reading's community character. It was prepared under the direction of the Town's Community Planning Commission in recognition of a widening affordability gap largely outside of the Town's control due to demographic and economic conditions. This situation has caused some previous residents to leave the community, some existing residents are struggling to stay, many who were raised in Town cannot afford to raise their own children locally, and most local workers are priced out of the housing market. This document serves as the roadmap for the Town to follow in producing housing that reflects local priorities and preferences.

Martins Brook Floodway Operation & Maintenance Plan (2014)

The purpose of the MBF-O&M Plan is to establish guidelines and procedures for inspecting and maintaining the Martins Brook stream channel and ensuring that the existing channel capacity is not compromised by debris, excessive vegetation growth, obstructions, unregulated filling and/or construction activities. The plan contains both proactive and reactive steps and is incorporated into this hazard mitigation plan by reference to support flood mitigation activities for Martins Brook and to alleviate flooding conditions in Martins Pond as further described in Chapter 4 (Risk Assessment).

Town of North Reading Comprehensive Emergency Management Plan (2012)

The Town's Emergency Management Director (EMD) has prepared a Comprehensive Emergency Management Plan (CEMP) for North Reading. The plan combines the four phases of emergency management, mitigation, preparedness, response, and recovery. The hazard mitigation plan is consistent with the hazards named in the CEMP, including floods, heavy rainstorms, nor'easters, hurricanes, tornadoes, drought, and earthquakes. The CEMP identifies the specific responsibilities of various Town officials and departments and in terms of mitigation, as well as the other three phases of emergency management. The hazard mitigation plan is consistent with the mitigation actions and responsibilities outlined in the CEMP.

Drought Management Plan for the Town of North Reading (2013)

The goal of North Reading's Drought Management Plan (DMP) is to identify a clear descriptive process in which anticipation of an unbalanced condition in the water supply and system demand is identified and measures required to prevent a failure of the water system are implemented.[101] The DMP is based upon specific factors related to the Town's water system and is considered a necessary tool to control increased water demands associated with drought conditions (reduction in supply). North Reading is limited in the amount of water in can provide residents, so balancing their needs in regard to water demands can be difficult, but it is especially critical during drought conditions. The DMP is designed to help with this process through a series of escalating control measures, such as water use restrictions, incentives for water conservation, or adjustments to supplemental water sources. The plan is revisited on a periodic basis to assess and improve the performance of drought management for the Town of North Reading. The DMP is primarily a response-oriented plan for managing drought events, but it provided helpful data and information for the risk assessment portion of the hazard mitigation plan.

Planning and Regulatory Findings

Table 35 represents Worksheet 4.1 from FEMA's Local Mitigation Planning Handbook. It was used by the Core Team to review the planning and regulatory capabilities of the Town including plans, policies, codes, and ordinances that prevent and reduce the impacts of hazards.

Table 35. Capability Assessment Worksheet: Planning and Regulatory Findings.

Plans	Yes/No & Year	Does the plan address hazards? Does the plan identify projects to include in the mitigation strategy? Can the plan be used to implement mitigation actions?
Comprehensive/Master Plan	Yes – 2020	The Town recently completed its first Master Plan since 2004, based heavily on input from community members, to help shape how and where the Town might grow moving forward. The plan addresses hazards and environmental constraints to development, including flooding, and identifies the protection of wetlands, floodplains, and other sensitive areas as critical. The plan references the Hazard Mitigation Plan, particularly with regard to the management of open space, and notes that the Town considers natural hazards in its development decisions.
Capital Improvements Plan	Yes – FY 2020	The Town's CIP is submitted to the Select Board each year by the Capital Improvements Planning Committee following its review of all capital requests from Town departments.

[101] Drought Management Plan for the Town of North Reading. 2013. P. ES-1.

Plans	Yes/No & Year	Does the plan address hazards? Does the plan identify projects to include in the mitigation strategy? Can the plan be used to implement mitigation actions?
		The CIP can be used to implement mitigation actions depending on available funding and the committee's priorities and recommendations.
Economic Development Plan	Yes – 2016	A short-term Economic Development Strategy was prepared by MAPC for the Town's main commercial corridor on Main Street, which includes the consideration of floodplains and wetlands as notable environmental features.
Local Emergency Operations Plan	Yes - 2012	The Comprehensive Emergency Management Plan (CEMP) does address specific hazards and mitigation responsibilities for Town officials and departments.
Continuity of Operations Plan	No	N/A
Transportation Plan	No	Although not considered a formal transportation plan, a study on paratransit options for North Reading was completed by MAPC in 2017, with specific focus on the mobility needs of the Town's elderly and disabled residents.
Stormwater Management Plan	Yes	The Town has a Stormwater Management Plan in place to protect water resources and prevent flooding. The DPW disseminates information to residents about the cause and effect of stormwater and the Town's policies, regulations, and initiatives that address it.
Community Wildfire Protection Plan	No	N/A – The Town experiences only small, localized brush fires that are quickly detected and extinguished (no need for a CWPP at this time).
Other special plans (e.g., brownfields redevelopment, disaster recovery, coastal zone management, climate change adaptation)	Yes – 2018	The Town's Municipal Vulnerability Preparedness (MVP) Plan was completed in 2018 to identify climate hazards, assess vulnerabilities, and develop action plans to improve resilience to climate change. The MVP plan focuses on flooding, winter storm, wind, and extreme temperature hazards and includes a prioritized list of projects to include in the mitigation strategy. Through adoption of this plan the Town has been designated as an MVP Community and is eligible for MVP Action Grants from the State to help implement priority actions.

Plans	Yes/No & Year	Does the plan address hazards? Does the plan identify projects to include in the mitigation strategy? Can the plan be used to implement mitigation actions?
		The Town's Open Space and Recreation Plan (OSRP) was updated in 2020 and specifically describes local hazards including drought, extreme heat, flooding, erosion, invasive species, and hazardous materials. The OSRP also effectively describes climate change and community needs as it relates to protecting natural resources and building community resilience through climate adaptation measures that are consistent with the Town's hazard mitigation strategies.

Building Code, Permitting, and Inspections	Yes/No	Are codes adequately enforced?
Building Code	Yes	Massachusetts State Building Code, 9th Edition (780 CMR), which includes of a series of international model codes (2015 ICC) and state-specific amendments adopted by the Board of Building Regulation and Standards (BBRS). The BBRS regularly updates the codes as new information and technology becomes available and change is warranted. The code is adequately enforced in North Reading through the Town's Building Department, with no enforcement or compliance issued noted by the Town's Building Commissioner.
Building Code Effectiveness Grading Schedule (BCEGS) Score	No	N/A – not yet rated by ISO, Inc.
Fire department ISO rating	Yes (2018)	04/4X

Land Use Planning and Ordinances	Yes/No	**Is the ordinance and effective measure for reducing hazard impacts?** **Is the ordinance adequately administered and enforced?**
Zoning ordinance	Yes	The Town has a Zoning Bylaw (Chapter 200), in addition to or inclusive of rules and regulations that are relevant to hazards including site plan review regulations, wetlands

Land Use Planning and Ordinances	Yes/No	**Is the ordinance and effective measure for reducing hazard impacts?** **Is the ordinance adequately administered and enforced?**
		protection, stormwater management, floodplain management, and aquifer protection.
Subdivision ordinance	Yes	The Town has a Subdivision of Land bylaw (Chapter 350). While the regulations have been adequate in years past some specific updates are needed relating to stormwater management and sedimentation/erosions control, as well as emergency access for firefighting vehicles and apparatus.
Floodplain ordinance	Yes	The Town has adopted a flood hazard ordinance in compliance with all NFIP standards (Chapter 200-44: Floodplain District). The Floodplain District is an overlay district superimposed on all other existing zoning districts. All uses and development in the Floodplain District, including structural and non-structural activities, is subject to all the provisions of this ordinance. The ordinance is effective for minimizing flood hazard impacts associated with new development and is adequately administered and enforced.
Natural hazard specific ordinance (stormwater, steep slope, wildfire)	Yes	The Town has a permitting process with bylaws and regulations that cover wetlands protection, stormwater management, and sedimentation and erosion. In the 2016 plan it was noted that the Town's Stormwater Management Bylaw needed some updates and improvements, specifically regarding exemptions and the minimum thresholds for triggering permit requirements. A mitigation action was identified to address this issue in the previous plan and through the Town's MVP Plan, but work is still needed to enhance the effectiveness of stormwater regulations for hazard risk reduction.
Flood Insurance Rate Maps	Yes	Official FIRMS are on file in the Town Hall. The Town has also made National Flood Hazard Layer (NFHL) data available through its Online Interactive Map Viewer. In August 2021, FEMA issued Preliminary FIRMs to all jurisdictions in Middlesex County. These updated map products are undergoing review by the Town and are scheduled to become effective by the end of 2022, along

Land Use Planning and Ordinances	Yes/No	**Is the ordinance and effective measure for reducing hazard impacts?** **Is the ordinance adequately administered and enforced?**
		with required updates to the Town's flood hazard ordinance.
Acquisition of land for open space and public recreation uses	Yes	Public funds are used to dedicate significant investments, for example, Swan Pond. These funds may come in the form of external grants or financing obligations (e.g., federal or state sources, land trusts, etc.) but can also be appropriated by the Town through Town Meeting. The 2020 OSRP identified the creation of a mechanism for funding and acquiring property that allows the Town to react quickly to opportunities as a current management need.

How can these capabilities be expanded and improved to reduce risk?

North Reading has strong planning and regulatory capabilities relating to hazards management, evidenced by its routine and recent updates to relevant town plans and regulations, as well as its adequate administrative and technical capabilities (further discussed below).

One meaningful way to improve the Town's planning and regulatory capabilities is related to the way it currently manages subdivision control and regulations through updates to its Subdivision of Land bylaw (Chapter 350). Over the years, North Reading has experienced a decrease in the number of subdivisions being developed, but an increase in the complexity associated with those that are under development today. Contemporary issues related to stormwater management, sedimentation, and erosion control (including offsite) need more attention through the implementation of the bylaw. Issues relating to flooding, loose soils, failing retention ponds, and offsite erosion extend beyond subdivision construction sites, and they are becoming more frequently reported through citizen complaints. Opportunities to increase the use of Low Impact Development (LID), No Adverse Impact (NAI), nature-based solutions, and other best management practices should be considered and incorporated into regulatory updates for the existing bylaw. Lastly, access and mobility for firefighting vehicles should be looked at again during any updates to existing subdivision regulations. These types of updates and enhancements to the Town's subdivision regulations, as well as any necessary administrative or technical capability improvements (i.e., inspections, reporting procedures, etc.) related to their enforcement, should be considered as a potential new mitigation action for this plan update.

Although not directly focused on hazard mitigation, another notable opportunity the Core Team identified regarding improving its planning capabilities is the development of a Continuity of Operations Plan (COOP) or Continuity of Government (COG) plan for the Town, perhaps as an annex to the CEMP.

Land Use and Zoning

The Town of North Reading has zoning provisions that protect wetlands, floodplains, and wellhead zones. These zoning regulations are critical to the future development of the Town. Since the initial Hazard Mitigation Plan was prepared in 2006 the Town has adopted and revised bylaws to protect open space and natural resources including the Open Space Residential Development bylaw (OSRD) in 2008 to replace its former Cluster Residential Development bylaw, and an Affordable Housing Overlay District.

The intent of the OSRD is to encourage more efficient forms of development and environmentally sensitive design that consume less land and protect open space and natural resources as well as provide a variety of housing choices. The bylaw provides that the Community Planning Commission may grant a special permit for the developments of six or more units in the RA, RR or RE districts provided the development meets the standards outlined in the bylaw including providing 50% of the total land as permanently protected common usable open space.

The Floodplain District is an overlay district, which includes wetlands and floodplains in the Town. Where its requirements conflict with those of the underlying zoning district, the more restrictive requirements are enforced. The floodplain boundaries are based on the 1-percent annual chance flood event (or 100-year flood) as designated by the FEMA on the Town's effective Flood Insurance Rate Maps (FIRMs).

The Town's Wetlands Bylaw protects wetlands, related water resources and adjoining lands which have a significant or cumulative effect on the quality of these resources. This bylaw falls under the jurisdiction of the Conservation Commission and regulates activities within 100 feet of the wetland areas. Specifically, the bylaw creates a 12-foot no-disturb zone around all wetlands resources and permits no more than 22% of the 100-foot buffer area to be covered by impervious surface material, and no more than 75% of the area to be altered significantly from its natural state. The Conservation Commission is also responsible for implementing the Wetlands Protection Act (and related Riverways Protection Act, see Section 4).

