TOWN OF TYNGSBOROUGH

2020 HAZARD MITIGATION – MUNICIPAL VULNERABILITY PREPAREDNESS PLAN

town of Tyngsborough massachusetts

Prepared by:

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EXECUTIVE SUMMARY

Hazard mitigation planning is a proactive process used to systematically identify policies, actions, and tools that can be used to reduce the dangers to life and property from natural hazard events. Climate adaptation planning recognizes that climate change will exacerbate the vulnerabilities and risks associated with natural hazards. The Town of Tyngsborough completed a planning process focused on both hazard mitigation planning and climate adaptation, which provides a robust assessment and implementation plan to build the Town's resilience. The Town is now also eligible for hazard mitigation funding through the Federal Emergency Management Agency (FEMA) and climate adaptation funding through the Massachusetts Executive Office of Energy and Environmental Affairs' Municipal Vulnerability Preparedness (MVP) Grant Program.

Planning Process

The Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan (HMP-MVP Plan) planning process was completed through the following steps.

1) Convened a core team of municipal department heads who provided key input through meeting, online surveys, and interviews.
2) Created a set of hazard mitigation and climate adaptation goals.
3) Established a list of critical facilities and assets.
4) Engaged the public through a workshop, in-person event and online comment period.
5) Conducted a vulnerability and risk assessment of historic hazards and the potential impact of climate change.
6) Documented the Town's capacity to mitigation and respond to hazards.
7) Updated the progress on the previous HMP.
8) Developed an action and implementation strategy.

Vulnerability and Risk

The Tyngsborough HMP-MVP Plan assesses the potential impacts to the Town from a variety of natural disasters including flooding, high winds, winter storms, brush fire, geologic hazards, extreme temperatures, and drought. These are anticipated to worsen with climate change.


Flooding


Drought and Extreme Heat


Severe Thunderstorms, Wind, Tornadoes, & Hurricanes


Nor'easters, Ice Storms, and Severe Snowstorms

The HMP-MVP Plan documents the location and exposure of over 100 critical facility and assets. Among them are emergency services, roads, utilities, social services, and natural resources.

Hazard Mitigation and Climate Adaptation Goals

The Town endorsed the following set of hazard mitigation and climate adaptation goals.

1. Develop programs and mitigation measures in the high-risk areas to protect the following from current and projected hazards:
    a. Residents' health, safety, and property.
    b. Commercial and industrial interests.
    c. Cultural and historic resources.

Hazard Mitigation and Climate Adaptation Goals (Continued)

2. Protect critical infrastructure and essential services from disruption as a result of current or projected hazards by improving the resiliency of, and developing mitigation plans for the following:
    a. Critical infrastructure and the built environment.
    b. Essential services, such as electric power delivery, public and private drinking water supplies, and sewer service.
3. Incorporate climate adaptation strategies into all Town departments and boards.
4. Incorporate climate adaptation and hazard mitigation measures into local plans, bylaws, regulations, and other planning tools to protect critical infrastructure and property and to encourage resilient development.
5. Stay up to date on emerging risks associated with climate change.
6. Plan for all phases of the emergency management cycle, including mitigation, preparation, response, and recovery.
7. Increase awareness and provide resources for hazard mitigation to businesses and residents through outreach and education.
8. Identify funding opportunities specific to hazard mitigation and climate adaptation projects.
9. Increase the Town's capacity for responding to a natural or climate hazard event through coordination with businesses, institutions, and non-profits, surrounding communities, and state, regional, and federal agencies.

Hazard Mitigation Strategy

Through the planning process, several hazard mitigation and climate adaptation measures were identified as high priorities.

- Install backup power in additional critical facilities and invest in renewable sources
- Build an updated public safety facility or satellite police station with ambulance service on the east side of the Merrimack River
- Provide wellness checks for vulnerable citizens
- Replace culverts and size appropriately for climate change.
- Work with cable, communication, an electric utility companies to increase proactive tree management
- Implement climate resilience action items in the recently updated Open Space and Recreation Plan and the Master Plan
- Conduct a stormwater infrastructure assessment to identify opportunities to utilize best management practices on municipal property
- Ensure that schools, businesses, medical facilities, and municipal buildings have a shelter in place in plan
- Implement improvements to existing initiatives and expand municipal service capacity.
- Assess and inventory stream crossings, such as culverts and bridges; prioritize/rank these assets based on vulnerability
- Identify problem areas with poor drainage, icing issues, and gaps in the stormwater system. Identify potential strategies to address these issues

Next Steps

The Town of Tyngsborough is dedicated to implementing the findings of this plan and documenting the process. As a now eligible community for funding through the MVP Program and FEMA, the Town will look to secure resources, and to work with regional and local stakeholders, to complete the projects identified herein. The Town will also continue to document hazard impacts and needed improvements to the Town's capacity to mitigation and adapt. Lastly, the Town will proactively incorporate the hazard mitigation and climate adaptation goals into municipal planning, budgeting, and operations. By doing so, the Town will be ready to update this plan in five years to maintain its eligibility for grant funding.

1.0 INTRODUCTION

The Town of Tyngsborough prepared this Hazard Mitigation and Municipal Vulnerability Preparedness Plan (HM-MVP Plan) as an action strategy to reduce the impacts of natural hazards and climate change within the community and the region. The Tyngsborough HM-MVP Plan was adopted by the Board of Selectmen on December 14, 2020 to update and replace the *Hazard Mitigation Plan for the Northern Middlesex Region* (2015) and to become an MVP certified community.

1.1 What is a Hazard Mitigation Plan?

Natural hazards, such as earthquakes, hurricanes, and flooding, can result in loss of life, disruptions to everyday life, and property damage. Hazard mitigation is the effort to reduce these disruptions through community planning, policy changes, education programs, infrastructure projects, and other activities (FEMA, 2020a). Hazard mitigation planning uses a stepped process with participation of a wide range of stakeholders to:

1. Define local hazards.
2. Assess vulnerabilities and risks.
3. Review current mitigation measures.
4. Develop priority action items.

The resulting hazard mitigation plan (HMP) and action strategy saves lives and money. For every dollar spent on federal hazard mitigation grants, an average of six dollars are saved (FEMA, 2018a). There are many additional benefits of mitigation planning. HMPs increase public awareness of natural hazards that may affect the community. They allow state, local, and tribal governments to work together and combine hazard risk reduction with other community goals and plans. HMPs focus resources and attention on the community's greatest vulnerabilities. The vulnerability assessment of an HMP documents data related to the National Flood Insurance Program (NFIP), such as repetitive loss sites, and ongoing work by the community related to floodplain management.

Figure 1. FEMA Hazard Mitigation Planning Saves Money Graphic (FEMA, 2018a)

By completing HMPs, municipalities also become eligible for specific federal funding and allow potential funding sources to understand a community's priorities (FEMA, 2019a). Hazard mitigation funding is available through the Federal Emergency Management Agency (FEMA). To be eligible for FEMA grants, local governments are required to prepare an HMP meeting the requirements established in the *Robert T. Stafford Disaster Relief and Emergency Assistance Act*, as amended by the *Disaster Mitigation Act of 2000*.

Table 1. FEMA Grants

FEMA Grants	Purpose
Hazard Mitigation Grant Program (HMGP)	Helps communities implement hazard mitigation measures following a Presidential Major Disaster Declaration.
Pre-Disaster Mitigation Program (PDM)	Assists in implementing a sustained pre-disaster natural hazard mitigation program, in order to reduce risk to the population and structures from future hazard events.
Public Assistance Grant Program (PA)	Provides supplemental grants so that communities can quickly respond and recover from major disasters or emergencies.
Fire Management Assistance Grant Program (FMAG)	Available for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands.

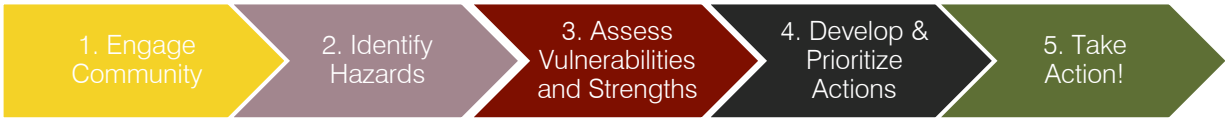
(FEMA, 2020b)

1.2 What is the Municipal Vulnerability Preparedness Program?

In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) initiated the Commonwealth's Municipal Vulnerability Preparedness (MVP) grant program to help communities become more resilient to the impacts of climate change. The program provides two grant phases. The first grant phase is the planning grant, which funds a planning process to identify priorities action items to address vulnerabilities and utilize strengths in preparation for climate change. The MVP planning process includes convening a team of municipal staff, engaging stakeholders in a Community Resilience Building Workshop following a guidebook developed by The Nature Conservancy and engaging the public. Communities that complete the planning grant program and

Community Resilience Building Workshop Guidebook

The *Community Resilience Building Workshop Guidebook* provides a process for developing resilience action plans. The process has been implemented and successful in over one-hundred communities. The process, outlined below, is rich in information and dialogue and results in actionable plans and strong collaboration.



The Community Resilience Building Workshop Guidebook's central objectives are to:

- Define top local natural and climate-related hazards of concern.
- Identify existing and future strengthen and vulnerabilities.
- Develop prioritized actions for the community.
- Identify immediate opportunities to collaboratively advance actions to increase resilience.

prepare an MVP Plan become eligible for the second phase of MVP grant funding, the action grants, and receive increased standing in other state grant programs. MVP action grants fund the implementation of priority climate adaptation actions described in the MVP Summary of Findings. Since these action grants are only distributed to Massachusetts municipalities, they are much less competitive than similar grants awarded at the national level.

1.3 Hazard Mitigation and Municipal Vulnerability Preparedness Planning in Tyngsborough

The Town of Tyngsborough (the "Town") received an MVP planning grant to simultaneously prepare an MVP Summary of Findings and an HMP. Many of the required steps of the MVP process also satisfy requirements for updating an HMP. As a result, the Town created an action strategy that considers both the impacts based on historic data and climate change protected threats, following the lead established by the Commonwealth when it adopted the first-ever Massachusetts State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPSS, 2018).