The Aquifer Protection District is an overlay district whose boundaries are determined by the primary and secondary recharge areas of the Town's public wellfields. Certain uses associated with a high risk of groundwater contamination are prohibited without exception and certain other uses require a special permit. Single-family dwellings are permitted by right, and certain commercial buildings on lots of at least 40,000 square feet with septic systems up to 1,500 gallons-per-day capacity are permitted by right in the secondary recharge areas only. There are restrictions on earth removal, grading, the extent of impervious coverage, snow disposal, and removal of vegetative cover. Within the boundaries of the Historic District, review by the Historic District Commission of all changes to exterior architectural features is required. Standards are based on certain architectural criteria relating to scale, proportion, and detail.

The Berry Center Smart Growth Overlay District (SGA) was established as part of the requirements of the Chapter 40R Act described earlier in this section to regulate redevelopment of the former J.T. Berry property. Regulations outline the requirements of site development including housing affordability.

In 2008 the Town adopted an Affordable Housing Overlay District to creating opportunities to increase housing diversity throughout Town and develop affordable housing including housing eligible to be included on the Chapter 40B Subsidized Housing Inventory. Zoning regulations outline use and site standards as well as affordability requirements.

The most recent build-out analyses to project future growth in North Reading were conducted more than twenty years ago. Build-out analyses illustrate the maximum development permitted according to the current local zoning in place. This information can be used to estimate future demands on public infrastructure and the environment.

The first study, by MAPC in 2000, projected the potential for the addition of 913 total new residential units. The second study, undertaken by the Town's Community Planning Commission (CPC) in 2001, projected the potential for 1,329 potential new homes. Reasons for the discrepancy in these projections were outlined in the Town's Community Development Plan and listed below:

- The Community Development Plan did not exclude large portions of wetlands, flood zone and river zone development, whereas MAPC did.
- The Community Development Plan included potential for in-fill development on parcels that had existing development, but MAPC only considered development potential on currently undeveloped parcels.
- The Community Development Plan build-out factors for subdivisions were based upon historical North Reading subdivision build-out data whereas MAPC's were not.

Build-out analyses are intended to be used as tools to guide development, but do not estimate the rate of development or how long it would take to reach build-out. Additional limitations of undeveloped land or the potential for redevelopment of existing parcels were not necessarily considered in the analysis. Therefore, the potential development densities and projected new units may be higher or lower than projected.

Implications of Growth and Development Patterns

Water supply protection continues to be an important factor to consider in any decisions about guiding future growth and development in North Reading. Protection of existing wells from contamination is a critical task. Town officials should continue to update and enforce local regulations including the Floodplain District, Aquifer Protection District, septic system regulations, stormwater runoff regulations, hazardous materials storage, and wetlands protection bylaws. Water preservation efforts will continue to be necessary, as well.

North Reading is a residential community and will likely continue to be so in the future. Its convenience to regional employment centers and attractive small-town character will continue to attract new residential development. At the same time, the community places a high value on its open spaces, public parks, and recreation areas. A balance will have to be struck between providing adequate services and affordable housing for residents while still protecting the valuable natural, scenic, and recreational resources of the Town.

While North Reading is primarily residential, there is a substantial amount of commercial and light industrial development along Concord Street, and commercial development along Route 28/Main Street. Both these parts of the Town have areas of floodplain and wetlands, with many commercial sites on both streets having had to file Notices of Intent, Aquifer Protection District special permits and Floodplain special permits prior to development or redevelopment. Another area of the Town with residential and some commercial growth, as well as important civic uses, is the historic Town center on Park Street. This area is constrained by substantial wetland, flood zone and riverfront.

The Town recently appropriated funds to design a sewer system to service the Concord Street, Main Street and North Street corridors. If the project continues as planned and a full sewer system is funded next year, the presence of sewer will change the Town's situation regarding septic discharges in these sensitive areas, and will also enable further development, including potentially substantial new residential development, along these two corridors that are currently characterized by low-intensity commercial activity.

Safe Growth Survey

As part of the plan update process, the Town Planner was asked to complete a Safe Growth Survey. This unique survey instrument was drawn from the Safe Growth Audit concept developed for the American Planning Association (APA) to help communities evaluate the extent to which they are positioned to grow safely relative to natural hazards. The survey covered six topic areas including the following:

- Land Use
- Transportation
- Environmental Management
- Public Safety, Zoning Ordinance
- Subdivision Regulations
- Capital Improvement Program and Infrastructure Policies

While somewhat of a subjective exercise, the Safe Growth Survey was used to provide some measure of how adequately existing planning mechanisms and tools for the Town of North Reading were being used to address the notion of safe growth. In addition, the survey instrument was aimed at further integrating the subject of hazard risk management into the dialogue of local community planning and to possibly consider and identify new actions as it relates to those local planning policies or programs already in place or under development. It is anticipated that the Safe Growth Survey will be used again during future updates to help measure progress over time and to continue identifying possible

mitigation actions as it relates to future growth and community development practices, and how such actions may better be incorporated into local planning mechanisms.

The results of the Safe Growth Survey are summarized in Table 36. Safe Growth Survey Results. This includes describing how strongly the Town Planner agrees or disagrees with 25 "Safe Growth Statements" as they relate to the Town of North Reading's current plans, policies, and programs for guiding future community growth and development, according to the following scale:

1=Strongly Disagree 2=Somewhat Disagree 3=Neutral 4=Somewhat Agree 5=Strongly Agree

Table 36. Safe Growth Survey Results.

MASTER PLAN	
Land Use	
1. The master plan includes a future land use map that clearly identifies natural hazard areas.	**1** 2 3 4 5
2. Current land use policies discourage development and/or redevelopment within natural hazard areas.	1 2 3 **4** 5
3. The master plan provides adequate space for expected future growth in areas located outside of natural hazard areas.	1 2 3 4 **5**
Transportation	
4. The transportation element limits access to natural hazard areas.	1 2 **3** 4 5
5. Transportation policy is used to guide future growth and development to safe locations.	1 2 **3** 4 5
6. Transportation systems are designed to function under disaster conditions (e.g., evacuation, mobility for fire/rescue apparatus, etc.).	1 2 **3** 4 5
Environmental Management	
7. Environmental features that serve to protect development from hazards (e.g., wetlands, riparian buffers, etc.) are identified and mapped.	1 2 3 **4** 5
8. Environmental policies encourage the preservation and restoration of protective ecosystems.	1 2 **3** 4 5

9.	Environmental policies provide incentives to development that is located outside of protective ecosystems.	1	2	**3**	4	5
Public Safety						
10.	The goals and policies of the master plan are related to and consistent with those in the Hazard Mitigation Plan.	1	2	3	**4**	5
11.	Public safety is explicitly included in the plan's growth and development policies.	1	2	3	**4**	5
12.	The monitoring and implementation section of the plan covers safe growth objectives.	1	2	3	**4**	5
ZONING ORDINANCE						
13.	The zoning ordinance conforms to the master plan in terms of discouraging development and/or redevelopment within natural hazard areas.	1	2	3	4	**5**
14.	The ordinance contains natural hazard overlay zones that set conditions for land use within such zones.	1	2	3	4	**5**
15.	Rezoning procedures recognize natural hazard areas as limits on zoning changes that allow greater intensity or density of use.	1	**2**	3	4	5
16.	The ordinance prohibits development within, or filling of, wetlands, floodways, and floodplains.	1	**2**	3	4	5
SUBDIVISION REGULATIONS						
17.	The subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas.	**1**	2	3	4	5
18.	The regulations provide for conservation subdivisions or cluster subdivisions in order to conserve environmental resources.	1	2	3	**4**	5
19.	The regulations allow density transfers where hazard areas exist.	**1**	2	3	4	5

CAPITAL IMPROVEMENT PROGRAM AND INFRASTRUCTURE POLICIES					
20. The capital improvement program limits expenditures on projects that would encourage development and/or redevelopment in areas vulnerable to natural hazards.	1	[2]	3	4	5
21. Infrastructure policies limit the extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards.	1	[2]	3	4	5
22. The capital improvements program provides funding for hazard mitigation projects identified in the Hazard Mitigation Plan.	1	2	[3]	4	5
OTHER					
23. Small area or corridor plans recognize the need to avoid or mitigate natural hazards.	1	2	3	4	[5]
24. The building code contains provisions to strengthen or elevate new or substantially improved construction to withstand hazard forces.	1	2	3	[4]	5
25. Economic development and/or redevelopment strategies include provisions for mitigating natural hazards or otherwise enhancing social and economic resiliency to hazards.	1	2	3	[4]	5

Administrative and Technical Findings

The Town of North Reading relies on strong administrative and technical capabilities through numerous committees, commissions, and departments under the leadership of the Select Board and a Town Administrator. Many of the local boards and committees are supported by citizen volunteers who coordinate closely on many important issues for the community. Those most relevant to hazard risk management include the Board of Health, Capital Improvement Planning Committee, Community Planning Commission, Conservation Commission, Land Utilization Committee, Martins Pond Reclamation Study Committee, Open Space and Recreation Plan Committee, Wastewater Planning Advisory Committee, and Zoning Board of Appeals. In addition, the work of these local boards and committees is supplemented by external community groups and non-profit organizations, such as the Martins Pond Association as described earlier in this chapter.

Figure 32 illustrates the Town of North Reading's Organization Chart as included in its 2020 Annual Report.[102] More detailed information on each Town department and the various local boards and

[102] Annual Report for the Town of North Reading. For the Year Ended December 31, 2020. P. 5.

committees, including a summary of their activities in 2020 is provided in the Annual Report. As noted in the report, 2020 was unlike any other year in terms of the challenges the nation and the Town faced due to the COVID-19 pandemic. However, the strength of the Town's existing administrative and technical capabilities helped keep Town operations running for the citizens of North Reading while also keeping the community safe.

Figure 32. Town of North Reading Organizational Chart.

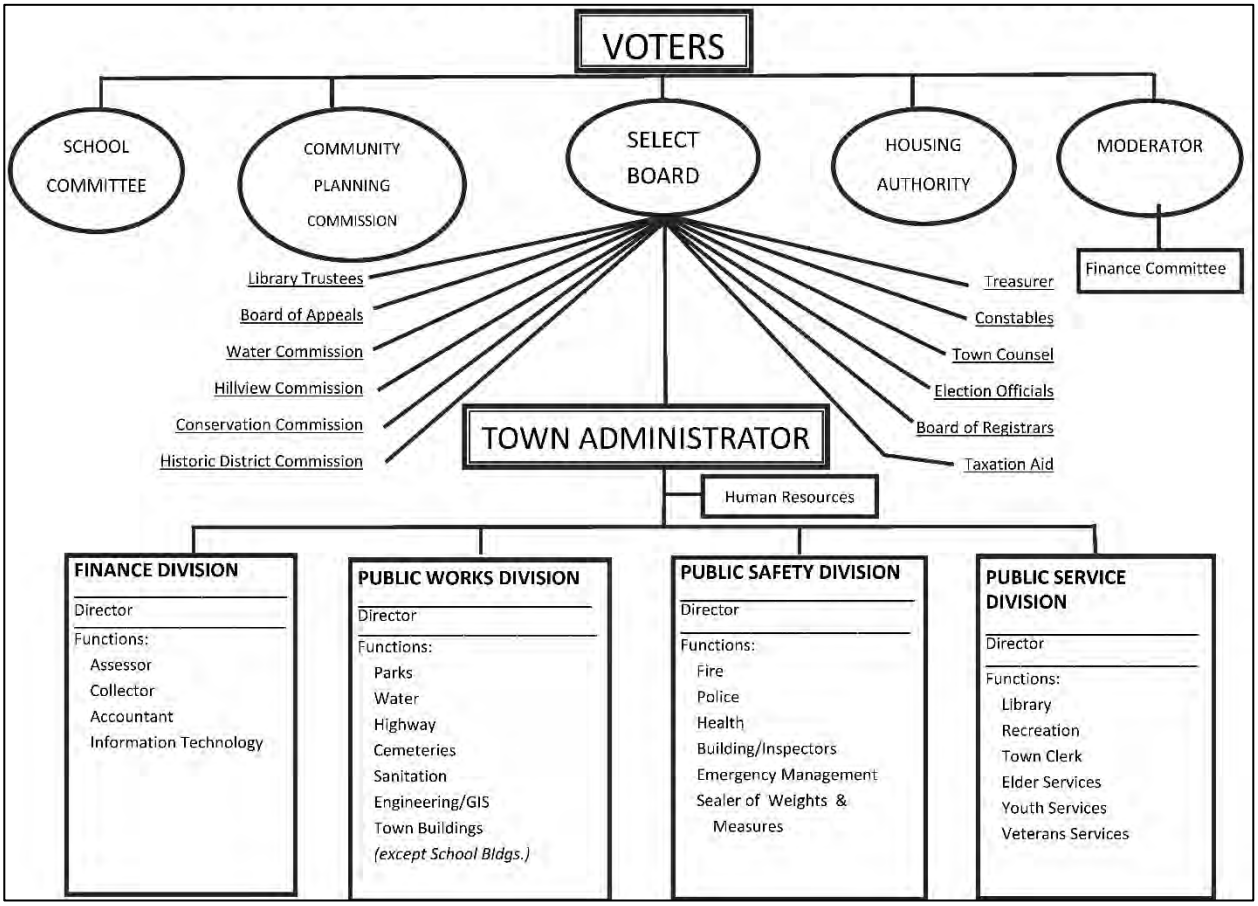


Table 37 represents Worksheet 4.1 from FEMA's Local Mitigation Planning Handbook. It was used by the Core Team to review administrative and technical capabilities of the Town. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions.

Table 37. Capability Assessment Worksheet: Administrative and Technical Findings.

Administration	Yes/No	Describe capability. Is coordination effective?
Community Planning Commission	Yes	The Community Planning Commission ("CPC") consists of five members elected to three-year terms of office, who actively

Administration	Yes/No	Describe capability. Is coordination effective?
		meet to review and issue decisions relating to development projects. The Community Planning Department acts as the administration for the CPC, providing technical assistance and plan review.
Mitigation Planning Committee	Yes	The Core Team (formerly known as the Hazard Mitigation Committee) was formed to create and implement this mitigation plan, with representation from a variety of the Town's key departments with responsibilities related to hazard risk management.
Maintenance programs to reduce risk (e.g., tree trimming, clearing drainage systems)	Yes	The Department of Public Works has an aggressive tree maintenance program. They also maintain roadways, bridges, and culverts to reduce flooding impacts as required.
Mutual aid agreements	Yes	North Reading's Police, Fire, and Public Works Departments are authorized to go to the aid of another city or town at the request of said city or town, and likewise North Reading may receive such aid from others as needed. For non-emergencies, the Town or North Reading is a member of the Tri-Town Consortium (along with the Towns of Lynnfield and Middleton) for the procurement of goods and services, including contractors for various technical projects.
Conservation Commission	Yes	The Conservation Commission is the official agency specifically charged with the protection of the Town's natural resources. The Commission is effective at coordinating with and advising other municipal officials and Town boards/commissions on conservation issues that relate to their areas of responsibility.
Economic Development Committee	Yes	The Economic Development Committee (EDC) acts as an advisory board to the Board of Selectmen and Community Planning Commission. The EDC focuses on developing the Town's economy and strengthening the local businesses. The EDC is supported administratively by the Community Planning Department and effectively coordinates with others as needed.
Wastewater Planning Advisory Committee	Yes	In 2010 the Town created the Water and Wastewater Commission to focus on stormwater issues and guide community decisions and actions. Today this is known as the Wastewater Planning Advisory Committee.

Staff	Yes/No	Is staffing adequate to enforce regulations? Is staff trained on hazards and mitigation? Is coordination between agencies and staff effective?
Chief Building Official	Yes	The Building Inspector fills this role, and he is well aware of hazards and mitigation. Coordination between agencies and Town staff is effective.
Floodplain Administrator	Yes	The Town Engineer now fills this role, and he is well aware of hazards and mitigation.
Emergency Manager	Yes	The Town's Emergency Management Coordinator is a part-time position with limited funding.
Community Planner	Yes	The Town Planner is not specifically trained on hazards or mitigation; however, she is particularly aware of flooding and stormwater-related risks and has a good understanding of other natural hazard threats facing the Town. She routinely coordinates with other Town staff as it relates to hazards and mitigation activities.
Civil Engineer	Yes	The Town Engineer is familiar with hazards and mitigation, particularly regarding flooding and stormwater issues, and serves as the Town's Floodplain Administrator. He routinely coordinates with other Town staff as it relates to hazards and mitigation activities.
GIS Coordinator	Yes	The Town now has a full-time GIS Coordinator position (previously this role was outsourced to a private vendor). The mission of North Reading's GIS program is to provide town-wide spatial information for mapping and analyzing data about the community. Data maintenance by Town staff is an on-going process but staffing is considered adequate at this time.
Other	Yes	The list of professionals and others come together as a Development Team to review large-scale projects.

Technical	Yes/No	Describe capability. Has the capability been used to assess/mitigate risk in the past?
Warning systems/services (Reverse 911, outdoor warning signals)	Yes	The Town has a Reverse 911 system. They also have two digital signboards that are strategically placed as needed. The Reverse 911 system and the signboards have been used during large snowstorms as well as during flooding events and during times of water shortage. The signs were placed on Route 62 and Haverill Street to warn of street closures due to flooding.
Hazard data and information	Yes	The Town's data and information capabilities related to hazards management have improved greatly with the transition from

Technical	Yes/No	Describe capability. Has the capability been used to assess/mitigate risk in the past?
		outsourcing GIS services to an internal, full-time coordinator position.
Grant writing	Yes	Both the Town Engineer and the Town Planner have grant writing experience. The Town Engineer prepared the grant applications for assistance to prepare this hazard mitigation plan as well as the Town's MVP Plan. In addition, Town staff are sometimes aided by outside consultants with the preparation of grant applications for capital project funding.
Hazus analysis	No	The Town currently does not use Hazus to assess/mitigate risk, but it can likely obtain the capability to do so through its GIS program in the future if needed.
Community Emergency Response Team (CERT)	No (but under development)	North Reading's Emergency Management Director is currently seeking volunteers to create a CERT to assist during emergencies.

How can these capabilities be expanded and improved to reduce risk?

The Town's existing administrative and technical capabilities are strong for a municipality of its size, and the various Town departments routinely coordinate well together on issues relating to hazards management. In addition to capable internal staff, the Town has numerous technical consultants to rely on when additional resources are needed for larger projects (for example, regarding flood control, culvert and culvert and drainage system maintenance, and stormwater management). It's likely that they could be enhanced through additional training opportunities on hazard mitigation and long-term climate adaptation, as well as the dedication of more staff time and/or other resources to support more grant writing in the pursuit of funding available for hazard risk reduction projects through federal, state, and other emerging sources.

Financial Findings

Table 38 represents Worksheet 4.1 from FEMA's Local Mitigation Planning Handbook. It was used by the Core Team to identify the Towns eligibility and access to a variety of funding sources for the implementation of hazard mitigation actions.

Table 38. Financial Findings.

Funding Resource	Access/ Eligibility (Yes/No)	**Has the funding resource been used in past and for what type of activities?** Could the resource be used to fund future mitigation actions?
Capital improvements project funding	Yes	There is a Capital Improvement Planning Committee that meets for several months leading up to Town Meeting to review and rank projects that are requested by each department. Projects are normally voted together rather than individually at Town Meeting. Funding is approved for projects at Town Meeting.
Authority to levy taxes for specific purposes	No	N/A
Fees for water, sewer, gas, or electric services	Yes	The Town does collect fees for water but not for sewer. Gas and electric services are private. Fees collected may not be used to fund future mitigation actions.
Impact fees for new development	No	N/A
Storm water utility fee	No	N/A, though this is something the Town may consider in the future.
Incur debt through general obligation bonds and/or special tax bonds	No	N/A
Incur debt through private activities	No	N/A
Community Development Block Grant	Yes	The Town can pursue non-entitlement CDBG grants from HUD (last done in 2015), though mitigation actions are typically not funded unless through a disaster recovery grant (CDBG-DR).
Other federal funding programs	Yes	The Town has received FEMA hazard mitigation grant funding in the past to assist with flood mitigation projects, and this will remain a resource to fund more mitigation actions in the future. The Town also receives EPA 604(b) Grant funding for water quality projects.
State funding programs	Yes	As a state-designated MVP Community, the Town is eligible to apply for MVP Action Grants from EEA to advance priority climate adaptation actions to address climate change impacts resulting from flooding, extreme weather, flooding, extreme heat, and other climate-related hazards. The Town also receives DEP 319 Grant funding to assist with projects that

Funding Resource	Access/ Eligibility (Yes/No)	**Has the funding resource been used in past and for what type of activities?** Could the resource be used to fund future mitigation actions?
		focus on nonpoint source pollution, management planning, and stormwater.

How can these capabilities be expanded and improved to reduce risk?

As noted above, North Reading's financial capabilities could be expanded through the dedication of more staff time and/or other resources to support more grant writing in the pursuit of funding available for hazard risk reduction projects through federal, state, and other emerging sources. This should include FEMA's Hazard Mitigation Assistance (HMA) funding programs as well as a variety of sources made available each year through the Commonwealth, such as EEA's MVP program and other related assistance programs, such as DER's Culvert Replacement Municipal Assistance Grant Program. Lastly, as noted in the Town's OSRP, it is recommended that the Town explore creating a mechanism for funding and acquiring property that allows the Town to react quickly to opportunities for increasing its lands dedicated for open space or recreation uses.

Finally, it is also worth noting that the Town was required to make dramatic reductions to the FY-2021 operating budget due to economic uncertainty related to the COVID-19 pandemic, which resulted in several departmental requests not being able to be filled and in multiple positions being held vacant. A reduced capital plan was also advanced to Town Meeting, followed by supplemental capital appropriations in October.

Education and Outreach Findings

Table 39 represents Worksheet 4.1 from FEMA's Local Mitigation Planning Handbook. It was used by the Core Team to identify education and outreach programs used to implement mitigation activities.

Table 39. Education and Outreach Findings.

Program/Organization	**Yes/No**	**Describe program/organization and how relates to disaster resilience and mitigation.** **Could the program/organization help implement future mitigation activities?**
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access, and functional needs	Yes	The Martins Pond Association is actively involved in environmental protection, including the treatment of invasive species. They also work toward mitigating the flooding risk to protect all their constituents.

Program/Organization	Yes/No	Describe program/organization and how relates to disaster resilience and mitigation. Could the program/organization help implement future mitigation activities?
populations, etc.		
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education)	Yes	The Martins Pond Association does some public education and outreach specific to flooding.
Natural disaster or safety related school programs	Yes	The police and fire departments work with the school district on education programs as well as safety planning.
StormReady certification	No	The North Reading Fire Department and the Emergency Management Director do storm preparedness, but they are not certified with StormReady.
Firewise Communities certification	No	Not particularly applicable to North Reading as they experience only minor brush fires which are quickly detected and suppressed through municipal fire protection services.
Public-private partnership initiatives addressing disaster related issues	Yes	Martins Pond Association worked actively with the Core Team and works with many other Town entities.
Other		Benevento works to mitigate risk to the Benevento culvert. Moynihan Lumber works with the Town to mitigate flood risk on their property as well.

How can these capabilities be expanded and improved to reduce risk?

North Reading's education and outreach capabilities to reduce risk may be improved through future risk communication and awareness campaigns, and particularly as it relates to flood hazards. Members of the Core Team expressed their concern that residents in general are underinsured when it comes to flood insurance, so a focus for future education and outreach activities will be on communicating flood risk, as well the availability of flood insurance and possibly financial assistance for flood mitigation projects that will reduce risk at the individual or neighborhood level. These activities should be coordinated with any outreach efforts associated with the Town's forthcoming adoption of updated FEMA Flood Insurance Rate Maps (FIRMs) and required updates to the Town's Floodplain Overlay District bylaw which is anticipated in 2023.

National Flood Insurance Program (NFIP) Participation and Compliance

As summarized in Table 40, the Core Team used Worksheet 4.3 from FEMA's Local Mitigation Planning Handbook to collect information regarding the Town's participation in and compliance with the NFIP. This worksheet, in addition to a separate NFIP Survey for the Town's Community Floodplain Administrator, helped the Core Team to identify areas for improvement and other ideas that could be potential mitigation actions. These actions, including those related to continued compliance with NFIP requirements, are identified and further discussed in Chapter 6 (Mitigation Strategy). Also, Chapter 4 (Risk Assessment) has a subsection for NFIP information within the hazard profile for Flooding. This section describes the Town's participation in the NFIP, including information on the number of currently active policies, total coverage, premiums paid, and past claims. It also provides detailed information on repetitive loss properties located within North Reading as provided by FEMA.

Table 40. NFIP Participation and Compliance Findings.