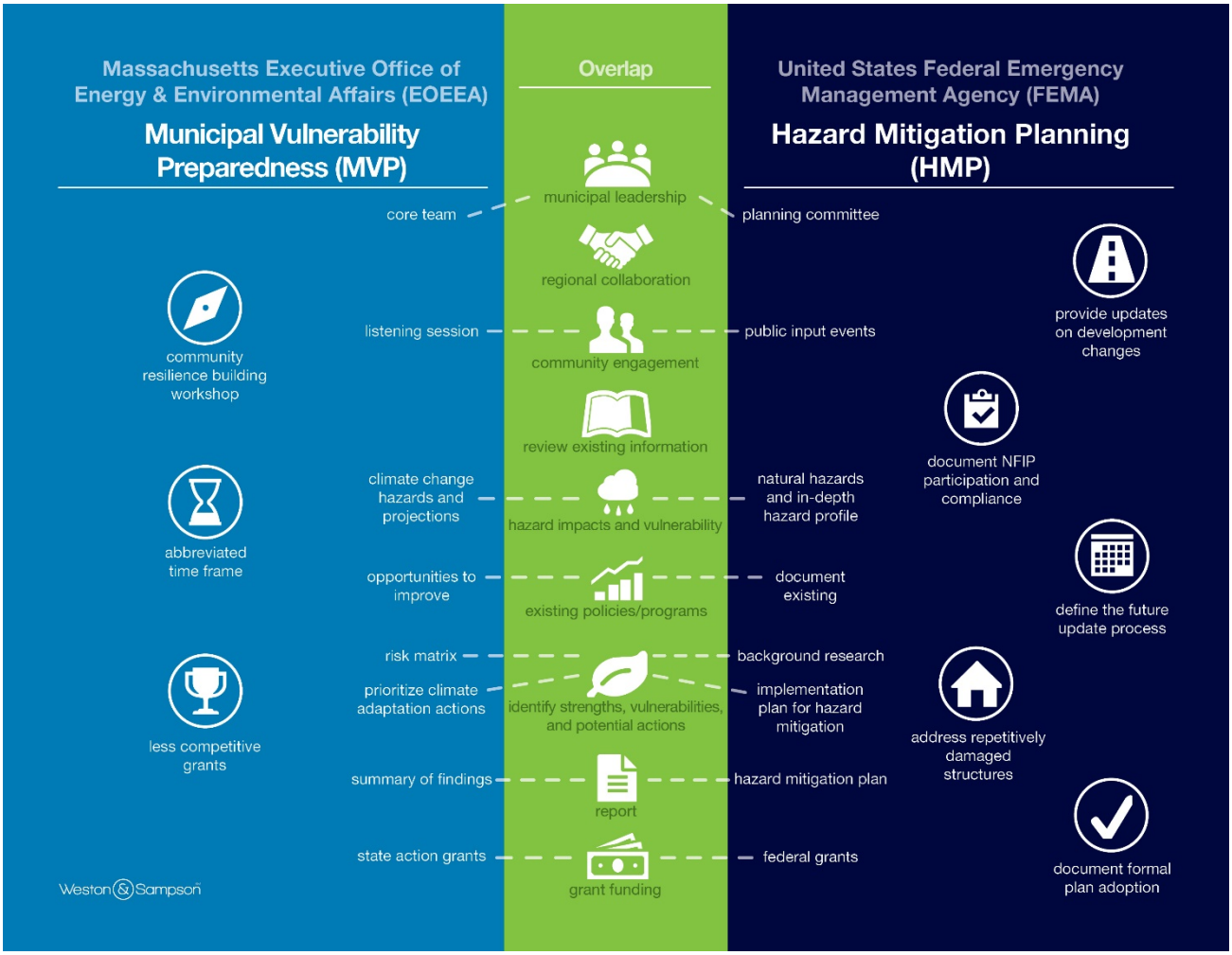


Figure 2. Comparison of the MVP and HMP Process (Weston & Sampson, 2020)

1.4 Planning Process Summary

To prepare for the development of this HM-MVP Plan, the Town convened a core team of municipal leaders to lead the process and provide local expertise. The Town also followed the process described in the *Community Resilience Building Workshop Guidebook.* The guidebook provides a clear approach on how to organize the public process for mitigating the impacts of, and increasing resilience against, natural hazards and climate change. An important aspect of the natural hazard and climate change impact mitigation planning process is the discussion it promotes among community members about creating a safer, more resilient community. Developing a plan that reflects the Town's values and priorities is likely to produce greater community support and result in greater success in implementing mitigation strategies that reduce risk.

Federal regulations for HMP approval also guided the process. Most importantly, FEMA requires that stakeholders and the general public have opportunities to be involved during the planning process and in the plan's maintenance and implementation. Community members can therefore provide input that can affect the content and outcomes of the mitigation plan. The planning and outreach strategy used to develop this HM-MVP Plan had three tiers: 1) the core team, with representation from municipal leadership at the Town, 2) stakeholders who could be vulnerable to, or provide strength against, natural hazards and/or climate change, and 3) the public, who live and work in the Town.

1.4.1 Core Team

The Town convened the core team to act as a steering committee for the development of the HM-MVP Plan. The core team met on September 11, 2019 to plan for the Workshop, review public comments, develop the mitigation plan, and transition to implementation of the plan's mitigation strategies. More information on these meetings is included in Appendix A.

Figure 3. Tyngsborough Core Team (Weston & Sampson, 2019)

The core team established goals for the plan, provided information on hazards affecting the Town, identified critical infrastructure, identified key stakeholders, reviewed the status of existing mitigation measures, and developed proposed mitigation measures for this plan. Members of the core team are listed in Table 2.

Table 2. Tyngsborough's Core Team

Name	Title
Eric Salerno	Town Planner/Project Lead
Danielle Mucciarone	Conservation Director
Justin Sultzbach	Assistant Town Administrator
Matt Hanson	Town Administrator
Wes Russell	Fire Chief
Patrick Sands	Assistant Fire Chief
Richard Howe	Police Chief
Kathy Cayer	Sewer Administrator
Kerri Oun	Health Director
Jim Hustins	Highway Lead Foreman

The core team developed the invitation list for the Community Resilience Building Workshop at which key stakeholders were invited to help the Town identify hazards, vulnerabilities, strengths, and proposed actions to mitigate the impacts of natural hazards and climate change. The core team sought to include municipal leaders as well as politicians, representatives from local nonprofit organizations, local universities, other local jurisdictions, regional organizations, and state government. The core team was also interviewed to update the status of the previous hazard mitigation plan and weighed in the prioritization of the action items through a survey. The core team also suggested or made available reports, maps, and other pertinent information related to natural hazards and climate change impacts in Tyngsborough. These included:

- *Draft 2019 Tyngsborough Open Space & Recreation Plan Update* (Tyngsborough, 2019)
- *Tyngsborough Open Space & Recreation Plan 2009 Update* (Tyngsborough, 2009)
- *Hazard Mitigation Plan for the Northern Middlesex Region, 2015 Update,* (Northern Middlesex Council of Governments, 2015)
- *Tyngsborough Master Plan* (Tyngsborough Master Plan Committee, 2004)
- *Town of Tyngsborough Emergency Plan for Sewer Systems* (Tyngsborough, n.d.)
- *Town of Tyngsborough Sewer Service Area* (Tyngsborough, 2018)
- Massachusetts Climate Change Projections (NECSC, 2018)
- *Massachusetts Climate Change Adaptation Report* (EEA, 2011)
- *Massachusetts State Hazard Mitigation and Climate Change Adaptation* (EEA and EOPSS, 2018)
- *Local Mitigation Plan Review Guide*, October 2011 (FEMA, 2011)
- Flood Insurance Rate Maps (FIRM) for Middlesex County, MA, (FEMA, 2010)
- National Center for Environmental Information (NOAA)
- National Water Information System (USGS)
- US Decennial Census (US Census Bureau, 2010)
- American Community Survey (US Census Bureau, 2018)

1.4.2 Stakeholder Involvement: Community Resilience Building Workshop

Stakeholders with subject matter expertise and local knowledge and experience, including public officials, regional organizations, neighboring communities, environmental organizations, and local institutions, were invited to engage in a two-part Community Resilience Building Workshop, held on October 30, 2019. During the first part of the Workshop, Weston & Sampson provided information about natural hazards and climate change and participants identified top hazards; infrastructural,

societal, and environmental features in the Town that are vulnerable to or provide strength against these challenges. During the second part of the Workshop, participants identified and prioritized key actions that would improve the Town's resiliency to natural and climate-related hazards. Community representatives who were invited and those who participated in the process are presented in the Appendix B with the materials from the Workshop.

Staff members of the Town Planning Board, Engineering Department and Sewer Department – along with many other municipal officials - provided input into the plan as participants in the Community Resilience Building Workshop on October 30, 2019. There was a representative from the Board of Selectman, the Sustainability Committee, and the Northern Middlesex Council of Governments present at the Workshop as well. The Fire Chief and Emergency Management Director and a Health Agent participated in the Workshop and were able to share their perspectives. Representatives from Tyngsborough Public Schools, Charter Schools, and the Public Library participated in the Workshop. The MVP Regional Program Director was able to attend and observe the Tyngsborough Community Resilience Building Workshop. Leadership from neighboring communities of Dracut, Chelmsford, Lowell, Westford, and Dunstable in Massachusetts as well as Nashua and Hudson, New Hampshire were invited to participate in the workshop but were unable to attend. This broad representation of local and regional entities ensures the HM-MVP Plan aligns with the operational policies and any hazard mitigation strategies at different levels of government and implementation.

Figure 4. Tyngsborough CRB workshop (Weston & Sampson, 2019)

1.4.3 Listening Session

To gather information from the general public and to educate the public on hazard mitigation and climate change, the Town hosted a public listening session. The Community Resilience Building Workshop process and findings were presented at a listening session open to the general public on January 8, 2020 at the public library. The meeting was publicized and was co-hosted with the Planning Board. A public comment period on the draft report was available online between April 10th-30th. An email was also sent to the core team and CRB workshop stakeholders. The Town received a few public comments that were incorporated throughout the plan. A summary of the public input is available in the Appendix C.

1.4.4 Report Layout

The report presents the results and input derived from the core team, CRB workshop, and listening session in addition to the documentation of features, hazard profiles, and a vulnerability assessment.

Features are assets or characteristics of the Town that may contribute to the Town's resilience or may be a considered a vulnerability. Features are categorized into several types—societal, economic, infrastructure, land use, and environmental. The strength and vulnerability of these features are generally documented in Chapter 3, but Chapter 4 provides a more detailed assessment of the Town's vulnerability and strengths by hazard type. The hazard types cover flooding, wind-related risk (hurricanes, tropical storms, tornados, nor'easters, severe thunderstorms, winter storms, geological hazards (earthquakes and landslides), brushfires, extreme temperatures, and drought. Each hazard type's historic occurrences and impact, frequency, level of risk, and climate change projections are also described in each hazard profile. Chapter 5 lays out the existing mitigation measures the town is already taking. Chapter 6 provides an update of the progress made since the last HMP and Chapter 7 provides the action plan for moving forward. Chapter 8 describes the plan adoption and maintenance, and details on implementation.

1.5 Planning Timeline

The HM-MVP process proceeded according to the timeline below.

Figure 5. HMP- MVP Planning Process Timeline

2.0 HAZARD MITIGATION AND CLIMATE ADAPTATION GOALS

The Town's core team convened to review and discuss the hazard mitigation and climate adaptation goals for the HM-MVP Plan. The following nine goals were developed and endorsed by the core team.

1) Develop programs and mitigation measures in the high-risk areas to protect the following from current and projected hazards:
   a) Residents' health, safety, and property.
   b) Commercial and industrial interests.
   c) Cultural and historic resources.

2) Protect critical infrastructure and essential services from disruption as a result of current or projected hazards by improving the resiliency of, and developing mitigation plans for the following:
   a) Critical infrastructure and the built environment.
   b) Essential services, such as electric power delivery, public and private drinking water supplies, and sewer service.

3) Incorporate climate adaptation strategies into all Town departments and boards.

4) Incorporate climate adaptation and hazard mitigation measures into local plans, bylaws, regulations, and other planning tools to protect critical infrastructure and property and to encourage resilient development.

5) Stay up to date on emerging risks associated with climate change.

6) Plan for all phases of the emergency management cycle, including mitigation, preparation, response, and recovery.

7) Increase awareness and provide resources for hazard mitigation to businesses and residents through outreach and education.

8) Identify funding opportunities specific to hazard mitigation and climate adaptation projects.

9) Increase the Town's capacity for responding to a natural or climate hazard event through coordination with businesses, institutions, and non-profits, surrounding communities, and state, regional, and federal agencies.

3.0 COMMUNITY PROFILE, LAND USE AND DEVELOPMENT TRENDS

3.1 Community Profile

The Tyngsborough community is full of involved citizens, whose major goal has always been to protect the Town's past, while continuing to plan for future generations. Tyngsborough has a rich historic past. Tyngsborough was originally settled in 1661 and land was purchased from the Wamisit and Naticook tribes. The Town was officially incorporated in 1809 and was known for ferries, quarries, and box companies. In the 1960s, Tyngsborough was a vacation community but has since experienced rapid growth (Town of Tyngsborough, 2019a). In fact, Tyngsborough is one of the fastest growing communities in northern Middlesex County (Tyngsborough, 2019b). In 2018, the population was 12,418 people (U.S. Census Bureau, 2018), which is approximately a 10% increase from 2010 (U.S. Census Bureau). Despite its growth, Tyngsborough has been able to maintain hundreds of acres of parks and agricultural lands.