NFIP Topic	Source of Information	Comments
Insurance Summary		
How many NFIP policies are in the community? What is the total premium and coverage?	State NFIP Coordinator, FEMA Community Information System	As of September 2, 2021, 43 NFIP policies are in North Reading. Total premium is $59,368 for a total of $11,192,900 coverage in force.
How many claims have been paid in the community? What is the total amount of paid claims? How many of the claims were for substantial damage?	State NFIP Coordinator; FEMA Community Information System	122 flood losses reported since 1978, totaling $790,590, including one paid loss for substantial damage.
How many structures are exposed to flood risk within the community?	GIS Coordinator	It has been estimated that 2,236 properties are at risk for the combined total of 1.0 percent annual chance and 0.2 percent annual chance.
Describe any areas of flood risk with limited NFIP policy coverage	Community Floodplain Administrator (FPA)	No specific areas identified, though in general it is believed that property owners located in floodplain areas are underinsured when it comes to NFIP policy coverage.
Staff Resources		
Is the Community FPA or NFIP Coordinator certified?	Community FPA	The Town Engineer functions as the floodplain manager but is not currently certified as a CFM.
Is floodplain management an auxiliary function?	Community FPA	Yes

NFIP Topic	Source of Information	Comments
Provide an explanation of NFIP administration services (e.g., permit review, GIS, education or outreach, inspections, engineering capability)	Community FPA	Any changes or updates to the Town's FIRM maps must be approved at Town meeting. Once approved, the Town's building permit process, wetlands permitting process, and zoning bylaw control activities in the floodplain. However, the last step is issuance of a building permit, which is under the complete control of the Building Inspector.
What are the barriers to running an effective NFIP program in the community, if any?	Community FPA	No barriers identified. The State's Flood Hazard Management Program provides useful information and resources to assist the Town with running an effective program.
Compliance History		
Is the community in good standing with the NFIP?	State NFIP Coordinator, FEMA NFIP Specialist, community records	Yes
Are there any outstanding compliance issues (i.e., current violations)?		No
When was the most recent Community Assistance Visit (CAV) or Community Assistance Contact (CAC)?		Last CAC was 3/7/2017 Last CAV was 3/17/2004
Is a CAV or CAC scheduled or needed?		No
Regulation		
When did the community enter the NFIP?	FEMA Community Status Book	4/3/1978
Are the FIRMs digital or paper?	Community FPA	Digital
Do floodplain development regulations meet or exceed FEMA or State minimum requirements? If so, in what ways?	Community FPA	Floodplain regulations are met by the Conservation Commission and Zoning Bylaws, which meet all current FEMA/NFIP requirements and State minimum requirements. These regulations will be routinely updated as necessary

NFIP Topic	Source of Information	Comments
		to maintain compliance with existing NFIP and State minimum standards for floodplain management.
Provide an explanation of the permitting process.	Community FPA, community records	As stated above, most activities are regulated through various local permitting regulations. The most significant are building location and loss of flood storage. These local regulations must meet the State's minimum requirements. They can be more restrictive, not less. The Building Inspector and Conservation Commission (ConCom) are aware of all requests to perform work within the floodplain through the permitting process. The 100-year floodplain is considered a resource area by the MA Wetland Protection Act. No work (filling) can proceed without filing a Notice of Intent and receiving an Order of Conditions through the ConCom. Any structure getting through the ConCom process would then need a Building Permit signed by the Building Inspector.
Community Rating System (CRS)		
Does the community participate in CRS?	Community FPA	No – however, the Town will continue to explore the benefits of CRS participation as Risk Rating 2.0 goes into effect and as changes to the CRS program are made by FEMA.
What is the community's CRS Class Ranking?		N/A
What categories and activities provide CRS points and how can the class be improved?	N/A	N/A
Does the plan include CRS planning requirements	Yes	Yes – many of the planning requirements under CRS Activity 510 are included in this plan but will not be evaluated or scored for credit until the Town decides to apply for CRS participation.

Regional Relationships

The Town of North Reading has an excellent relationship with adjacent communities. For example, the Town of Wilmington typically responds to North Reading's request to clear the Route 62 culvert on

Martins Brook whenever debris/beavers cause backups. Since the 2016 plan was completed, North Reading has also developed Memorandums of Understanding with the Towns of Wilmington and Andover (as well as the State Department of Conservation and Recreation) to help monitor any current or proposed activities within the Martins Brook watershed, taking into consideration the potential impact to homes and businesses located in the Martins Brook Floodplain. The Town also works with the Town of Middleton relative to the operation of the Bostik Dam during floods along the Ipswich River.

North Reading also collaborates with the Ipswich River Watershed Association (IRWA). Their mission is to make sure that the river will be clean and healthy for the benefit and enjoyment of people, and for the aquatic life in the river. Guided by this mission, IRWA directs a series of innovative and interconnected programs that strive for both scientific excellence and community awareness and participation. Driven by the energy and expertise of volunteers and partnering scientific institutions, technical programs are designed to yield valid data on the health of the Ipswich River and its greater ecosystem. Education programs provide Ipswich River watershed citizens and communities with the information and tools they need to preserve the health of their river.

Conclusion

The Town of North Reading's capabilities for hazard mitigation haven't changed much since the previous hazard mitigation plan was completed, though several enhancements are notable. This includes the creation of the Town's own internal GIS program (including a full-time GIS Coordinator), decreasing their reliance on an outside vendor for GIS-related services. It also includes the completion of updates to several key planning documents such as the Town's Master Plan and Open Space and Recreation Plan. The preparation of the Town's MVP Plan has also greatly enhanced and renewed the community's focus on mitigating the impacts of natural hazards, climate change, and changing future conditions.

The Town of North Reading continues to prove that they can effectively mitigate risk by implementing multiple mitigation projects; these are identified in the next chapter. The Town has successfully received grant funding for mitigation projects. The Town Department heads are aware of their department's role in hazard mitigation. Since 2006 when the first version of this plan was written, many departments have added hazard mitigation measures in their plans. Overall, the Town does recognize hazard risk when considering building and infrastructure development.

Chapter 6. Mitigation Strategy

The hazard mitigation strategy is the culmination of work presented in the planning area profile, risk assessment and capability assessment. It is also the result of multiple meetings and thorough public outreach. The work of the Core Team was essential in developing the mitigation goals and actions included in this chapter. As described in Chapter 3 Planning Process, the Core Team worked in a consistent, coordinated manner to identify and prioritize the goals and mitigation actions for this Plan.

Mitigation Goals

Mitigation goals represent broad statements that are achieved through the implementation of more specific mitigation actions. These actions include both hazard mitigation policies (such as land use regulations) and hazard mitigation projects (such as structure or infrastructure projects). To develop goals for this Hazard Mitigation Plan Update the Core Team reviewed the previous plan's goal statements, the Municipal Vulnerability Preparedness (MVP) plan goal statements, and the goals of the State's Hazard Mitigation and Climate Adaptation Plan.

The Core Team made slight revisions to the 2016 Mitigation Plan goal statements by adding reference to climate change and removing the action related to Disaster Response. They also categorized the goal statements in the following areas of focus:

- Save Lives and Property
- Public Awareness and Education
- Regional Collaboration and Capacity Building
- Community Planning

The Core Team believes that these are the four main areas of action needed to mitigate natural hazard risk in North Reading and increase the Town's ability to withstand natural hazards. All the hazards identified in this plan, while not named specifically in the goal statements, are implied and many named specifically in the mitigation actions. The goal statements when achieved mitigate risk to all identified hazards. The 2021 Hazard Mitigation Plan Update goal statements are shown in the figure below.

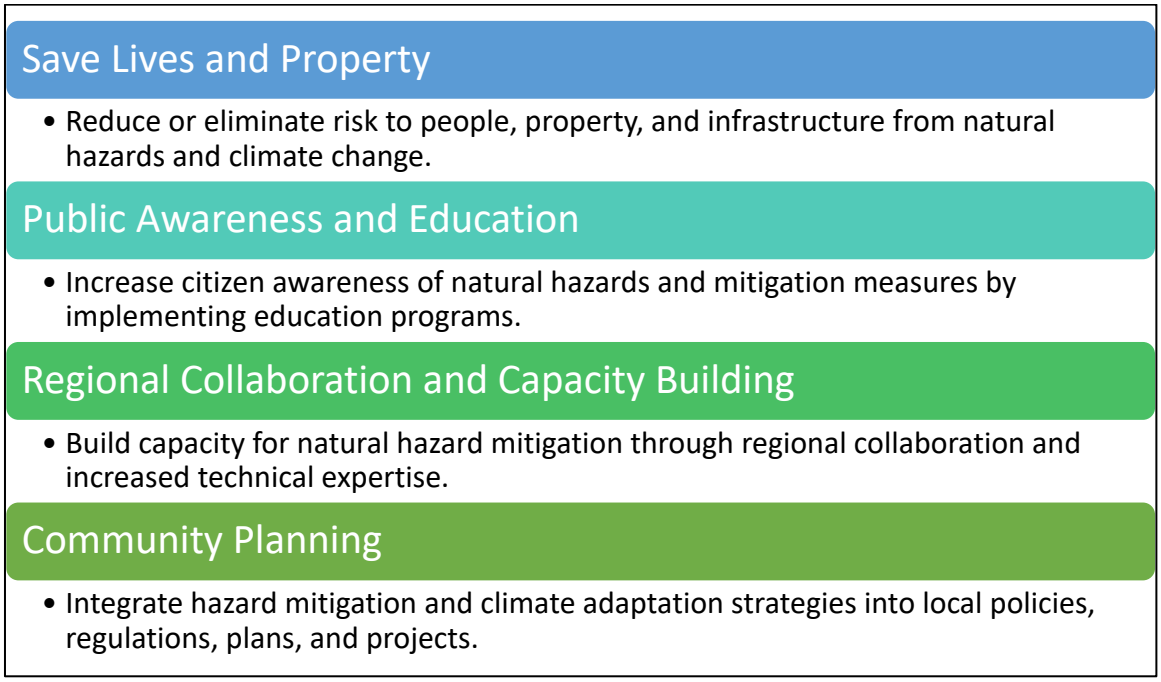


Figure 33. 2021 Hazard Mitigation Plan Goal Statements.

The mitigation actions from the 2016 Hazard Mitigation Plan were reviewed for their status and relevance to this plan update. The following table shows the previous plan's twenty-three mitigation actions and the status of each. Some of the actions that were marked as "delayed" or "to be continued" were included in this plan in combination with other actions, some were deemed no longer relevant.

Table 41. 2016 Mitigation Plan Action Status.

Project Description	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
Develop a comprehensive debris management response plan for post extreme weather events.	DPW	Town	$25,000	Delayed
Expand the Town's GIS with pre-designed maps.	DPW	Town/FEMA	$25,000	Partially Completed or In Progress
Purchase a generator for the senior center.	Elder Services	Town/FEMA	$20,000	Completed
Develop a Town Community Emergency Response Team (CERT).	Emergency Management	Town	$5,000	Delayed
Adopt the Operation and Maintenance Plan for Martins Brook.	Martin's Pond Association	Town	$5,000	Delayed

Project Description	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
Replace and upgrade the Benevento Culvert.	Martin's Pond Association	Private	$500,000	Delayed
Implement channel clearing and maintenance between Benevento and the pond.	Martin's Pond Association	Town	$20,000	Partially Completed or In Progress
Coordinate with USGS and Ipswich River Watershed for flow monitoring stations at key locations.	DPW & Martin's Pond Association	Town/MA Riverways Program	$40,000	Completed
Update the Ipswich River FEMA Flood Mapping Study.	Building Inspector & Town Engineer	FEMA	Not Available	Delayed
Raise Profile of Burroughs Road to reduce overtopping and maintain access to west side of pond.	DPW	Town/FEMA	$1,000,000	Delayed
Move all critical equipment, debris, etc., out of the 100-year floodplain near the DPW garage.	DPW	Town	$50,000	Completed
Flood-proof the Town's water supply facilities up to the 500-year flood elevation, especially the Central Street well field pumping facility.	DPW & Utility Department	Town/FEMA	$100,000	Partially Completed or In Progress
Establish a Floodplain and Stormwater Management Public Education Program.	DPW	Town	$10,000	Delayed
Replace the Chestnut Street Culvert over the Ipswich River to prevent overtopping of the roadway.	DPW	Town/FEMA	$750,000	Delayed
Detain stormwater upstream of Lindor Road by installing control weirs at three locations per Green International study.	DPW	Town/FEMA	$50,000	Delayed
Review current operation/maintenance procedures within the Town relative to cleaning storm drain systems. Consider creating a stormwater utility for	DPW	Town	$25,000	Partially Completed or In Progress

Project Description	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
funding for maintenance and capital improvements.				
Replace the Haverhill Street Culvert and raise the profile of Haverhill Street.	DPW	Town/FEMA	$500,000	Delayed
Develop a public education campaign regarding tree care on private property relative to electric wires.	DPW	Town/FEMA	$500,000	Delayed
Build a storage shed for a season's supply of rock salt.	DPW	Town/ MassDOT	$200,000	Completed and to be continued
Evaluate the structural capacity of flat roofs on critical and public facilities.	DPW	Town/FEMA	$35,000	Delayed
Renovate DPW garage with facilities to accommodate Town employees during severe weather events and disasters.	DPW	Town/FEMA	$150,000	Completed and to be continued

The Municipal Vulnerability Preparedness (MVP) plan was developed in 2018 and includes twenty-three suggested actions. The MVP is part of a Massachusetts state-wide initiative through the Executive Office of Energy and Environmental Affairs (EEA) to provide support to cities and towns to plan for resiliency and implement climate change adaptation actions. The actions identified in North Reading's MVP were reviewed and considered when developing mitigation actions for this plan update. Below is the status of each of the MVP actions as of Fall 2021.

Table 42. MVP Action Status.

Project No.	Mitigation Action	Timeframe	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
1	Establish a Floodplain and Stormwater Management Public Education Program.	2018	DPW	Town	$10,000	Delayed
2	Develop a Town Community Emergency Response Team (CERT).	2018	Emergency Management	Town	$5,000	Delayed

Project No.	Mitigation Action	Timeframe	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
3	Adopt the Operation and Maintenance Plan for Martins Brook.	2018	Martin's Pond Association	Town	$5,000	Delayed
4	Collect data to be used toward future benefit-cost-analysis.	2018-2019	DPW	Town	Minimal Town Funds	
5	Updates to the Stormwater Bylaw so all projects exceeding the 1-acre threshold comply with the bylaw.	2018-2019	Community Planning Commission, Town Planner	Flood	Minimal Town Funds	Completed
6	Coordinate with USGS and Ipswich River Watershed to access flow monitoring information along Ipswich River. Install monitors at key locations on Martins Brook.	2016-2017	DPW & Martin's Pond Association	Grants	$40,000	Completed
7	Expand the Town's GIS with pre-designed maps and the updated base map for asset management during disaster events.	2018	DPW	Town	Minimal Town Funds	Partially Completed or In Progress
8	Support upgrade of the Benevento Culvert along Martins Brook.	2018-2020	Martin's Pond Association	Private	$500,000	Delayed
9	Implement channel clearing and maintenance between Benevento and the pond.	2018-2019	Martin's Pond Association	Town	$20,000	
10	Renovate DPW garage with facilities to accommodate Town employees during	2018-2020	DPW	Town/ FEMA	$150,000	Partially Completed or In Progress

Project No.	Mitigation Action	Timeframe	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
	severe weather events and disasters. Create Emergency Action Plan for access through flooded access roads					
11	Review current operation/maintenance procedures within the Town relative to cleaning storm drain systems. Consider creating a stormwater utility for funding for maintenance and capital improvements.	2018-2019	DPW	Town	$25,000	Partially Completed or In Progress
12	Rehabilitate Three salt storage shed for a season's supply of rock salt.	2018-2020	DPW	Town/ MassDOT	$200,000	Partially Completed or In Progress
13	Develop a public education campaign under the leadership of Reading Municipal Light Department regarding tree care on private property relative to electric wires.	2018	DPW	Town/ RMLD	$10,000	Delayed
14	Develop a comprehensive debris management response plan for post extreme weather events.	2018	DPW	Town	$25,000	Partially Completed or In Progress
15	Update the Ipswich River FEMA Flood Mapping Study.	2018	Building Inspector & Town Engineer	FEMA	$100,000	
	Develop H&H Models for both Ipswich River					Delayed

Project No.	Mitigation Action	Timeframe	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
	and Martins Brook Watersheds that consider Climate Change Projections					
16	Replace the Chestnut Street Culvert over the Ipswich River and raise existing road grade to prevent overtopping	2018-2020	DPW	Town/ FEMA	$750,000	Delayed
17	Replace the Haverhill Street Culvert and raise the Haverhill Street roadway.	2018-2020	DPW	Town/ FEMA	$500,000	Delayed
18	Purchase a permanent generator for the senior center.	2018	Elder Services	Town/ FEMA	$20,000	Delayed
19	Evaluate the structural capacity of flat roofs on critical and public facilities. Install strain gauges to monitor snow loads.	2018	DPW	Town/ FEMA	$35,000	Delayed
20	Flood-proof the Town's water supply facilities up to the 500-year flood elevation, especially the Central Street well field pumping facility.	2018-2019	DPW & Utility Department	Town/ FEMA	$100,000	Partially Completed or In Progress
21	Move all critical equipment, debris, etc., out of the 100-year floodplain near the DPW garage.	2016-2017	DPW	Town	$50,000	Completed
22	Raise Profile of Burroughs Road to reduce overtopping	2018-2022	DPW	Town/ FEMA	$1,000,000	Delayed

Project No.	Mitigation Action	Timeframe	Responsible Organization	Potential Funding Source	Estimated Cost	Current Status
	and maintain access to west side of pond.					
23	Detain stormwater upstream of Lindor Road by installing control weirs at three locations per Green International study.	2018-2019	DPW	Town	$25,000	Delayed

Comprehensive Range of Mitigation Actions

Beyond reviewing the mitigation actions from previous plans, the Core Team considered a comprehensive range of mitigation actions. During each Core Team meeting, the group was educated on the possible range of mitigation actions. The Federal Emergency Management Agency's online Mitigation Ideas publication was shared, and the following list of example actions was shared electronically with the Core Team.

Table 43. Types of Mitigation Actions.

Mitigation Action Category	Examples of Mitigation Actions
Local Plans and Regulations	• Comprehensive plans • Land use ordinances • Subdivision regulations • Development review • Building codes and enforcement • NFIP Community Rating System • Capital improvement programs • Open space preservation • Stormwater management regulations and master plans
Structure and Infrastructure Projects	• Acquisitions and elevations of structures in flood-prone areas • Utility undergrounding • Structural retrofits • Floodwalls and retaining walls • Detention and retention structures • Culverts
Natural Systems Protection	• Sediment and erosion control • Stream corridor restoration

Mitigation Action Category	Examples of Mitigation Actions
	• Forest management • Conservation easements • Wetland restoration and preservation
Education and Awareness Programs	• Radio or television spots • Websites with maps and information • Real estate disclosure • Presentations to school groups or neighborhood organizations • Mailings to residents in hazard-prone areas
Preparedness and Response Actions	• Creating mutual aid agreements with neighboring communities to meet emergency response needs • Purchasing radio communications equipment for the Fire Department • Developing procedures for notifying citizens of available shelter locations during and following an event

The Core Team considered previously identified actions, areas of weakness and mitigation opportunities identified in the risk assessment and capability assessment, as well as the possible types of mitigation actions when developing the action list for this plan update.

Mitigation Action Plan

An online Mitigation Action Tracker was developed for the Town to track the implementation of each mitigation action. The Mitigation Action Tracker is a Google Sheet with separate tabs showing pre-sorted actions and can sort the list of actions based on several criteria or essential details. These details listed below are included to facilitate the Town's ability to sort through the actions as well as to apply for grant funding.

- Action Title
- Action Description
- Implementation Timeline
- Responsible Department
- Supporting Agencies
- Potential Funding Sources
- Estimated Cost
    - High (over $100,000)
    - Medium ($20,000 - $100,000)
    - Low (under $20,000)

- Benefit (high, medium, low)
- Hazard(s) Addressed
- Critical Facility Protection
- Type of Mitigation Action
- Priority

Details sorting the actions are included in Appendix B.

- Hazards Addressed and Critical Facilities Protected
- Types of Mitigation Actions

The priority order was chosen based weighing cost versus benefits. Benefits were given a weighting of high, medium, or low based on the following criteria.

- High – action will result in a significant risk reduction for people and/or property from a hazard event
- Medium – action will result in a moderate risk reduction for people and/or property from a hazard event
- Low – action will result in low-risk reduction for people and/or property from a hazard event

Finally, the actions were sorted into priority order based on the following criteria. The Town recognizes that they may implement actions in any order. The priority list is meant to function as a guide. Actions will be implemented in the order the Town receives funding. Appendix B includes the Action Priority Ranking Consideration table.

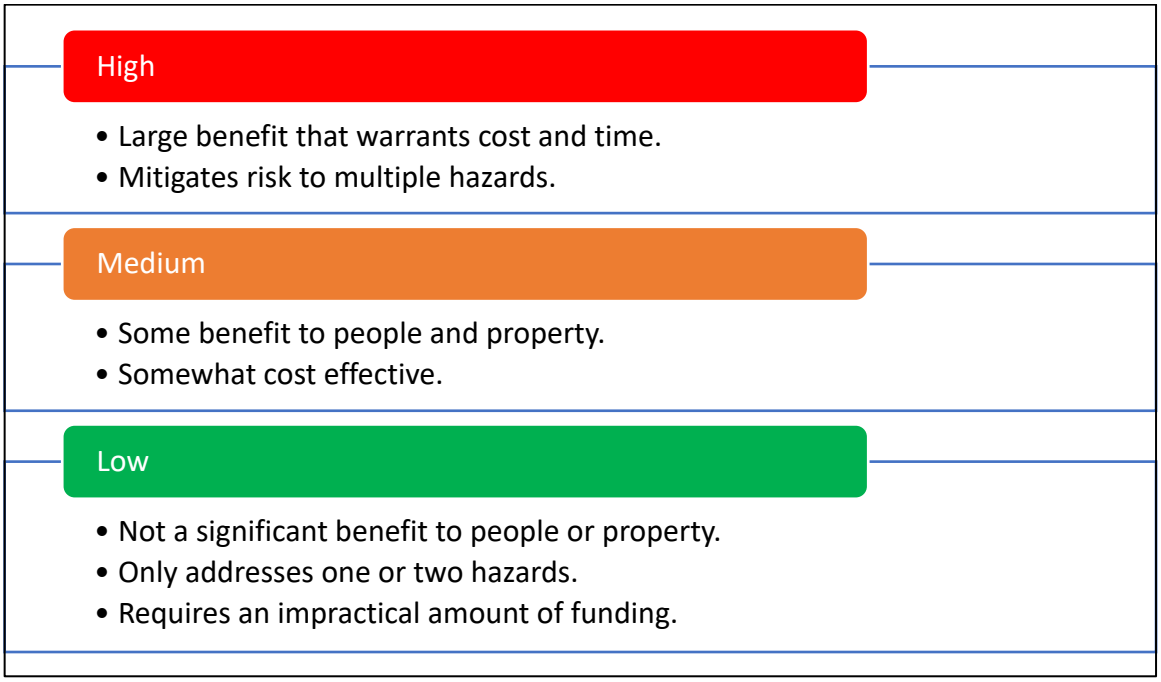


Figure 34. Priority Ranking Criteria.

Below is a list of all mitigation actions sorted by priority. The highest-ranking actions are shown in red, the medium priority actions in orange, and the low priority actions in green. The Core Team and the Town Selectmen understand that mitigation actions may not be implemented in order of priority, they may be implemented in the order by which they receive funding. The actions are also included in Appendix C.

Table 44. 2021 Hazard Mitigation Actions.

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
High Priority Actions						
1	**Conduct flood risk and NFIP education and outreach.**	Conduct a public outreach campaign to property owners in the Special Flood Hazard Area and in other flood prone areas to be aware of the value of flood insurance and possible mitigation actions they can take. Educate homeowners about the value of obtaining flood elevation certificates and potentially modifying their basements into flow-through crawl spaces to prevent excessive flood insurance premiums and damages. Develop maps to support this effort by identifying the SFHA and identifying older structures that may no longer have a mandatory flood insurance requirement due to ownership.	Engineering Division	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant or FEMA/MEMA	January 2022 - December 2027	Community Planning Department
2	**Replace culverts on Haverhill Street and Chestnut Street and raise the profile of these roads.**	These culverts are insufficient for rain the town receives.	Engineering Division	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant or FEMA/MEMA Division of Ecological Restoration (DER) Culvert Replacement	January 2022 - December 2032	Community Planning Department

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
				Municipal Assistance Grant Program		
3	**Replace Park Street Bridge over Martins Brook.**	Flooding overtops this bridge, and it should be replaced.	Engineering Division	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant, FEMA, MA Department of Transportation (DOT)Chapter 90, Municipal Small Bridge Program	January 2022 - December 2032	Community Planning Department
4	**Bridge and culvert upgrades.**	Maintain a list of all town owned bridges and culverts and their effectiveness. Replace inadequate structures.	Public Works Department, Engineering Division	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant or FEMA/MEMA, Division of Ecological Restoration (DER) Culvert Replacement Municipal Assistance Grant, MA Department of Transportation (DOT)Chapter 90, Municipal Small Bridge Program Program	January 2022 - December 2032	Community Planning Department

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
5	**Review Stormwater Bylaw.**	Identify what triggers a Building Inspector review. Consider whether subdivision regulations should be adjusted to result in less pervious surface in developments (roadway width is 28 feet, for example); need recommendations on how to reconcile LID best practices with current regs relating to traffic/fire safety which require more pavement, as well as weighing LID against need for accessibility measures such as sidewalks. Make this consistent with Low Impact Development (LID).	Community Planning	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant	January 2022 - December 2027	Engineering Division
6	**Subdivision regulations review.**	Make sure regulations are consistent with stormwater permit regulations. Incentive nature-based solutions and green building practices.	Community Planning	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant	January 2022 - December 2027	Engineering Division
7	**Add stand-alone automatic generators to the Senior Center.**	Add permanently wired, automatic generators to the Senior Center.	Building Department	FEMA/MEMA	January 2022 - December 2027	Department of Public Works
Medium Priority Actions						