Tyngsborough is part of the Greater Lowell and Nashua, New Hampshire region, and is located just 28 miles northwest of Boston. Tyngsborough is in northwest section of Middlesex County, Massachusetts, bordered by Westford and Chelmsford on the south, and Dunstable and Groton on the west, New Hampshire on the north, and Dracut and Lowell on the east. Governance of the Town is overseen by the Board of Selectmen and Town Administrator and operates under the open town meeting format. Tyngsborough is also home to the iconic green painted single-arched iron bridge over the Merrimack River. The bridge has become the Town's emblem and more practically serves as a major river crossing for residents of Massachusetts and New Hampshire. The Town maintains a website at http://www.tyngsboroughma.gov.

Table 3. Population Demographics

2018	Tyngsborough	Massachusetts
Population	12,418	6,902,149
Under the Age 18	20%	20%
65+ Over Age 65	11%	17%
Bachelor's degree or higher	46%	42%
Median household income	$109, 652	$79,835
Poverty Rate	7%	11%
With a Disability	10%	8%
Limited English-Speaking Skills	3%	6%
Housing Units	4,206	2,864,989
Renter-Occupancy Rate	14%	38%
Burdened by Housing Costs	41%	50%

(US Census Bureau, 2018)

3.2 Societal Features

Tyngsborough is a tightknit community with a wealth of dedicated and able volunteers. The Town offers numerous social services including an active senior center, public library, and youth programming. The Town's volunteer base and services are strengths that can be utilized for hazard mitigation planning, especially to reach the Town's most vulnerable populations. Vulnerable populations are folks whose everyday stressors make it harder to adapt and recover when shocks or hazards occur. In Tyngsborough, seniors, youth, people who are disabled, and low-income individuals are considered vulnerable. Youth are the largest vulnerable group in Tyngsborough, but the percentage of youth compared to the total population is comparable to Massachusetts as a whole (Table 3). Tyngsborough is home to the Greater Lowell Technical High School, a public vocational school that serves the immediate area around Tyngsborough, as well as other private and public schools. Tyngsborough's rapidly growing population may also be considered a vulnerability, as well as a strength. Emergency services capacity will need to grow at the same rate of population growth.

3.2.1 CRB workshop Discussion of Societal Features

Workshop participants identified those key societal aspects of Tyngsborough that are most vulnerable to, or provide protection against, natural hazards and climate change impacts.

Table 4.Societal Features as Identified in the CRB Workshop

Vulnerabilities	Both Vulnerability and Strength	Strengths
• Limited Shopping Sources/Urgent Care • Farming	• People who are disabled • Veterans • Historic Buildings • Schools and Daycares • Senior Center, Council on Aging, Elderly Population, and Group Housing • Youth and Youth Organizations	• Support from Bordering Municipalities • Commercial District-Middle Rd • Community Spirit • Municipal Services (Library, Veterans, Town Hall) • Non-Profit Groups • Places of Worship • Emergency Shelters (Council on Aging and Elementary School)

Figure 6. Societal Features – Old Town Hall and Gathering Space (Weston & Sampson, 2019)

3.3 Economic Features

A small, primarily residential community, Tyngsborough's rapid growth has also turned it into business-friendly community. Several large businesses and commercial/industrial developments operate in Tyngsborough, including Allied Waste Management, Beacon Power, Piconics, and a growing number of technology-based companies (EOLWD, 2019). Industries in Tyngsborough with the most employees (top employment industries) are business management, science, and arts (United States Census Bureau, 2018). Communication between businesses and the Town will be key when moving forward the hazard mitigation planning efforts and ensuring large employers have emergency protocols in place. Many of Tyngsborough's residents commute out of Town to go to work. Around 45% of commuters travel more than thirty minutes to work.

Table 5. Economic Statistics

	Tyngsborough	Massachusetts
Labor Force	6,158	3,755,481
Unemployment Rate	2.4%	6.0%
Employed in Top Employment Industry	19.1%	28.2%
Commuters with > 30 min travel time to work	45.7%	45.1%

(United States Census Bureau, 2010, United States Census Bureau, 2018)

3.4 Infrastructure Features

Route 3 bisects Tyngsborough north to south through the center of the Town and parallel to the Merrimack River. This provides easy access to I-95, connecting Tyngsborough to Boston and Nashua. The nearby MBTA stop in Lowell provides commuter rail access to Boston. Roads and bridges are at risk of closure and increased wear by snow, ice, downed trees, and in some cases flooding. Thirty percent of the Town is currently serviced by public drinking water while the remaining 70% are served by onsite private wells. Tyngsborough sources water from five distribution systems, which are shared with neighboring towns. The Lowell water treatment facility is one source, which treats and filters water from the Merrimack River. In addition, the Dracut Water Supply District furnishes water from the Frost Road well field in Tyngsborough and the Pennichuck Water treatment facility treats and filters water from the Merrimack River and Pennichuck Brook (Town of Tyngsborough, 2019a). Water supply redundancy and the impact of drought is a concern, especially for private wells. Approximately 40% of the Town is served by the public sewer system and the remaining is supported by on-site septic. Septic systems can be vulnerable to rising groundwater. Backup power of all critical facilities providing water and sewer is essential. All pump station in

Figure 7. Tyngsborough Fire Department (Weston & Sampson, 2019)

Tyngsborough have back up power. Emergency services are generally well equipped, however, services to the East side of the Merrimack River could be decreased if critical roadways and bridges were flooded. See Section 3.7 for more information on critical facilities in Tyngsborough.

3.4.1 CRB workshop Discussion of Existing Infrastructure

Workshop participants identified those key infrastructure features in Tyngsborough that are most vulnerable to, or provide protection against, natural hazards and climate change impacts. As noted below, the majority of the existing infrastructure features were determined to be both a vulnerability and a strength.

Table 6. Infrastructure Features as Identified in the CRB Workshop

Vulnerability	Both Vulnerability and Strength	Strengths
• Aging Buildings • Roadways that flood, especially Red Gate Rd, Dunstable Rd, Middlesex Rd	• Bridges, especially Tyngsborough Bridge • Dams • Power Lines • Public Water Supply and Infrastructure • Stormwater Infrastructure • Utilities • Waste Management	• Emergency Services • Municipal Buildings • Roadways • Sewer, Regional and Local • Communication and Public Safety Infrastructure

3.5 Environmental Features

The Town has a total land area of just over 18 square miles. The Merrimack River bisects Tyngsborough and is a source of riverine flooding. Five other perennial streams (Bridge Meadow Brook, Lawrence Brook Limit Brook, Scarlett Brook, Locust Brook), Mascuppic Lake and various ponds are sources of localized flooding. There are seven large lakes and ponds. Nonpoint source pollution is a concern within many of the waterbodies (stormwater runoff, yard fertilizers, etc.). There are several aquifers or groundwater recharge areas within the town boundaries and surrounding towns that protect the Town's drinking water supplies (Town of Tyngsborough, 2019b). Aquifers are located under the Dracut well fields, downstream between the river and Middlesex Road, along Bridge Meadow Brook, near the intersection of Westford Road and Dunstable Road, near Flint Pond, along the Merrimack River and at Tyng Island. According to the Massachusetts Natural Heritage and Endangered Species Program and the Town of Tyngsborough's Open Space Plan (2019b) there is one Aquatic Core Habitat (the river corridor) and two Coldwater Fishery resource Streams (Deep Brook and Johnson Brook). Tyngsborough also has a portion of the Petapawag Area of Critical Environmental Concern (100-foot border of Massapoag Pond) as designated by EEA. One Priority Natural Community (acidic shrub fen), designated by NHESP, is located east and southeast of Althea Lake.

Unlike many New England municipalities, Tyngsborough does not have many, if any, major environmental concerns from past industrial uses (Town of Tyngsborough, 2019b). There is one Superfund site, the Charles-George Reclamation Trust Landfill, which has been capped and is currently being restored to a more natural or productive use.

3.5.1 CRB workshop Discussion of the Environment

Workshop participants identified those key environmental features in Tyngsborough that are most vulnerable to, or provide protection against, natural hazards and climate change impacts.

Table 7. Environmental Features as Identified in the CRB Workshop

Vulnerabilities	Both Vulnerability and Strength	Strengths
• Invasive Species • Vector Borne Diseases • HAZMAT Sites/Pollutants • Landfill (Superfund Site) • Private Wells	• Wildlife, Plants, and Trees • Frost Road Park • Lakes and Ponds • Merrimack River • Open Space • Recreation Areas • Streams and Wetlands	• Community Programs • Regulations-Floodplain/Wetland Bylaw • Local Environmental Groups

Figure 8. Upper Flint Pond (Weston & Sampson, 2019)

3.6 Land Use

Tyngsborough is approximately 11,564 acres. Most of the land is considered residential (52%) followed by state-owned land and other tax-exempt parcels (19%). Commercial and industrial each account for 6% each of the land area. Agriculture and open space and recreation account for 3% of land use each. Approximately 19% of Tyngsborough is state owned.

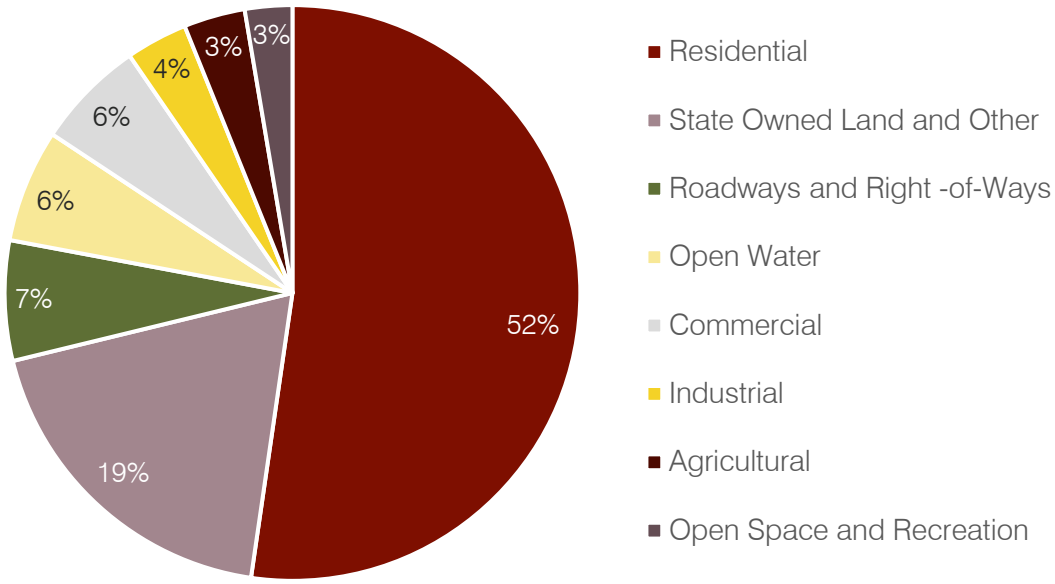


Figure 9. Tyngsborough Land Use

3.7 Recent and Potential Development

Tyngsborough has experienced a boom of growth and development. Many newly developed parcels have been converted to residential and from previously open space and recreation (which includes forested land). Tyngsborough has converted an average of 52 acres of forest per year between 1971 and 2018 (Town of Tyngsborough, 2019b). The remaining privately owned, forestland between Route 3 and the Route 3A corridor may be attractive for development (Town of Tyngsborough, 2019b). This area is zoned for industrial and commercial use. Besides loss of natural habitat, stormwater impacts are a growing concern and new regulatory updates may be necessary to help reduce polluted runoff from entering waterways.