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
8	**Snow load capacity.**	Evaluate the structural capacity of flat roofs on critical public facilities. Install strain gauges to monitor snow loads.	Building Department	FEMA/MEMA	January 2022 - December 2027	Department of Public Works
9	**Establish a public outreach campaign for hazard mitigation on private property.**	Prepare written educational materials, for distribution and web publication, that make the public aware of what steps need to be taken for certain types of work on their properties and the reasons for regulation. Include tree care and electric wire caution.	Building Department	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant or FEMA/MEMA	January 2022 - December 2027	Community Planning Department, Public Safety
10	**Develop an outreach and education campaign for all hazards with an emphasis on high-risk hazards such as infectious disease, winter storms, and flooding.**	The Covid 19 Pandemic has increased awareness of public health risks and mitigation. Building on that knowledge, develop a public outreach campaign, that includes training, social media, and written materials to increase awareness of all hazards that may impact North Reading.	Health Department	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant or FEMA/MEMA	January 2022 - December 2027	All Town Departments
11	**Public health mitigation.**	Review and exercise public health mitigation plans, include emphasis for extreme heat and infectious disease.	Public Health Department	EPA Healthy Communities Grant Program	January 2022 - December 2027	Public Safety

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
12	**Protect at risk populations.**	Hold quarterly meetings with Elders Services, Health Department, and Fire and Police departments to proactively plan to mitigate risk to vulnerable populations in North reading.	Emergency Management Department	CCP Grant, Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant	January 2022 - December 2027	Public Safety
13	**Develop a Continuity of Operations Plan (COOP) and a Continuity of Government (COG) Plan.**	Continuity of Government is a coordinated effort to ensure that governance and essential functions continue to be performed before, during, and after an emergency. Disasters can cause local or regional emergencies by threatening the ability of jurisdictions to execute their statutory authorities, perform essential functions, and deliver essential services. Plans should be scalable and flexible to meet the varying requirements, threats, and needs. COOP plans are used by local governments to prepare procedural and operational guidance. Developing this plan mitigates risk by identifying areas of weakness that may be addressed prior to a disaster. COOP plans take an all-hazards approach. Developing this plan will foster a system for personnel and resources in North Reading to maintain critical government functions. COOP plan details essential functions threat scenarios and responses, and training and testing.	Fire Department	MEMA Emergency Management Performance Grant (EMPG)	January 2022 - December 2027	Emergency Management

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
14	**Tree policy.**	Develop a tree policy to encourage tree planting and protection for carbon and shade benefits as well as roadway protection.	Public Works Department, Roads & Streets/Highway Division	FEMA/MEMA, Department of Conservation and Recreation (DCR) Community Forest Stewardship Implementation Grant	January 2022 - December 2027	
15	**Develop a debris management response plan for post extreme weather events or for incidents that create debris during construction.**	Also consider additions to the subdivision regulations dealing with storms that happen during construction	Public Works Department, Roads & Streets/Highway Division	FEMA/MEMA	January 2022 - December 2027	Community Planning Department
16	**Emergency Access Roads**	Require roads and driveway widths accommodate emergency vehicles and apparatus for emergency response access.	Community Planning	FEMA Fire Prevention and Safety Grant (FP&S)	January 2022 - December 2027	Public Safety
17	**Incorporate mitigation strategies in other town plans such as Master Plan, Conservation**	As Town plans get updated, the hazard mitigation strategy will be considered as will details regarding risk and critical facilities.	Community Planning	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant , FEMA/MEMA	January 2022 - December 2027	All Town Departments

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
	Plan, and Open Space and Recreation Plan.					
18	**Expand National Flood Insurance Program participation and capacity.**	Training is necessary to understand the changes to the NFIP. The Town should also consider participation in the Community Rating System program every 5 years.	Public Works Department, Engineering Division	FEMA/MEMA	January 2022 - December 2027	Water Department
19	**Forest Maintenance and Brush Management**	Forest maintenance and clear cutting are necessary to reduce fire hazard. Eisenhaure Pond Park is an example of an area that the Town's Forest Committee identified as needing maintenance. Many pine saplings died after the 2015 drought which is creating an abundance of tinder on the forest floor. Explore a volunteer or neighborhood association to do this work.	Department of Public Works	MA Department of Conservation and Recreation	January 2022 - December 2027	MA Department of Conservation and Recreation
Low Priority Actions						
20	**Develop a North Reading Community Emergency Response Team (CERT).**	Conduct outreach and training to residents and business owners to support local first responders.	Emergency Management Department	MEMA Citizen Corps Program (CCP) Grant	January 2022 - December 2027	Public Safety

Action #	Action Title	Project Description	Responsible Department	Potential Funding Source	Implementation Timeframe	Supporting Agencies
21	**Adopt new FEMA DFIRM maps and the State's Model Floodplain Bylaw.**	The Town received Preliminary DFIRMs from FEMA in August 2021, and it is anticipated that the Letter of Final Determination (LFD) for communities within Middlesex County will be issued in December of 2022, thus requiring that the community adopt a compliant floodplain bylaw within six months of the date of that LFD letter. DCR's Flood Hazard Management Program staff (Eric Carlson) remain available to assist the Town through this process.	Public Works Department, Engineering Division	N/A	January 2022 - June 2023	MA Department of Conservation and Recreation, Community Planning
22	**Recognize the Operation and Maintenance Plan for Martin's Brook.**	This plan was developed in 2014 and includes information relevant to hazard mitigation as well as response and recovery. It should be reviewed and considered a resource when town plans are updated or developed.	Community Planning	Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Grant	January 2022 - December 2032	Martins Pond Assoc., Department of Public Works, Engineering

System to Integrate this Plan with other Planning Mechanisms

During the Core Team meeting on September 23, 2021, the consulting team asked how the 2016 Hazard Mitigation Plan has been implemented and incorporated into other planning mechanisms in North Reading. The Core Team reported that the 2016 Hazard Mitigation Plan was not frequently referred to or incorporated into other planning mechanisms. However, the Core Team does intend to implement this 2021 Hazard Mitigation Plan Update by including specific mitigation actions, capabilities, and risk analysis into future versions of the Master Plan and the Open Space and Recreation Plan. The Core Team reports expecting to use the 2021 Hazard Mitigation Plan as a data source for grant applications and project development.

On careful review of the North Reading 2020-2030 Master Plan, the 2016 Hazard Mitigation Plan is frequently quoted and referenced. It was used to support background information and recommendations included in the Master Plan.

Possible funding sources

All the mitigation actions included in this plan have identified one or more potential funding sources. The Core Team focused on projects eligible for MVP Grant funding and FEMA BRIC funding. Below is a list of some of the federal and state funding mechanisms to keep in mind when identifying or implementing mitigation actions.

Federal Emergency Management Agency (FEMA) Mitigation Grants

The Federal Emergency Management Agency (FEMA) makes grant funding available for a range of mitigation activities via several Hazard Mitigation Assistance (HMA) programs. These grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages. They are not intended to fund repair, replacement, or deferred maintenance activities but are rather designed to assist in developing long-term, cost-effective improvements that will reduce risk to natural hazards.

- **Building Resilient Infrastructure and Communities (BRIC)**
  BRIC is a new FEMA hazard mitigation program designed to replace the agency's former HMA Pre-Disaster Mitigation (PDM) grant program, aiming to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. It is a result of recent amendments made to Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) by Section 1234 of the Disaster Recovery Reform Act of 2018 (DRRA). BRIC will support states, local communities, tribes, and territories as they undertake hazard mitigation projects reducing the risks they face from natural hazards. The BRIC program's guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.

- **Hazard Mitigation Grant Program (HMGP)**
  The HMGP is authorized under Section 404 of the Stafford Act. The HMGP provides grants to states, tribes, and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not lost during the recovery and reconstruction process following a disaster. HMGP is typically available only in the months after a federal disaster declaration, as funding amounts are determined based on a percentage of the funds spent on FEMA's Public and Individual Assistance programs.

- **Flood Mitigation Assistance (FMA) Program**
  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 NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities. One limitation of the FMA program is that it is generally used to provide mitigation for structures that are insured or located in Special Flood Hazard Areas (SFHAs) as mapped by FEMA. Federal funding for this nationally competitive grant program is generally an annual allocation (subject to Congressional appropriation) and eligibility is linked to a community's good standing in the NFIP.

Municipal Vulnerability Preparedness Action Grants[103]

The MVP Action Grant offers financial resources to municipalities seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

Responses to the RFR may be submitted by municipalities who have received designation from the Executive Office of Energy and Environmental Affairs (EEA) as a Climate Change Municipal Vulnerability Preparedness (MVP) Community, or "MVP Community." All projects are required to provide monthly updates, project deliverables, a final project report, and a brief project summary communicating lessons learned. The municipality is also required to match 25% of total project cost using cash or in-kind contributions. All proposals must include the following:

- Completed application template

- Project budget and deliverables

[103] State of Massachusetts. *MVP Action Grant.* https://www.mass.gov/service-details/mvp-action-grant.

- MVP yearly progress report describing any relevant work toward advancing community priorities since earning MVP designation
- Statement of match
- Letters of support from landowner (if applicable), partners, and the public

Project types include:

- ***Detailed Vulnerability and Risk Assessment*** – In-depth vulnerability or risk assessment of a particular sector, location, or other aspect of the municipality.
- ***Public Education and Communication*** – Projects that increase public understanding of climate change impacts within and beyond the community and foster effective partnerships to develop support.
- ***Local Bylaws, Ordinances, Plans, and other Management Measures*** – Projects to develop, amend, and implement local ordinances, bylaws, standards, plans, and other management measures to reduce risk and damages from extreme weather, heat, flooding, and other climate change impacts.
- ***Redesigns and Retrofits*** – Engineering and construction projects to redesign, plan, or retrofit vulnerable community facilities and infrastructure (e.g., wastewater treatment plants, culverts, and critical municipal roadways/evacuation routes) to function over the life of the infrastructure given projected climate change impacts.
- ***Energy Resilience Strategies*** — Projects that incorporate clean energy generation and that are paired with resilience enabling technology to maintain electrical and/or heating and cooling services at critical facilities.
- ***Chemical Safety and Climate Vulnerabilities*** — Projects that seek to engage the business and manufacturing community through assistance or training on identifying vulnerabilities to chemical releases due to severe weather events, reducing use of toxic or hazardous chemicals, outreach to improve operations and maintenance procedures to prevent chemical releases and accidents, outreach to improve emergency and contingency planning, and/or identifying existing contaminated sites that pose chemical dispersion risks during flood events.
- ***Nature-Based Storm-Damage Protection, Drought Mitigation, Water Quality, and Water Infiltration Techniques*** – Projects that utilize natural resources and pervious surfaces to manage coastal and inland flooding, erosion, and other storm damage, such as stormwater wetlands and bio-retention systems, and other Smart Growth and Low Impact Development techniques.
- ***Nature-Based, Infrastructure and Technology Solutions to Reduce Vulnerability to Extreme Heat and Poor Air Quality*** – Projects that utilize natural resources, vegetation, and increasing

pervious surface to reduce ambient temperatures, provide shade, increase evapotranspiration, improve local air quality, and otherwise provide cooling services within the municipality.

- ***Nature-Based Solutions to Reduce Vulnerability to other Climate Change Impacts*** – Nature-based projects that address other impacts of climate change such as extreme weather, damaging wind and power outages, and increased incidence of pests and vector-borne illnesses and other public health issues.

- ***Acquisition of Land to Achieve a Resiliency Objective*** — Land purchases are eligible for grant funding if the parcel has been identified through a climate vulnerability assessment as an appropriate location for a specific eligible adaptation activity to occur, such as accommodating an infrastructure or facility redesign or retrofit project, providing natural flood storage to reduce downstream flooding, or removal of pavement and planting of trees to reduce flooding and heat island effects.

- ***Ecological Restoration and Habitat Management to Increase Resiliency*** — Projects that repair or improve natural systems for community and ecosystem adaptation, such as right-sizing culverts, dam removal, restoration of coastal wetlands, etc.

- ***Subsidized Low Income Housing Resilience Strategies*** — Investments in resiliency measures for affordable housing to protect vulnerable populations that may not have the resources to recover from an extreme climate event.

- ***Mosquito Control Districts*** — Projects to reduce the risk to public health from mosquito-borne illness and to increase mosquito surveillance and control capacity by incentivizing municipalities not in an organized mosquito control project or district to form a new mosquito control district or join an existing mosquito control district. Also funding for municipalities currently in a mosquito control district for new or proactive mosquito control measures.