MAPC's MassBuilds Database provides an inventory of recently constructed or planned developments. MassBuilds records housing projects with over ten housing units and commercial projects over 20,000 square feet for rural and suburban communities. The earliest development identified in Tyngsborough from the MassBuilds Database was 2014. The database included four residential developments, three retail-commercial developments and one mixed use development in the Tyngsborough. Thirteen additional developments were identified by the Town Planning Department. The recently constructed and planned developments in Tyngsborough include a total of 658 housing units, 553,900 square feet of commercial and industrial/manufacturing space (Table 8).

Table 8. Current and Future Development in Tyngsborough

Name	Year of Completion	Housing Units	Commercial Sq Ft	Project Type
400 Business Park Dr	2014		7,000	Industrial/ Manufacturing
2-98 Westford Road	2014	80		Residential
Maple Ridge	2014	124		Residential
81 Westford Road Plaza	2015		10,000	Commercial
347 Middlesex Rd	2017		10,000	Commercial
Tyngsborough Crossing	2017	196		Residential
2 Technology Dr.	2018		10,300	Commercial
Tyngsborough Commons	2018	192	126,200	Retail/Residential
422 Middlesex Road/3A	2018		35,000	Retail
420 Middlesex Rd	2019		3,600	Retail/Commercial
500 Potash Hill Rd.	2019		40,000	Industrial
32 Progress Ave	2019		9,900	Industrial
352 Middlesex Rd	2019		7,300	Commercial
Tyngsborough Crossing/Middlesex Rd	2020	66		Residential
44 Old Tyng	Under construction		28,800	Commercial/ Industrial
50 Old Tyng	Under construction		12,800	Commercial/ Industrial
0 Industrial Way	Planned		15,800	Commercial/ Industrial
161-163 Westford Rd.	Planned		10,000	Retail
150-160 Westford	Planned		144,000	Residential/ Commercial
200 Business Park Drive	Planned		55,000	Commercial/ Industrial
Westech Drive	Planned		28,200	Commercial/ Industrial
Total		658	553,900	

(MAPC, 2020 and Core Team Input)

3.8 Critical Facilities and Vulnerable Populations

Critical facilities are extremely essential components to the Town's function and protecting them from natural hazards is paramount. Critical facilities range in function from: (a) resources that can be utilized to respond and recover from natural hazards; (b) facilities where additional assistance might be needed; and (c) hazardous sites that could be dangerous if it is compromised during a natural disaster. Critical facilities in the Town of Tyngsborough have been identified with help from knowledgeable Town staff, MassGIS data, and existing plans. The Northern Middlesex Hazard Mitigation Plan (NMCOG, 2015) was especially helpful. Critical facilities and vulnerable populations have been broken into four categories: emergency response, nonemergency response, dangerous/hazard materials and facilities, and vulnerable populations and community facilities. Emergency response facilities that are necessary for the Town in the event of a disaster. Nonemergency facilities are considered essential for the everyday operation.

Table 9. Category 1 – Emergency Response Facilities

Type	Name	Location
Public Safety	Police Department	20 Westford Road
	Fire Department Headquarters	26 Kendall Road
	Fire Station 2	144 Lakeview Avenue
	Fire Station 3	27 Chestnut Road
Town Facilities	Tyngsborough Highway Department	89 Kendall Road
	Town Hall	25 Bryant Lane
	Tyngsborough Public Library	25 Bryant Lane
Communication and Utilities Infrastructure	Verizon Control Center	
	National Grid Electric Switching Station	
	Tyngsborough Water District Water Supply Water Tank	
	Communications Infrastructure	
	Dracut Water Supply District Infrastructure	
	North Chelmsford Water District Infrastructure	
Official Emergency Shelters	Tyngsborough Elementary School	205 Westford Road
	Senior Center	169 Westford Road
Unofficial Emergency Shelters	Tyngsborough High School	50 Norris Road
	Greater Lowell Vocational High School	250 Pawtucket Boulevard
Primary Evacuation Routes	US Rte 3	
	Rte 113	
	Middlesex Rd.	
	Frost Rd / Rte 3A	
	Westford Rd	
Critical Bridges, Intersections, and Sites	Tyngsborough Bridge on Route 113	
	Middlesex Rd & Kendall Rd	
	Pawtucket Blvd & Frost Rd	
	Flint's Corner, Dunstable Rd & Westford Rd	
	Westford Rd & Old Stonehill Rd	

	Westford Rd & Middlesex Rd	
	Boston Express Bus Station, 99 Kendall Road	

Table 10. Category 2 – Non-Emergency Response Facilities

Type	Name	Location
Private Sewer Pump Stations	Located within the condo complex	Merrimack Landing
	Located within the Condo complex	Wyndbrook Lane
	River Crossing (two pumps)	Village Lane
	Stonehedge Inn	160 Pawtucket Boulevard
	Vesper Country Club	185 Pawtucket Boulevard
	Tyngsborough Housing	Red Pines
	Innovation Academy	72 Tyng Road
	Middlesex Road Pump	104 Middlesex Road
Public Sewer Pump Stations	Audrey Ave	
	Jefferson Drive	
	Willowdale Avenue	
	Mascuppic Trail	
	Phalanx Street	
	Elm Street	
	Sequoia Drive	
	Coburn Drive	
	Progress Ave	
	Farwell Road	
	Middlesex Road	
	Parker Lane	
	Cummings Road	
	Bridgeview	
	Bridgemeadow	
	Flint's Corner	
	Kendall/Flint Road	
Natural Resources	FEMA National Flood Zones	
	DEP Wetlands	
	Lake Althea	
	Bridge Meadow Brook	
	Riverfront Park	
	Hunter Nordam Property	
	Open Space & Conservation Land	
	Merrimack River	
	Lake Mascuppic	
	Long Pond	
	Flint Pond	
	Upton's Pond	
	Locust Pond	
	Massapoag Pond	

Table 11. Category 3 – Dangerous/Hazardous Materials and Facilities

Type	Name	Location
Dams	Cow Pond Brook Dam Locust Pond Dam Upper Flint Pond Dam Mascuppic Lake Dam Lower Flint Pond Dam	
Gas Stations	54 Pawtucket Boulevard 95-97 Westford Rd 383 Middlesex Rd 54 Pawtucket Blvd 397 Middlesex Rd Middlesex Road	
Landfills	Charles Landfill	Dunstable Road
Underground Storage Tanks of Petroleum Fuels or Hazardous Substances	Browning Ferris Industrial Inc. (Republic Services) Highway Dept-Gas & Diesel, Grey Water for wash station High School 54 Pawtucket Boulevard 95-97 Westford Rd 383 Middlesex Rd 54 Pawtucket Blvd 397 Middlesex Rd Middlesex Road	385 Dunstable Road 89 Kendall Road 50 Norris Road

Table 12. Category 4 – Vulnerable Populations and Community Facilities

Type	Name	Location
Housing Authority	Red Pine Terrace	186 Frost Road
	Brinley Terrace	204 Middlesex Rd
	Live Oak Terrace	130 Coburn Road
Affordable Housing	Wyndbrook	2-98 Westford Road
	Merrimack Landing	Middlesex Road
	Maple Ridge	Old Tyng Road
	Whispering Pines	Lakeview Avenue
Hotels	160 Pawtucket Boulevard	
School and Daycare Facilities	Notre Dame Academy	180 Middlesex Rd
	Gr Lowell Reg Vocational Tech. High School	250 Pawtucket Boulevard
	Tyngsborough High School	36 Norris Road
	Tyngsborough Middle School	50 Norris Rd
	Tyngsborough Elementary	205 Westford Road
	Valley Collaborative	135 Coburn Road
	Innovation Academy Charter School	72 Tyngs Road
	The Learning Experience	81 Westford Rd
	Little Angels Academy	262 Middlesex Rd
	Amazing Minds Child Care Center	315 Middlesex Rd #4A
	Creative Minds Early Learning Center	164 Westford Rd
	Carrieanne's Daycare	41 Shakespeare St
	Diane's Home Daycare	7 Bishop Dr
Census Blocks with 25% of population over 65	250173131011016	
	250173131011033	
	250173131011064	
	250173131024007	
	250173131024037	
	250173131024047	

Table 12. Category 4 – Vulnerable Populations and Community Facilities

Type	Name	Location
Census Blocks with 25% of population under 18	250173131011002	
	250173131011003	
	250173131011018	
	250173131011024	
	250173131011040	
	250173131011069	
	250173131012001	
	250173131012004	
	250173131012006	
	250173131012008	
	250173131012022	
	250173131012025	
	250173131012036	
	250173131012037	
	250173131012044	
	250173131012046	
	250173131012047	
	250173131012052	
	250173131012053	
	250173131012058	
	250173131013000	
	250173131013014	
	250173131013015	
	250173131021001	
	250173131022000	
	250173131022006	
	250173131023018	
	250173131023023	
	250173131023030	
	250173131023039	
	250173131023052	
	250173131024019	
	250173131024024	
	250173131024027	
	250173131024038	

4.0 HAZARD PROFILES, RISK ASSESSMENT & VULNERABILITIES

Each hazard profile contains information on the areas vulnerable to the hazard, documentation of historic events, a risk and vulnerability assessment, and projected climate risk. The risk and vulnerability assessment examines both the frequency and severity of hazards and their potential impact to the Town of Tyngsborough. Each hazard risk and vulnerability assessment uses previous occurrences and along with climate projects to determine areas that are more at risk as well as the likelihood that a hazard will occur. The vulnerability analysis looks at various factors in the community, such as existing and future buildings, infrastructure, and critical facilities. In some cases, an estimate of the potential dollar loss to vulnerable structures is available. Land uses and development trends were of particular interest in the flood vulnerability assessment.

The hazard profiles were updated with information from the *2013 Massachusetts State Hazard Mitigation Plan* (MEMA and DCR, 2013); the *2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (SHMCAP) (EEA and EOPSS, 2018) and additional research and assessment. The core team, CRB workshop, and listening session results provided local accounts of each hazard. A Geographic Information System (GIS) assessment was conducted to analyze the potential impact of flooding in Tyngsborough on current and future development. FEMA's Hazus software was used to model potential damage of hurricanes.

4.1 Statewide Overview of Hazards

4.1.1 Massachusetts State Hazard Mitigation and Climate Adaptation

The *2013 Massachusetts State Hazard Mitigation Plan* (MEMA and DCR, 2013) and the *2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (SHMCAP) (EEA and EOPSS, 2018) examined the natural hazards that have the potential to impact the Commonwealth. These plans summarize the frequency and severity of hazards of greatest concern. The frequency classification ranges from very low to high. Severity classifications are listed as a range from minor severity to catastrophic. The box below gives further definitions of the frequency and severity characterizations. The figures on the following pages display the severity of hazard risk in Tyngsborough.

Definitions used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency

- *Very low frequency*: events that occur less frequently than once in 100 years (less than 1% per year)
- *Low frequency*: events that occur from once in 50 years to once in 100 years (1% to 2% per year)
- *Medium frequency*: events that occur from once in 5 years to once in 50 years (2% to 20% per year)
- *High frequency*: events that occur more frequently than once in 5 years (greater than 20% per year)

Severity

- *Minor:* Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.
- *Serious:* Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.
- *Extensive:* Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.
- *Catastrophic:* Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities.

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Table 13. Massachusetts Hazard Risk Summary

Hazard	Frequency	Severity
Inland Flooding	High (1 flood disaster declaration event every 3 years; 43 floods per year of lesser magnitude)	Serious to Catastrophic
Dam failures	Very Low	Extensive to Catastrophic
Coastal Hazards	High (6 events per year over past 10 years)	Serious to Extensive
Tsunami	Very Low (1 event every 39 years on East Coast, 0 in MA)	Extensive to Catastrophic
Hurricane/ Tropical Storm	High (1 storm every other year)	Serious to Catastrophic
High Wind	High (43.5 events per year)	Minor to Extensive
Tornadoes	High (1.7 events per year)	Serious to Extensive
Thunderstorms	High (20 to 30 events per year)	Minor to Extensive
Nor'easter	High (1 to 4 events per year)	Minor to Extensive
Snow and Blizzard	High (1 per year)	Minor to Extensive
Ice Storms	High (1.5 per year)	Minor to Extensive
Earthquake	Very Low (10-15% change of a magnitude 5.0+ every 10 years in New England)	Minor to Catastrophic
Landslide	Low (1 every 2 years in Western MA)	Minor to Extensive
Brush Fires	High (at least 1 per year)	Minor to Extensive
Extreme Temperatures	High (1.5 cold weather and 2 hot weather events per year)	Minor to Serious
Drought	High (8% chance of "Watch" level drought per month [recent droughts in 2016 and 1960s])	Minor to Serious

(MEMA and DCR, 2013; EEA and EOPSS, 2018)

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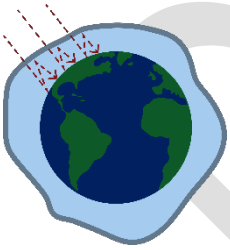
Not all hazards included in the 2018 State Hazard Mitigation and Climate Adaptation Plan or the *2013 Massachusetts State Hazard Mitigation Plan* apply to the Town of Tyngsborough. Given Tyngsborough's inland location, coastal hazards and tsunamis are unlikely to directly affect the Town. Given the type of fires that have occurred in Tyngsborough's history, the Town will focus on brushfires rather than wildfires. It is assumed that the entire Town of Tyngsborough and its critical facilities are susceptible during the occurrence of events such as earthquakes, high-wind events, hurricanes, winter storms, temperature extremes and snow and ice. Flood risk is elevated in the vicinity of the flood zones. Landslides are more likely in areas with more unstable soil types.

4.1.2 Federally Declared Disasters in Massachusetts

Tracking historic hazards and federally declared disasters that have occurred in Massachusetts, and more specifically Middlesex County, helps planners understand the possible extent and frequency of hazards. Massachusetts has experienced multiple type of hazards, including flooding, blizzards, and hurricanes. Since 1991, there have been 22 storms in Massachusetts that resulted in federal or state disaster declarations. Sixteen disaster declarations occurred in Middlesex County. Federally declared disaster open up additional FEMA grant opportunities for regional recovery and mitigation projects. The hazard profiles provided below contain further information about federally declared disasters.

4.1.3 Impacts of Climate Change

Many of the hazards that Tyngsborough commonly experiences are projected to worsen due to climate change. Climate change refers to changes in regional weather patterns that are linked to warming of the Earth's atmosphere as a result of both human activity and natural fluctuations. The Earth's atmosphere has naturally occurring greenhouse gases (GHGs), like carbon dioxide (CO_2), that capture heat and contribute to the regulation of the Earth's climate. When fossil fuels (oil, coal and gas) are burned, GHGs are released into the atmosphere and the Earth's temperature tends to increase. The global temperature increase affects the jet stream and climate patterns. The climate in Massachusetts is expected to reflect historic climate patterns of Southern New England or Mid-Atlantic States depending upon GHG emission scenarios. Climate change has already started to change the climate in Massachusetts and these trends are likely to continue. Climate change is likely to affect Massachusetts's typical precipitation cycle, leading to more intense rainfall and storms and more episodic or flash droughts. Temperatures will increase in both summer and winter. Each of the hazard profiles provided below includes more detail on how hazard frequency and intensity are likely to shift with climate change.



4.1.4 Top Hazards as Defined in the CRB Workshop

Workshop participants were asked to identify the four top hazards that Tyngsborough faces. There was extensive discussion that lead to the selection of these top hazards. They were:

1. Nor'easters, Ice Storms, and Severe Snowstorms
2. Flooding (including riverine and stormwater)
3. Extreme Temperatures and Drought
4. Severe Thunderstorms, Wind, Tornadoes, and Hurricane

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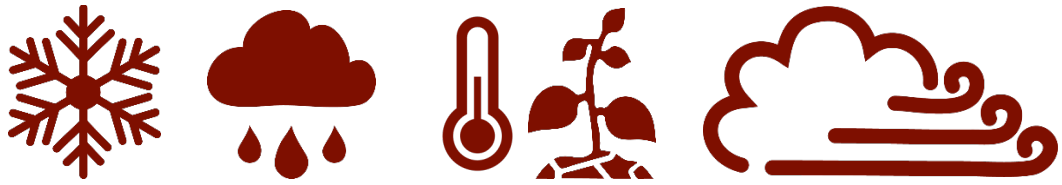

Figure 10. Top hazards defined by Tyngsborough's workshop participants

Extensive discussion about winter storms and power outages resulting from windstorms took place during the portion of the workshop that introduced known and potential natural hazards and climate change impacts that currently occur or are predicted to occur in Tyngsborough. Stakeholders described the Town's power, in which the major national grid substation is located in the neighboring Town of Westford. This substation can be susceptible to outages as a result of severe storms. This can leave residents without power for extended periods. Tyngsborough is a Town with a large number of trees, which can be a great strength to the community, but can also be a challenge, especially in conjunction with overhead power lines and strong storms. There was lengthy discussion with a representative from National Grid about maintenance on the overheard powerlines and the feasibility of relocating the lines below ground. Moving utilities underground is a very complex issue that—depending upon context—can be costly and lengthy process. Workshop participants highlighted that access to power, including backup power sources, during natural hazards is one of the most pressing issues in Tyngsborough.

Figure 11. Tyngsborough's CRB Workshop

Another prevalent natural hazard for Tyngsborough was identified as stormwater and riverine flooding. Workshop participants expressed concern that poorly designed stormwater management systems can cause localized flooding during extreme precipitation events.

Regarding stormwater infrastructure, there was concern that there are several areas that suffer from recurring flooding in Tyngsborough. Some of these areas could cut off access to vulnerable populations in the event of an extreme flood. There was discussion on stormwater projects that have already been implemented, such as installing a culvert on the Elementary School access road, and those that are planned, such as correcting flooding on Westford Road. There was interest in using Town property and Riverfront open space as areas to hold flood waters or to create rain gardens.

4.2 Flood-Related Hazards

Flooding was among the four main hazards identified by participants during Tyngsborough's MVP workshop. Flooding can be caused by various weather events including hurricanes, extreme precipitation, thunderstorms, nor'easters, and winter storms. Beaver dams can also contribute to flood concerns in Tyngsborough. This section also covers dam failure. Flooding events in Tyngsborough have been classified as a high frequency event. As defined by the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPSS, 2018), this hazard occurs once in three years (33% chance per year). While Tyngsborough experiences these events, the impacts of climate change will likely lead to increasingly severe storms and, therefore, increasingly severe impacts. The impacts of flooding include injury or death, property damage, and traffic disruption. Flood storage in riverfront parks, smart development and stormwater infiltration can mitigate flooding.

Areas within the FEMA Flood Zones, repetitive loss sites, and local areas identified as flood prone are more vulnerable to the impacts of flooding. The following sub-sections provide more information on historic flooding events, potential flood hazards, a vulnerability assessment, locally identified as areas of flooding, and information on the risk of dam failures. This analysis of flood hazard areas was informed by the FEMA NFIP Flood Insurance Rate Maps (FIRMs), a GIS vulnerability assessment, information from Tyngsborough town staff, and accounts of past flood events provided by participants during the Tyngsborough MVP Workshop.

Flood hazards are also directly linked to erosion, which can compromise the stability of building foundations. This puts current and future structures and populations located near steep embankments, or along the Merrimack River, at risk. Erosion can also undercut streambeds and pose a risk to those walking along the banks. Structures or critical facilities located near the streams and lakes in Tyngsborough may be considered at risk from fluvial erosion.

4.2.1 Areas Vulnerable to Flooding

Flooding can be both riverine (topping the banks of streams, rivers, ponds) and from stormwater that is not properly infiltrated into the ground.

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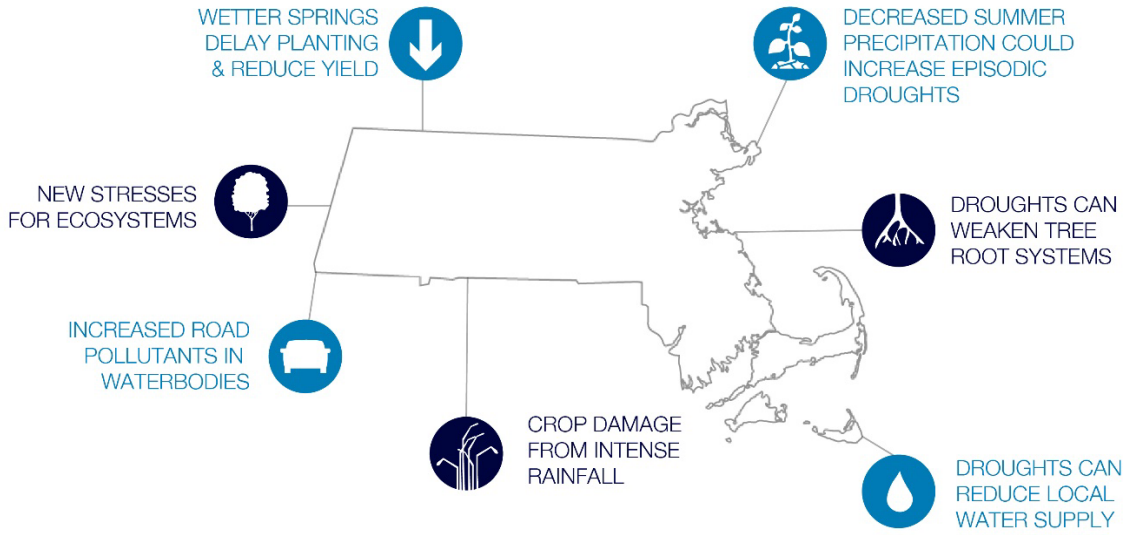

Figure 12. Potential Impacts of Increasing Precipitation (Weston & Sampson based on EEA, 2018)

Riverine Flooding

Tyngsborough is roughly split by the Merrimack River, which runs roughly north-south approximately through the center of Tyngsborough. Areas adjacent are typically more prone to flooding than other areas of town. When the River is at flood stage it overtops its banks and floods a section of Route 113 near the Vesper Country Club. Flooding from the river also tends to occur in the vicinity of Bridgeview Circle. Bridge Meadow Brook can also flood the access road to the Tyngsborough Elementary School, which has a large impact on the community. However, there is secondary gated access point to the school via Diamond Road. Town officials also reported repetitive flooding on Riverbend Road, River Road, and Red Gate Road, Kendall Road Bridge, and Larson Avenue.

The last major flood event in memory was in 2006. Multiple roads had flooding issues, including Pawtucket Blvd. The entrance to Elementary School crossing also washed out along with Bridgemeadow Brook. Several houses along the Merrimack River had significant flooding, and an apartment complex was evacuated. In the last five years there has been minor roadway flooding in low areas, or stream crossings but has not damaged infrastructure, or of significant duration. A series of lakes and ponds may also cause flooding. These include:

- Bridge Meadow Brook
- Lawrence Brook
- Limit Brook
- Scarlett Brook
- Locust Brook
- Cow Pond Brook
- Flint Pond
- Locust Pond
- Mascuppic Lake

FEMA maps flood zones as part of the NFIP called Flood Insurance Rate Maps (FIRMS). Areas within the flood zones are vulnerable to storm events that have a 1% chance or a 0.2% chance of occurring on an annual basis. The definitions of these flood zones are provided below. Most of the FEMA floodplain in Tyngsborough borders the Merrimack River. A map of the FEMA designated flood zones from the NFIP FIRM are included in Appendix B.