Chapter 7. Plan Implementation and Maintenance

The Core Team will implement the mitigation strategy and specific mitigation actions outlined in this plan, and update and maintain the plan according to the guidelines below. The Core Team includes key stakeholders in the Town, who will use the plan's goals, as well as continued analysis of hazard risks and capabilities, to weigh the available resources against the costs and benefits for each mitigation action. The Town understands the value of this plan and its positive mitigation impact and intend to continue updating this plan and implementing the plan's strategies.

Continued Public Participation

Public participation is an integral component of the mitigation planning process and will continue to be essential as this plan is implemented and updated over time. Based on the high level of interest in the mitigation planning process and in the Municipal Vulnerability Preparedness project, Town residents and stakeholders are interested in mitigation. The Core Team included several education and outreach mitigation actions designed to engage the public. The Town intends to involve the public throughout the five-year implementation of this plan, as well as in the reviewing and updating process. The Fire Chief and Emergency Manager will take the lead in soliciting participation from the public. This participation will take multiple forms, including all of those outlined in the Planning Process Chapter of this plan. Efforts to involve the public include:

- Advertising on the Town's website and the Fire Department website, and via flyers and press release.
- Private sector representatives will join Town officials in implementing mitigation actions.
- Copies of this plan will remain on the Town's website; the Fire Department's website and a hard copy will be kept in the Community Planning Department office for public review. Updates to the plan will also be posted on the Town's and the Fire Department website.
- The Town of North Reading will continue to work with private industry, regional agencies, and adjacent communities as this plan is implemented.

Method and Schedule for Keeping the Plan Current

The Core Team and the Town of North Reading recognize the importance of keeping the mitigation plan up to date. Keeping the plan current includes monitoring, evaluating, and updating the plan over a five-year period, a process jointly led by the Fire Chief and the Emergency Management Director. They have the support of the Core Team.
The Core Team has agreed to the following procedures.

- The overall responsibility for monitoring the implementation of the plan rests jointly with the Core Team members, led by the Fire Chief. Together they will maintain the Mitigation Action Tracker (a tool to record the status of all mitigation actions). They will send a reminder email with a link to the web-based Mitigation Action Tracker on a semi-annual basis to all Department Heads responsible for a mitigation action. They may also distribute the Mitigation Action Progress Worksheet (shown in Appendix D) for Department Heads who prefer a form over a spreadsheet.

- If the Town experiences a large-scale disaster, they will call a Core Team meeting to update the list of mitigation actions and review the order of priorities.

- The Core Team has agreed to meet on a semi-annual basis to review the implementation of the mitigation plan. The first meeting will take place in January; the second, in July.

    - At the first meeting (January 2022), the Core Team will review the effectiveness of the planning process, public and stakeholder engagement, risk analysis, and the mitigation strategy, including its implementation. It is recommended that the Core Team use the worksheet provided in Appendix D.

    - At each semi-annual meeting, the Core Team will review the plan's goal statements and mitigation action status. If necessary, the goal statements and mitigation actions may be revised to reflect current Town priorities. In addition, the Core Team will discuss methods for continuing to integrate the mitigation plan with other plans, processes, and projects in the Town.

    - They will prepare a one-page brief regarding the January Core Team meeting to share with the Selectmen and to post on the Town and Fire Department websites. The Core Team and the Fire Chief and the Emergency Manager recognize the value in keeping the public informed about the implementation and status of the mitigation plan.

- Core Team members will continue to participate in regional and state-based meetings to stay current with best risk-mitigation practices. Such meetings may include the Massachusetts Emergency Management Agency (MEMA), the Metropolitan Area Planning Council (MAPC), and the MA Department of Conservation and Recreation.

The Town of North Reading agrees to update and adopt this mitigation plan on a five-year basis. The update will include a comprehensive review and planning process like the one used to develop this mitigation plan update. It will update the mitigation action list, current land use practices, collecting and reviewing best available data, reviewing the capability assessment, and engaging the public and stakeholders. This process will occur according to FEMA guidelines. The Core Team will seek funding for the development of the plan update a year before the plan expires. The plan update process gives the Town the chance to add and/or re-prioritize mitigation actions based on current risk, capabilities, and

public/stakeholder suggestions. The Fire Chief and the Emergency Management Director will serve as the Project Managers for the update process.

Responsible Parties for Plan Implementation and Maintenance

Fire Chief Don Stats

North Reading Fire Department

152 Park Street

North Reading, MA 01864

Phone: 978-664-3112

Theophilos Kuliopulos, Emergency Manager

North Reading Emergency Management

19 Williams Road

North Reading, MA 01864

Phone: 978-664-4536

For State resources:

Massachusetts Emergency Management Agency:

Address: 400 Worcester Road, Framingham, MA 01702-5399

Phone: 508-820-2000 (MEMA Headquarters and Communications Center)

or 978-328-1500 (MEMA Region 1 Office)

Website: https://www.mass.gov/orgs/massachusetts-emergency-management-agency

For Federal resources:

Federal Emergency Management Agency:

Address: 99 High Street, Boston, MA 02110

Phone: 877-336-2734

Email: fema-r1-info@fema.dhs.gov

Website: https://www.fema.gov/region-i-ct-me-ma-nh-ri-vt

Appendix A. Planning Process Supporting Materials

Core Team Meetings

Core Team Meeting Participants 8/10/2021

Robert Bracey, Health Director
Fire Chief Don Stats, North Reading Fire Department
Deputy Chief Barry Galvin, North Reading Fire Department
Mark Clark, Water Superintendent, North Reading Department of Public Works
Robert Collins, Town of North Reading Human Resources Director
Marc Hamel, Building Superintendent
Lt. Joe Thibodeau, North Reading Police Department
Steve Lutterman, GIS Coordinator
Danielle McKnight, Town Planner

Core Team Meeting Participants 9/23/2021

Andrew Campagna, Director of Facilities North Reading Public School District
Lt Joe Thibodeau, North Reading Police Department
Fire Chief Don Stats
Health Agent Bob Bracey
Mark Clark, Water Superintendent
Danielle McKnight, Town Planner
John Klipfel, Town Engineer
Theophilos Kuliopulos, Emergency Management Director
Joseph P. Parisi, Jr., Director Department of Public Works

Core Team Meeting Participants 10/28/2021

Bob Bracey, Health Department Director
Mark Clark, Water Superintendent
Robert Collins, Director of Human Resources
Theo Kuliopulos, Emergency Management Director
Danielle McKnight, Town Planner
Don Stats, Fire Chief

Core Team Meeting Participants 11/15/2021

Robert Bracey, Health Director
Fire Chief Don Stats, North Reading Fire Department
Mark Clark, Water Superintendent, North Reading Department of Public Works
Robert Collins, Town of North Reading Human Resources Director
Danielle McKnight, Town Planner
Theophilos Kuliopulos, Emergency Management Director

Public Meeting Participants

Participants 9/30/2021

Bob Bracey, Health Director
Andrew Campagna, Director of Facilities North Reading Public School District
Fire Chief Don Stats
Mark Clark, Water Superintendent
Robert Collins, North Reading Human Resources Director
Barry Galvin, Deputy Fire Chief
Theophilos Kuliopulos Emergency preparedness
Patrick Lynch, Director of Policy and Planning, Ipswich River Watershed Association
Danielle McKnight, Town Planner

Participants 10/28/2021

Bob Bracey, Health Department
Robert Collins, North Reading HR Director
Theo Kuliopulos Emergency Management Department
Danielle McKnight, Town Planner
Don Stats, Fire Chief

Press Release September 17, 2021

PRESS RELEASE
For Immediate Release
September 17, 2021

Contact: Don W. Stats, Jr.
Fire Chief
978-357-5100

Town of North Reading Invites the Public to a Virtual Meeting to Learn About the Hazard Mitigation Plan Update

The Town of North Reading is developing an update to the 2016 Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change. Citizen participation is essential.

A virtual public meeting will be held on Thursday, September 23rd at 4pm via Zoom.
Join on your computer or mobile app

Click here to join the meeting
https://us02web.zoom.us/j/83954908968?pwd=UlQ5UnU4ZXVpemxnNWM3VnFBd3lGZz09
Meeting ID: 839 5490 8968
Passcode: 161834
Phone: 301-715-8592

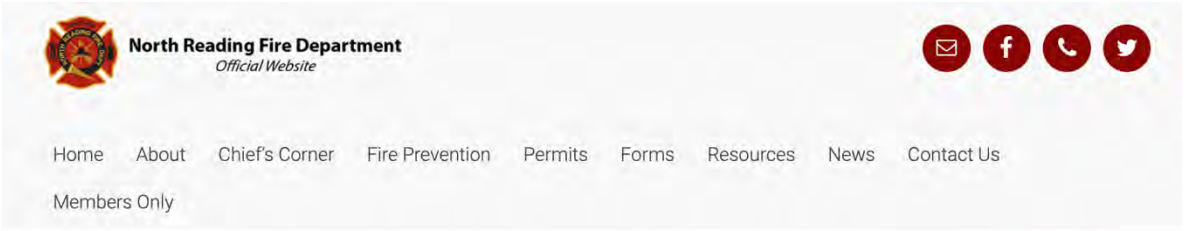
At the meeting, you will have an opportunity to contribute your ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. This plan is being developed by a Core Team of Town officials and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan Update allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

North Reading developed a Municipal Vulnerability Preparedness (MVP) plan in 2018 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan Update will include all of those identified actions still relevant today.

For questions regarding this project, please contact Don Stats, Fire Chief, Town of North Reading, phone: 978-357-5100 or email: dstats@northreadingma.gov.

North Reading Fire Department Website Announcement

https://northreadingfire.org/2021/09/20/town-of-north-reading-invites-the-public-to-a-virtual-meeting-to-learn-about-the-hazard-mitigation-plan-update/



Town of North Reading Invites the Public to a Virtual Meeting to Learn About the Hazard Mitigation Plan Update

Town News

September 20, 2021

The Town of North Reading is developing an update to the 2016 Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change.

The participation of the citizens of North Reading is encouraged and essential in making this a success.

A virtual public meeting will be held on Thursday, September 30th at 4pm via Zoom.

Join on your computer or mobile app

Click here to join the meeting https://us02web.zoom.us/j/83954908968?pwd=UlQ5UnU4ZXVpemxnNWM3VnFBd3lGZz09

Meeting ID: 839 5490 8968

Passcode: 161834

Phone: 301-715-8592

At this meeting, the public will have an opportunity to contribute their ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures.

This plan is being developed by a Core Team of Town officials and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort.

Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan Update allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

North Reading developed a Municipal Vulnerability Preparedness (MVP) plan in 2018 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan Update will include all of those identified actions still relevant today.

For questions regarding this project, please contact Don Stats, Fire Chief, Town of North Reading, phone: 978-357-5100 or email: dstats@northreadingma.gov.

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Recent Posts

North Reading Fire Department Urges Residents to Consider Safety Tips and 'Learn the Sounds of Fire Safety' During Fire Prevention Week

Town of North Reading Invites the Public to a Virtual Meeting to Learn About the Hazard Mitigation Plan Update

North Reading Police and Fire Departments Share Tips for Residents During Emergency Preparedness Month

Canadian Wildfire Smoke Impacting North Reading

North Reading Fire Department Extinguishes House Fire

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Embed View on Twitter

Press Release October 25, 2021

PRESS RELEASE
For Immediate Release
October 25, 2021

Contact: Don W. Stats, Jr.
Fire Chief
978-357-5100

The Public is Invited to a Zoom Meeting Regarding the Hazard Mitigation Plan Update.
Learn about the Mitigation Actions Identified to Lessen the Risk of Hazards in North Reading.

The Town of North Reading is working on an update to the 2016 Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change.Public participation is essential to the plan's development.

A virtual public meeting will be held on **Thursday, October 28th at 4pm via Zoom**.Join on your computer or mobile app.

https://us02web.zoom.us/j/85284053736?pwd=Mmt1R0gvWGU5NEQra3FxMGdHU1pDdz09
Meeting ID: 852 8405 3736
Passcode: 543279

At the meeting, you will learn about the actions identified to lessen the risk of hazards such as flooding, winter storms, and extreme temperatures. These ideas include adding a generator to the Senior Center, conducting public education, and replacing insufficient culverts and bridges.

The Town requests your participation at this meeting to provide feedback on the plan and contribute your ideas to mitigating natural hazard risks.

This plan is being developed by a Core Team of Town officials and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort. Federal Emergency Management Agency approval, and Town adoption, of the Hazard Mitigation Plan Update allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

For questions regarding this project, please contact Don Stats, Fire Chief, Town of North Reading, phone:978-357-5100 or email: dstats@northreadingma.gov.

Appendix B. Mitigation Actions.