Flood Insurance Rate Map Zone Definitions

Zone A (1% annual chance or 100-year flood zone): Zone A is the flood insurance rate zone corresponding to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Detailed hydraulic analyses are not performed for such areas, therefore, no BFEs (base flood elevations) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30 (1% annual chance or 100-year flood zone): Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone X (0.2% annual chance or 500-year flood zone): Zone X is the flood insurance rate zone that corresponds to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or depths are shown within this zone.

(FEMA, 2019b)

Repetitive Loss Sites

As defined by FEMA and the NFIP, a repetitive loss property is any insured property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978 (FEMA and NFIP, 2018). Tyngsborough has eight repetitive loss structures. Five of the town's repetitive loss sites are located within the designated Zone A floodplain. The remaining three repetitive loss sites are located within B, C, or X zones, which are defined by FEMA as areas of moderate or minimal flood hazard (MA DCR, 2020); however in 2019, close to 40% of the flood loss claims occurred outside of the 100-year flood zone (Town of Tyngsborough, 2019b). Four of the repetitive flood loss structures are insured through the National Flood Insurance Program (Town of Tyngsborough, 2019b). Six of the flood loss structures are residential and located next to the Merrimack River (Town of Tyngsborough, 2019b).

Table 14. Summary of Repetitive Loss Properties

Flood Insurance Data		Repetitive Loss (RL) Data	
Flood Insurance Policies in Force	50	RL Buildings	8
Premium	$112,571	RL Losses	16
Insurance in Force	$19,853,200	RL Payments (total)	$2,129,486
Number of Closed Paid Losses	28	RL Payments (building)	$1,901,995
Dollar Amount of Closed Paid Losses	$2,167,314	RL Payments (contents)	$227,491

(MA DCR, 2020)

During Tyngsborough's MVP Workshop in October 2019, participants expressed concern that the data available for repetitive loss structures underrepresents the damage that their community has experienced. Repetitive loss data only includes buildings that qualify for the repetitive loss

Over $2 million have been spent to repair or replace property damaged by floods in Tyngsborough

designation, which workshop attendees felt only included a fraction of the loss that they experienced during previous flood events. As of January 28, the Town of Tyngsborough has paid out 28 losses totaling $2,167,314 for flood insurance. Land acquisitions or design features that allow properties to better withstand flood events are possible solutions to decreases costs in the long-term.

Stormwater Flooding

Stormwater flooding occurs during a precipitation event where the rate of rainfall is greater than the stormwater management system can handle. This may be due to an undersized culvert, poor drainage, topography, high amounts of impervious surfaces, or debris that causes the stormwater system to function below its design standard. In these cases, the stormwater management system becomes overwhelmed, causing water to inundate roadways and properties. Stormwater flooding can occur anywhere in Town and is not limited to areas surrounding water bodies.

Most stormwater systems in Massachusetts are aging and have been designed with rainfall data that is no longer accurate. Figure 13 shows how the amount of rainfall of design storm data has increased from 1961 to 2015, especially for the larger 24-hour, 100-year event. Green infrastructure or low impact development improvements can help reduce stress on the capacity of the existing stormwater system by increasing infiltration on site. A rain garden or pervious pavement are example strategies. Upsizing culverts with new rainfall data is also recommended. The Westford Culvert is critical for access to the Senior Center and should be repaired and upgraded.

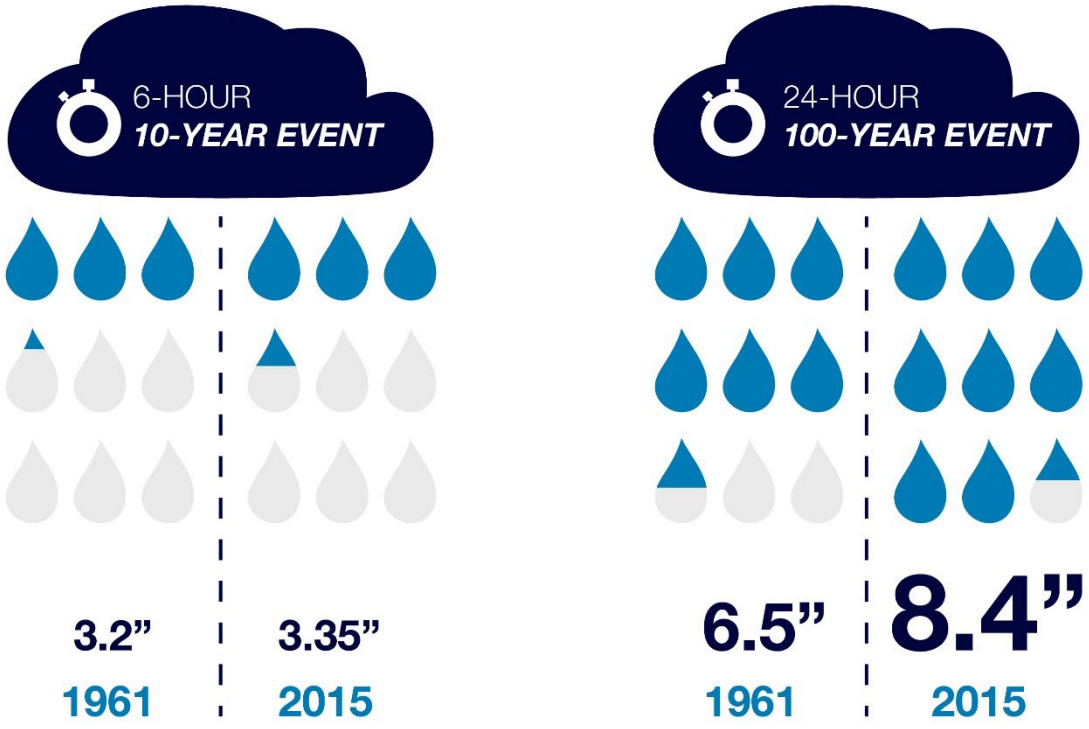

Figure 13: Stormwater Design Standards (NOAA TP-40, 1961) and NOAA Atlas Volume 10 (2015)

4.2.2 Historic Flood Events

Locally Significant Floods

Since the 1960s, several significant floods have impacted the Town of Tyngsborough. Major floods events that affected the Town are presented in the list below.

- March 1968
- January 1979
- April 1987
- October 1996
- June 1998
- March 2001
- April 2004
- October 2005
- May 2006
- April 2007
- April 2007
- March 2010
- December 2010
- September 2011
- August 2012
- February 2013
- January 2015
- October 2016
- October 2017

(NOAA, 2019)

Middlesex Flooding Events

NOAA's National Centers for Environmental Information Storm Events Database (NOAA, 2019) provides information on previous flood events for Middlesex County and the Town of Tyngsborough is in the Central Middlesex Zone. Flash Flood events are considered by the NOAA's National Centers for Environmental Information Storm Events Database as "a life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam)." Floods are considered, "any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property" (NOAA, 2018c).

Climate change projections suggest that precipitation events will become increasingly frequent and severe

Looking at Tyngsborough's most severe hazard events can help us prepare for events intensified by climate change

Middlesex County had 160 flood events between 2000 and 2019. Thirty of these events were flash floods. No deaths or injuries were reported. The property damage totaled $53.439 million dollars (not adjusted for inflation). Incredibly, flooding during March 2010 caused more than 80% of the total property damage reported during this time period (over $35 million dollars) and property damages ranged from $1,000 to $26 million. Events like this are significant because climate change projections suggest that precipitation events will become increasingly frequent and severe.

Two events listed in the database were documented as county-wide impacts in May 2006 with $5 million in damages. Surrounding communities of Lowell and Chelmsford were listed as having direct impacts. Although most of the flooding documented in the database did not directly affect Tyngsborough, the monetary impact of flooding is a proxy for the potential damage that could occur. Damages that occur regionally can also have an indirect impact on Tyngsborough due to regionally

dependent utilities, supply of goods, transportation networks, and economic impacts, among other considerations.

Federally Declared Flood Disasters in Middlesex County

A disaster declaration is a statement made by a community when the needs required by a disaster or emergency is beyond the capabilities of that community. Eight disaster declarations were made in Middlesex County due to flooding between 2000 and 2015, as can be seen in Table 15.

Table 15. Previous Federal and State Disaster Declarations- Flooding

Disaster Name and Date of Event	Type of FEMA Assistance	Counties Under Declaration
Severe Storms/Flooding October 20-25, 1996	Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain and Flooding June 13-July 6, 1998	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms & Flooding March 5-April 16, 2001	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Flooding April 1-30, 2004	Individual & Households Program; Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester
Severe Storms and Flooding October 7-16, 2005	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storms and Flooding May 12-23, 2006	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	Middlesex, Essex, Suffolk
Severe Winter Storm and Flooding December 11-18, 2008	Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storm and Flooding March 12-April 26, 2010	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	Public Assistance; Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	Public Assistance; Hazard Mitigation Grant Program	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester

(MEMA, 2019; FEMA, 2018b; EEA and EOPSS, 2018)

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4.2.3 GIS Flooding Exposure Analysis

Hazard location and extent of riverine flooding was determined using the current effective FEMA FIRM data for Tyngsborough dated 2010. The FIRM is the official map on which FEMA has delineated both the special flood hazard areas and the risk premium zones. Under the NFIP, the 100-year floodplain is linked to mandatory purchase requirements for federally backed mortgage loans. The 500-year floodplain is defined as a moderate- to low-risk areas. For the purposes of this exposure analysis, the following special flood hazard areas as identified in the Town of Tyngsborough's current FIRMs were included: Flood Zone AE – Regulatory Floodway, Flood Zone A (AE, AH) – 1% Annual Chance Flood Hazard, Flood Zone X (shaded) – 0.2% Annual Chance Flood Hazard.

A flood exposure analysis was conducted for critical facilities and vulnerable populations throughout the municipality utilizing MassGIS data, FEMA flood maps, and information gathered from the municipality. Table 16 displays critical facilities in Tyngsborough that are located within either the 100-year or 500-year FEMA flood zone, and Table 17 shows all census blocks in Tyngsborough that contain a high concentration of a vulnerable population.

Table 16. Critical Facilities Located within the FEMA Flood Zone

Facility Name	Location	100-Year FEMA Flood Zone, Only	500-Year FEMA Flood Zone
Affordable Housing Unit	Merrimac Landing		X
Critical Intersection	Pawtucket Blvd & Frost Road		X
Gas Station	54 Pawtucket Blvd		X
Privately Owned Pump Station	Merrimack Landing		X
Privately Owned Pump Station	Stonehedge Hotel		X
Privately Owned Pump Station	Vesper Country Club		X
Greater Lowell Vocational High School (Emergency Shelter)	250 Pawtucket Blvd	X	
Underground Storage Tank	385 Dunstable Road	X	
Underground Storage Tank	54 Pawtucket Blvd		X

Of the 97 critical facilities identified in Tyngsborough, nine of them are located within a FEMA flood zone. These facilities are essential to the ongoing operations of the Town and it is important that they are protected so that they can continue to function even during times of a crisis. Some of these facilities house vulnerable populations

During the workshop, stakeholders discussed concern around the location of vulnerable populations. Some of these community members rely on assistance and it is important that someone is able to access them if needed. It becomes a concern if the vulnerable populations are located within a flood zone or in an area that extreme flooding could isolate them from the rest of the town. Of the 109 census blocks that have a high percentage of a vulnerable population, 41 are located partially within a FEMA flood zone.

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Table 17. Census Blocks with a Higher Concentration of Elderly or Youth Residents Located in a Flood Zone (acres)

Census Block [1]	Total Area	Area in 100-Year Flood Zone	Area in 500-Year Flood Zone
11016**	77.3	7.1	0.0
11033**	15.0	1.5	0.0
11064**	199.0	16.2	0.1
24007**	3.9	3.9	0.0
24037**	42.9	25.6	7.2
24047**	27.4	2.8	0.0
11002	49.9	5.0	4.7
11003	92.5	27.5	15.0
11018	208.8	31.3	0.0
11024	142.2	0.0	0.4
11040	214.0	18.7	0.0
11069	178.0	15.8	0.0
12001	37.2	1.8	0.0
12004	328.0	9.7	0.0
12006	25.5	5.4	0.0
12008	22.5	5.1	0.0
12022	120.9	41.4	0.0
12025	468.0	61.8	0.0
12036	15.9	0.6	0.0
12037	69.5	10.0	0.0
12044	89.2	1.9	0.0
12046	289.0	59.9	0.0
12047	14.2	0.2	0.0
12052	37.6	8.0	0.0
12053	25.6	2.5	0.0
12058	141.7	1.0	0.0
13000	335.2	3.0	0.0
13014	25.1	0.0	0.0
13015	565.9	45.1	0.0
21001	12.3	0.8	0.0
22000	89.6	32.8	19.6
22006	24.9	0.0	0.0
23018	18.3	4.2	1.2
23023	46.3	18.8	8.1
23030	5.8	0.4	0.1
23039	82.2	0.6	0.0

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Table 17. Census Blocks with a Higher Concentration of Elderly or Youth Residents Located in a Flood Zone (acres)

Census Block [1]	Total Area	Area in 100-Year Flood Zone	Area in 500-Year Flood Zone
23052	196.1	18.2	4.5
24019	39.2	0.7	0.0
24024	37.4	4.1	0.0
24027	74.4	4.3	0.0
24038	6.2	3.1	1.0

[1] Census Blocks with 25% of population under 18 or ** denotes Census Blocks with 25% of population over 65

From the data available, there is no way of knowing if residents living in the floodplain are seniors and youth. However, the population living in the Census Blocks in Table 17 have a greater proportion of seniors or youth and also have some areas within the floodplain. The greater the percentage of the Census Block in the flood zone the greater likelihood that residences, or infrastructure serving the residents, could be impacted by flooding. Because Census Blocks vary greatly by size, the total land area within the flood zone may also indicate how widespread the flooding may be. Other factors, such as population density and location of residences, could help improve the assessment of the exposure of vulnerable populations to flooding.

The Town's existing tax parcel and property value data, obtained from MassGIS, were used to estimate the number of parcels (developed and undeveloped) and buildings located in identified hazard areas along with their respective assessed values. The parcel data set provides information about the parcel size, land use type, and assessed value among other characteristics. The parcel data was also classified into various land use types based on the Massachusetts Department of Revenue's Property Type Classification Code, 2016.

An analysis was conducted on all developed parcels in the Town. To determine the vulnerability of each parcel and building, a GIS overlay analysis was conducted in which the flood hazard extent zones were overlaid with the parcel data and existing building footprint data. These developments were overlaid with historic flood zones to determine these parcels vulnerability to flooding. They were categorized by land use type, and the exposure of each land use type was documented by the total area and percentage of parcels that overlap with a flood zone. The risk or impact of potential flooding was captured by summarizing the total property value in each parcel.

Approximately 49% of the developed parcels in Tyngsborough are located within a flood zone. Residential properties have the greatest building value located in both the 100-year flood zone and the 500-year flood zone. However, the percentage of commercial, institutional, and state-owned land in the 100-year flood zone is around 70%. These properties are the economic center of Tyngsborough. If the infrastructure on these properties were to become compromised during a flood, it could lead to an economic hardship in the Town. The tables below show the exposure of developed parcels in the Town of Tyngsborough.

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Table 18. Developed Parcels in 100-Year FEMA Flood Zone Only

Land Use Type	Total # of Parcels	Area of Parcels (acres)	# of Parcels in the Flood Zone	Area in the Flood Zone (acres)	% of Area in the Flood Zone	Property Value in the Flood Zone
Residential	3,331	5,022	464.0	1,280.6	25.5	$80,960,400
Commercial	85	561	25.0	386.8	68.9	$25,556,500
Industrial	34	148	9.0	72.6	49.2	$6,412,600
State-Owned Land & Other	38	765	11.0	547.5	71.6	$55,695,100
Agricultural	1	4	1.0	46.6	100.0	$256,600
Recreation & Open Space	1	107.1	N/A	N/A	N/A	N/A
Total	**3,490**	**6,650.0**	**510.0**	**2,334.2**	**35.1**	**$168,881,200**

Table 19. Developed Parcels in 500-Year FEMA Flood Zone Only

Land Use Type	Total # of Parcels	Area of Parcels (acres)	# of Parcels in the Flood Zone	Area in the Flood Zone (acres)	% of Area in the Flood Zone	Property Value in the Flood Zone
Residential	3,331	5,022.1	143.0	354.7	7.1	$22,726,700
Commercial	85	561.4	22.0	331.0	59.0	$11,467,400
Industrial	34	147.6	4.0	20.6	14.0	$3,140,000
Government Owned Land	38	765.2	10.0	84.1	11.0	$27,225,900
Agricultural	1	46.6	1.0	46.6	100.0	$256,600
Recreation & Open Space	1	107.1	1.0	107.1	100.0	$27,200
Total	**3,490**	**6,650.0**	**181.0**	**944.1**	**14.2**	**$64,843,800**

Information about recent developments, or redevelopments, within the past 10 years (2010 – 2020) was obtained from MassBuilds (MAPC, 2020) and verified by the Town's Director of Economic Development (Salerno, 2020). An exposure analysis was done on these parcels. To determine the vulnerability of each parcel and building, a GIS overlay analysis was conducted in which the flood hazard extent zones were overlaid with the parcel data for recent developments and building footprint data (when available). These developments were overlaid with historic flood zones to determine these parcels vulnerability to flooding. They were categorized by land use type, and the exposure of each land use type was documented by the total area and percentage of parcels that overlap with a flood zone. The risk or impact of potential flooding was captured by summarizing the total property value in each parcel. Although MassGIS parcel data is dated 2019, not all property values have been updated to reflect the most recent developments. Some limitations exist in the accuracy of the data resulting from delay in updates to the building and property value.

Table 20. Recently Developed Parcels in the 100-Year FEMA Flood Zone

Development Name	Development Address	Development Type	Area of Parcel (acres)	Area in the Flood Zone (acres)	% of Area in the Flood Zone	Property Value in the Flood Zone
N/A	420 Middlesex Rd	Commercial	3.3	0.0	0.8	$643,500
N/A	400 Business Park Dr	Industrial	8.7	0.1	0.9	$581,700
Tyngsborough Crossing Development	22 Merrimac Way	Residential	12.9	2.0	15.8	$215,100
Tyngsborough Crossing Development	22 Merrimac Way	Residential	4.1	0.1	2.1	N/A[1]
Wyndbrook (Westford Road)	Westford Rd	Residential	42.8	14.1	33.1	$896,000
Total			71.7	16.4	22.8	$2,336,300

[1]Building and property values have not yet been determined.

Table 21. Recently Developed Parcels in the 500-Year Flood Zone

Development Name	Development Address	Development Type	Area of Parcel (acres)	Area Flood Zone (acres)	% of Area in the Flood Zone	Property Value in the Flood Zone
Tyngsboro Crossing/Middlesex Road	44 Riley Road	Industrial	2.1	0.2	10.4	N/A
Tyngsborough Crossing Development	22 Merrimac Way	Residential	4.1	0.5	12.7	N/A
Tyngsborough Crossing Development	22 Merrimac Way	Residential	12.9	9.5	73.5	N/A
N/A	50 Old Tyng Rd	Commercial	4.1	4.1	100.0	N/A
Tyngsboro Crossing/Middlesex Road	44 Riley Road	Residential	11.8	10.5	88.9	$164,500.00
Total			35.1	24.8	70.8	$164,500.00

[1]Building and property values have not yet been determined

To further resiliency in the Town, a flood exposure analysis was completed on all vacant, developable parcels. The analysis was conducted utilizing MassGIS data (2019), FEMA flood maps, and information from the Town. The result of this analysis will bring light to future flooding that could occur on these parcels if they were to be developed.

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The output of the ArcGIS overlay analysis showed all vacant, developable parcels that intersected with a flood zone. The number of parcels was totaled for each land use type within each of FEMA flood zones. While 2,900 acres of land in Tyngsborough are vacant and developable, 62% of that land is located within the 100-year flood zone and an additional 15% in the 500-year flood zone. It is recommended that as the Town expands development, additional analysis be conducted on these parcels to reduce damage from flooding.

Table 22. Developable, Vacant Land in the 100-Year FEMA Flood Zone

Land Use Category	Parcels	Area of Parcels (acres)	# of Parcels in Flood Zone	Area in Flood Zone (acres)
Residential	119	507.2	29.0	193.8
Commercial	36	162.4	4.0	90.1
Industrial	27	267.0	9.0	151.8
Institutional	150	1420.5	40.0	946.0
Agricultural	14	352.0	7.0	239.1
Recreation & Open Space	13	200.7	7.0	185.8
Total	359	2909.9	96.0	1806.6

Table 23. Developable, Vacant Land in the 500-Year FEMA Flood Zone

Land Use Category	Parcels	Area of Parcels (acres)	# of Parcels in Flood Zone	Area in Flood Zone (acres)
Residential	119	507.2	51.0	10.1
Commercial	36	162.4	79.8	49.1
Industrial	27	267.0	31.9	12.0
Institutional	150	1420.5	212.5	15.0
Agricultural	14	352.0	39.6	11.3
Recreation & Open Space	13	200.7	10.5	5.2
Total	359	2909.9	425.5	14.6

Planned development noted by MassBuilds (MAPC, 2020) were reviewed and updated by the Town's Director of Economic Development. These parcels were overlaid with FEMA flood zone maps to determine the vulnerability to flooding. They were categorized by development type. The exposure of potential development within each land use type was documented by the area and percentage of parcels that overlap with a flood zone. Of the 5 planned developments in Tyngsborough, one is located in the 100-year flood zone and none are located in the 500-year flood zone. This can be seen in Tables 24.

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Table 24. Planned Development in the 100-Year FEMA Flood Zone

Development Address	Development Type	Area of Parcel (acres)	Area of Parcel in Flood Zone (acres)	% of Parcel in the Flood Zone
200 Business Park Dr	Industrial	17.9	0.5	2.6

This planned development is located adjacent to a water resource area which can aid in flood storage and mitigation but could also become a hazard to adjacent infrastructure during a heavy rain or flood event. The existing 100-year flood elevation and future flood elevations should be taken into account during the design of the new industrial development. Resiliency measures, such as additional flood storage or flood protection should be included in the design of this new industrial development.

4.2.4 Dams and Dam Failure

Dam failure is defined as a collapse of an impounding structure resulting in an uncontrolled release of impounded water from a dam (DCR, 2017a). There are two types of dam failures that can occur. Catastrophic failure occurs when there is a sudden, rapid, uncontrolled release of impounded failure. The other is design failure, which occurs as a result of minor overflow events. Dam overtopping occurs when floods exceed the capacity of the dam and can occur as a result of inadequate spillway design, or other outside factors such as settlement of the dam crest or backage of spillways. Thirty-four percent of all dam failures that occur in the United States are a result of overtopping (EEA and EOPSS, 2018). Dam failures during flood events are of concern in Massachusetts, given the high density of dams constructed in the 19th century (MEMA and DCR, 2013).

Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage (MEMA and DCR, 2013).
Dam failure can cause property damage, injuries, and potentially fatalities. These impacts can be at least partially mitigated through advance warning to communities impacted by a dam failure. In addition, the breach may result in erosion on the rivers and stream banks that are inundated.