Action Priority Ranking Consideration

Action #	Action Title	Responsible Department	Estimated Cost	Estimated Benefits	Priority
1	**Conduct flood risk and NFIP education and outreach.**	Engineering Division	Low	High	High
2	**Replace culverts on Haverhill Street and Chestnut Street and raise the profile of these roads.**	Engineering Division	High	High	High
3	**Replace Park Street Bridge over Martins Brook.**	Engineering Division	High	High	High
4	**Bridge and culvert upgrades.**	Public Works Department, Engineering Division	High	High	High
5	**Review Stormwater Bylaw.**	Community Planning	Low	High	High
6	**Subdivision regulations review.**	Community Planning	Low	High	High
7	**Add stand-alone automatic generators to the Senior Center.**	Building Department	Medium	High	High
8	**Snow load capacity.**	Building Department	Medium	Medium	Medium
9	**Establish a public outreach campaign for hazard mitigation on private property.**	Building Department	Low	Medium	Medium
10	**Develop an outreach and education campaign for all hazards with an emphasis on high-risk hazards such as infectious disease, winter storms, and flooding.**	Health Department	Low	Medium	Medium

Action #	Action Title	Responsible Department	Estimated Cost	Estimated Benefits	Priority
11	**Public health mitigation.**	Public Health Department	Low	Medium	Medium
12	**Protect at risk populations.**	Emergency Management Department	Low	Medium	Medium
13	**Develop a Continuity of Operations Plan (COOP) and a Continuity of Government (COG) Plan.**	Fire Department	Medium	Medium	Medium
14	**Tree policy.**	Public Works Department, Roads & Streets/Highway Division	Medium	Medium	Medium
15	**Develop a debris management response plan for post extreme weather events or for incidents that create debris during construction.**	Public Works Department, Roads & Streets/Highway Division	Medium	Low	Medium
16	**Emergency Access Roads**	Community Planning	Low	Medium	Medium
17	**Incorporate mitigation strategies in other town plans such as Master Plan, Conservation Plan, and Open Space and Recreation Plan.**	Community Planning	Low	Medium	Medium
18	**Expand National Flood Insurance Program participation and capacity.**	Public Works Department, Engineering Division	Medium	Medium	Medium
19	**Forest Maintenance and Brush Management**	Department of Public Works	Medium	Medium	Medium
20	**Develop a North Reading Community Emergency Response Team (CERT).**	Emergency Management Department	Low	Low	Low

Action #	Action Title	Responsible Department	Estimated Cost	Estimated Benefits	Priority
21	**Adopt new FEMA DFIRM maps and the State's Model Floodplain Bylaw.**	Public Works Department, Engineering Division	Low	Low	Low
22	**Recognize the Operation and Maintenance Plan for Martin's Brook.**	Community Planning	Low	Low	Low

Hazards Addressed and Critical Facilities Protected

Action #	Critical Facility Protection	Severe Winter Storm/Nor'easter	Hurricanes/Tropical Storms	Flooding	Other Severe Weather	Average/Extreme Temperatures	Tornadoes	HAZMAT	Infectious Disease	Drought	Wildfires	Invasive Species	Earthquake	Dam Failure
1	No	Yes	Yes	Yes										Yes
2	Yes	Yes	Yes	Yes	Yes									
3	Yes	Yes	Yes	Yes	Yes									
4	Yes	Yes	Yes	Yes	Yes									
5	No	Yes	Yes	Yes	Yes									
6	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes		Yes	Yes	Yes						Yes	
8	Yes	Yes												
9	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Action #	Critical Facility Protection	Severe Winter Storm/Nor'easter	Hurricanes/Tropical Storms	Flooding	Other Severe Weather	Average/Extreme Temperatures	Tornadoes	HAZMAT	Infectious Disease	Drought	Wildfires	Invasive Species	Earthquake	Dam Failure
10	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	Yes	Yes	Yes				Yes						Yes	
15	No	Yes	Yes	Yes	Yes		Yes				Yes	Yes	Yes	Yes
16	No	Yes	Yes	Yes	Yes		Yes	Yes			Yes	Yes	Yes	
17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	No	Yes	Yes	Yes	Yes									
19	No					Yes				Yes	Yes	Yes		

Action #	Critical Facility Protection	Severe Winter Storm/Nor'easter	Hurricanes/Tropical Storms	Flooding	Other Severe Weather	Average/Extreme Temperatures	Tornadoes	HAZMAT	Infectious Disease	Drought	Wildfires	Invasive Species	Earthquake	Dam Failure
20	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
21	Yes			Yes										
22	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Types of Mitigation Actions

Action #	Action Title	Responsible Department	Priority
Education and Awareness Programs			
1	Conduct flood risk and NFIP education and outreach.	Engineering Division	High
9	Establish a public outreach campaign for hazard mitigation on private property.	Building Department	Medium
10	Develop an outreach and education campaign for all hazards with an emphasis on high-risk hazards such as infectious disease, winter storms, and flooding.	Health Department	Medium
12	Protect at risk populations.	Emergency Management Department	Medium
18	Expand National Flood Insurance Program participation and capacity.	Public Works Department, Engineering Division	Medium
20	Develop a North Reading Community Emergency Response Team (CERT).	Emergency Management Department	Low
Local Plans and Regulations			
5	Review Stormwater Bylaw.	Community Planning	High
6	Subdivision regulations review.	Community Planning	High
11	Public health mitigation.	Public Health Department	Medium
13	Develop a Continuity of Operations Plan (COOP) and a Continuity of Government (COG) Plan.	Fire Department	Medium
14	Tree policy.	Public Works Department, Roads & Streets/Highway Division	Medium
15	Develop a debris management response plan for post extreme weather events or for incidents that create debris during construction.	Public Works Department, Roads & Streets/Highway Division	Medium

Action #	Action Title	Responsible Department	Priority
16	Emergency Access Roads	Community Planning	Medium
17	Incorporate mitigation strategies in other town plans such as Master Plan, Conservation Plan, and Open Space and Recreation Plan.	Community Planning	Medium
21	Adopt new FEMA DFIRM maps and the State's Model Floodplain Bylaw.	Public Works Department, Engineering Division	Low
22	Recognize the Operation and Maintenance Plan for Martin's Brook.	Community Planning	Low
Natural Systems Protection			
19	Forest Maintenance and Brush Management	Department of Public Works	Medium
Structure and Infrastructure Projects			
2	Replace culverts on Haverhill Street and Chestnut Street and raise the profile of these roads.	Engineering Division	High
3	Replace Park Street Bridge over Martins Brook.	Engineering Division	High
4	Bridge and culvert upgrades.	Public Works Department, Engineering Division	High
7	Add stand-alone automatic generators to the Senior Center.	Building Department	High
8	Snow load capacity.	Building Department	Medium

Appendix C. Plan Implementation and Review Supporting Materials.

Plan Update Evaluation Worksheet

Plan Section	Considerations	Explanation
Planning Process	Should the town invite any additional stakeholders to participate in the planning process? What public outreach activities have occurred? How can public involvement be improved?	
Risk Assessment	What disasters has the town, or the region experienced? Should the list of hazards be modified? Are new data sources, maps or studies available? If so, what have they revealed, and should the information be incorporated into the plan update? Has development in the region occurred and could it create or reduce risk?	
Capability Assessment	Has the town adopted new policies, plans, regulations, or reports that could be incorporated into this plan? Are there different or additional administrative, human, technical, and financial resources available for mitigation planning? Are there different or new education and outreach programs and resources available for mitigation activities?	
Mitigation Strategy	Is the mitigation strategy being implemented as anticipated? Were the cost and timeline estimate accurate? Should new mitigation actions be added to the Action Plan? Should existing mitigation actions be revised or removed from the plan? Are there new obstacles that were not anticipated in the plan that will need to be considered in the next plan update? Are there new funding sources to consider? Have elements of the plan been incorporated into other planning mechanisms?	
Implementation Plan	Was the plan monitored and evaluated as anticipated? What are needed improvements to the plan implementation procedures?	

Mitigation Action Progress Worksheet

Mitigation Action Progress Worksheet				
Progress Report Period	From Date		To Date	
Action/Project Title				
Responsible Department				
Contact Name				
Contact Phone/Email				
Project Description				
Project Goal				
Project Objective				
Project Cost				
Project Status				
Date of Project Approval	Date of Project Start	Anticipated Date of Completion	Project Canceled	Project Delayed
Explanation of Delay or Cost Overruns				
Project Report Summary				
What was accomplished for this project during this reporting period?				
What obstacles, problems, or delays did the project encounter?				
Plans for next reporting period.				

Appendix D. Risk Assessment Supporting Materials

Preliminary Digital Flood Insurance Rate Maps (DFIRMs)

On August 13, 2021, FEMA released Preliminary Digital Flood Insurance Rate Maps (DFIRMs) along with other updated flood risk products for Middlesex County, including the Town of North Reading. As noted in Chapter 4 (Risk Assessment), preliminary copies of the DFIRMs are still undergoing review but are considered best available data for hazard mitigation planning purposes, even though not yet officially adopted by the Town for regulatory or other purposes.

High resolution copies of each Preliminary DFIRM panel have been provided in this appendix and are hereby incorporated into the plan. The map index below can be used to determine which panel should be utilized to obtain flood hazard information for a specific area within the Town of North Reading.

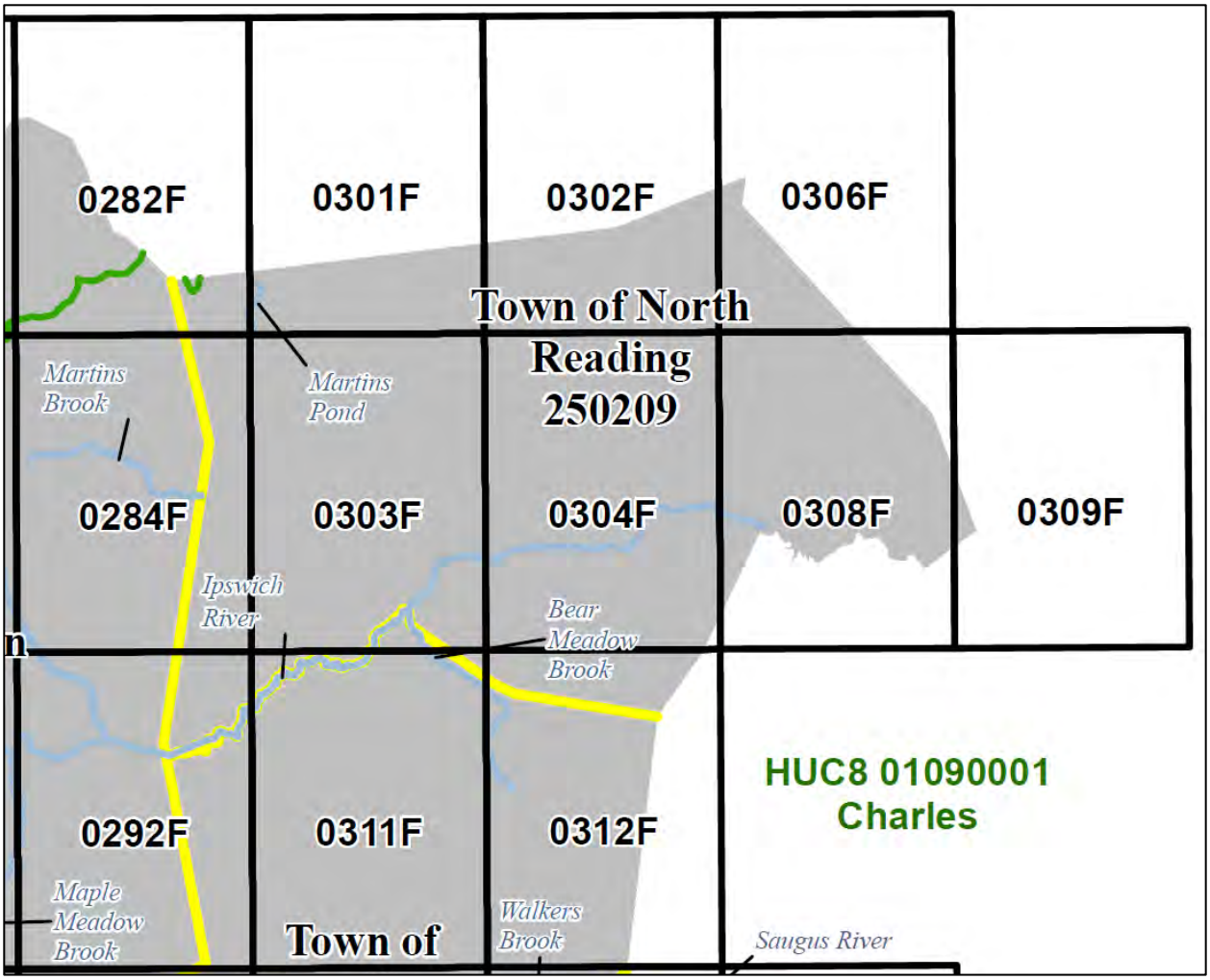

Figure 35. MAP INDEX for North Reading's Preliminary DFIRMs (dated August 13, 2021).