Climate change may indirectly affect dam breaches for a variety of reasons. Dams are typically designed based on historic water flows and known hydrology. Climate change projections indicate that the frequency, intensity, and amount of precipitation will increase in New England. Increased precipitation may push dams over capacity. Therefore, dams will have to be monitored for safety. There are several mechanisms in place to manage increases in water, such as slowly releasing water. It is advised that these events are monitored as it can add additional stress on the dam infrastructure.

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There have been no recorded dam failures in Tyngsborough, and dam failure is classified as a very low frequency event. Locust Ave & Middlesex Rd were identified as areas at risk if there were to be a dam overtopping of the Locust Pond Dam. Dam failure can still present a high level of risk and could result in a catastrophic event with extreme damage and loss of life. As defined by the *2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (EEA and EOPSS, 2018), a very low frequency hazard may occur less frequently than once in 100 years (less than a 1% chance per year).

According to Town officials and the Massachusetts Department of Conservation and Recreation's (DCR) Office of Dam Safety, there are five dams in Tyngsborough. Information related to these dams is summarized in Table 25. This summary table includes the hazard classification for each dam, which is defined by DCR as described below.

- *High:* Dams located where failure or mis-operation will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).
- *Significant:* Dams located where failure or mis-operation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause interruption of use or service or relatively important facilities.
- *Low:* Dams located where failure or mis-operation may cause minimal property damage to others. Loss of life is not expected.

Table 25. Inventory of Dams in Tyngsborough

Name	Owner	Hazard Potential Classification[1]	Downstream Population[2]
Upper Flint Pond Dam	Dept. of Fisheries and Wildlife	Significant	0
Lower Flint Pond Dam	Dept. of Fisheries and Wildlife	Low	450
Locust Pond Dam	Private	Significant	100
Mascuppic Lake Dam	Private	Non-jurisdictional	NA
Cow Pond Brook Dam	Private	Significant	100

[1]Army Corps of Engineers, 2018
[2]NMCOG, 2015

Upper Flint Pond Dam

The Upper Flint Pond Dam, located at in the center of the Tyngsborough, is owned and maintained by the Commonwealth of Massachusetts Department of Fisheries and Wildlife. This dam is rated as a significant-risk hazard and is in fair condition. The Upper Flint Pond Dam is currently under reconstruction to improve dam condition and safety.

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Lower Flint Pond Dam

The Lower Flint Pond Dam is located along the Merrimack River owned by the Commonwealth of Massachusetts Department of Fisheries and Wildlife. This dam is rated as a low-risk hazard class.

Other Dams

Locust Pond Dam (significant hazard class), Mascuppic Lake Dam (non-jurisdictional hazard class), and Cow Pond Brook Dam (significant hazard class) are all privately owned.

As of February 2017, all dams classified as high hazard potential or significant hazard potential were required to have an Emergency Action Plan (EAP) (DCR, 2020). This plan must be updated annually and submitted to the Commissioner and the Massachusetts Emergency Management Agency. The plan should also be retained by the dam owned and the Town in which the dam is located. Guidelines and a template were established by the Office of Dam Safety to ensure that all EAPs follow the proper format.

4.2.5 Climate Change Impacts: Flooding

Boston's average annual precipitation is 53.32 inches (NOAA, 2019b). Extreme rain and snow events are becoming increasingly common and severe particularly in the Northeast region of the country (Figure 14). Regional increases in heavy precipitation events exceed the rest of the US by a 74% increase in the heaviest 1% of all precipitation events since 1958. The eastern region of Massachusetts has shown an increase in heavy precipitation of two inches or more since 1970. Annual maximum daily precipitation in the area has also increased by up to 2 inches since 1970 (UMass, 2019).

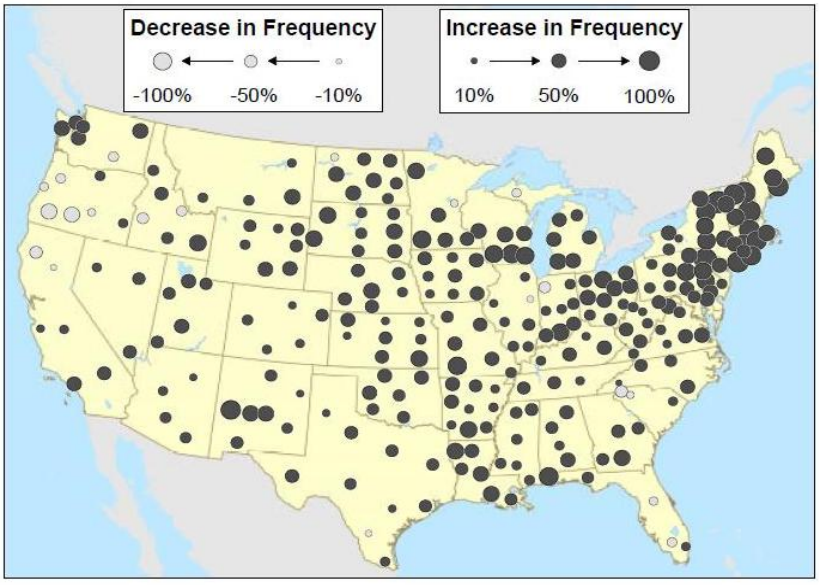

Figure 14. Changes in Frequency of Extreme Downpours (Madsen and Willcox, 2012, page 19)

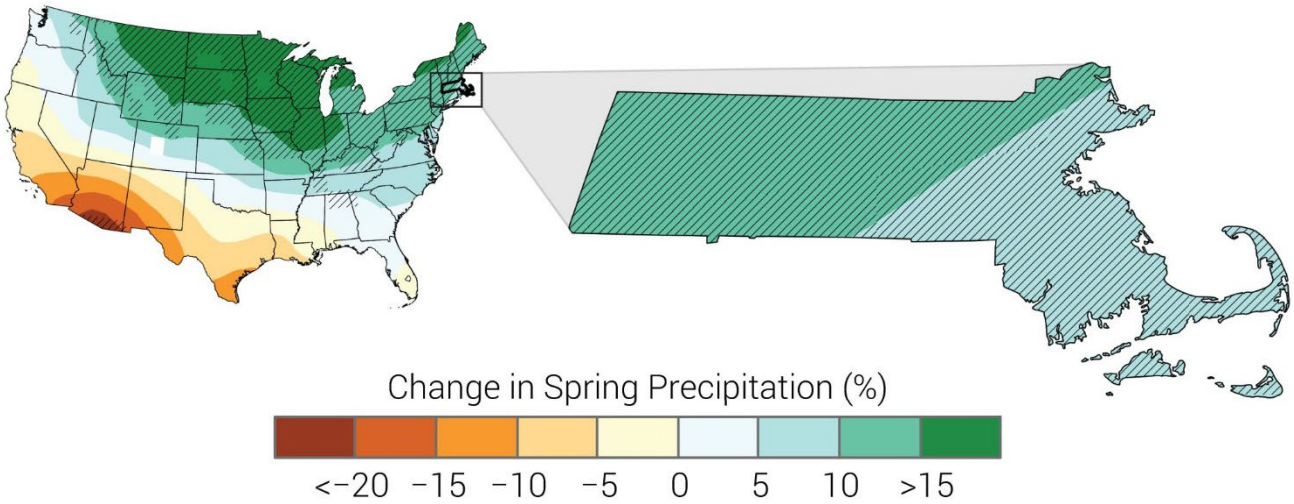

Figure 15. Projected Change in Spring Precipitation "Projected change in spring precipitation (%) for the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents portions of the state where the majority of climate models indicate a statistically significant change. Precipitation in the spring is projected to increase in Massachusetts by mid-century. Data from CICS-NC and NOAA NCEI" (NOOA and Department of Commerce, 2017)

4.3 Wind-Related Hazard

High winds can occur during hurricanes, tropical storms, tornadoes, nor'easters, and thunderstorms. The entire planning area is vulnerable to the impacts of high wind. All current and future buildings including critical facilities and populations are considered to be vulnerable during high wind events. Wind may down trees and power lines. High wind and storm events cause property damage and hazardous driving conditions. While Tyngsborough's current 100-year wind speed is 110 mph, climate change will likely increase events and severity.

Extreme winds can take down trees and branches that cause service disruptions. An identified issue during storms in Tyngsborough is the damage to power and phone wires from overhanging trees that have not been trimmed by National Grid or the phone or cable companies. The utilities' tree maintenance program should be upgraded to reduce the risk associated with tree damage to utility lines. Tyngsborough is disproportionally affected by power outages due to downed trees because the Town's power is sourced from a National Grid station located in Westford, MA, and all power must be brought to Tyngsborough through an aboveground power line corridor, much of which is wooded. High winds and heavy snow loads caused significant power line damage in Tyngsborough during a nor'easter in 2018. Falling trees and branches can also block traffic and emergency routes. This is a regional issue that affects cities and towns beyond Tyngsborough.

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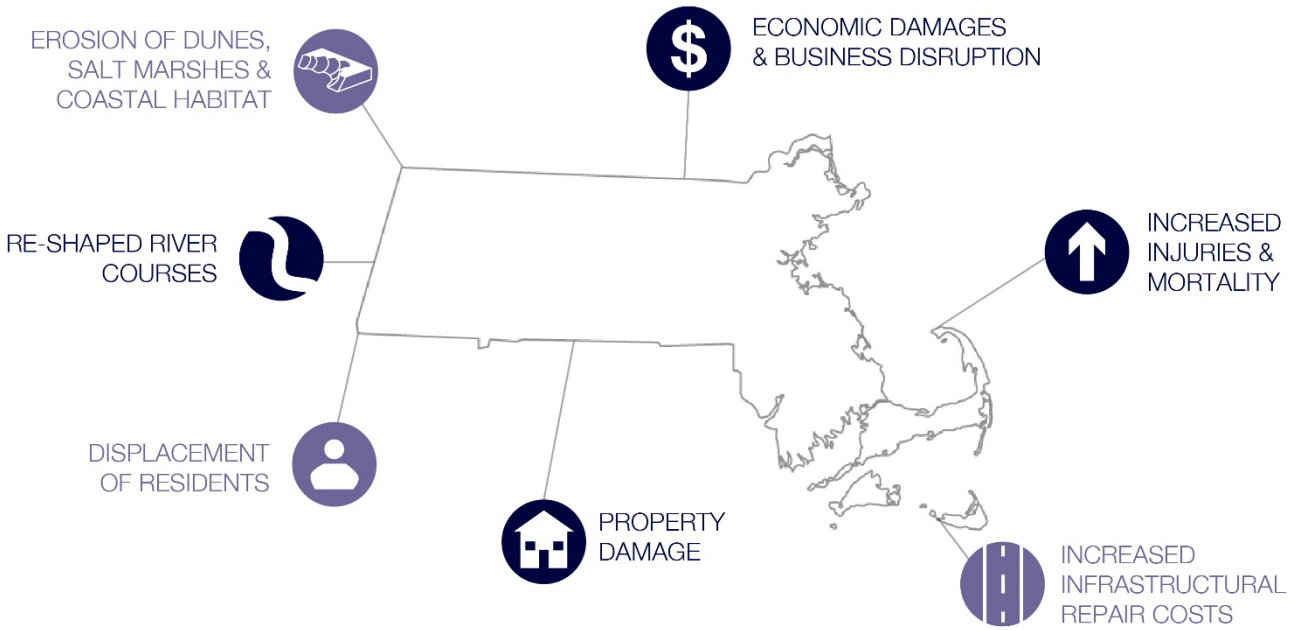

Figure 16: Potential Impacts of Extreme Storms (Weston & Sampson based on EEA, 2018)

4.3.1 Hurricanes and Tropical Storms

Tropical cyclones (including tropical depressions, tropical storms, and hurricanes) form over the warm waters of the Atlantic, Caribbean, and Gulf of Mexico. A tropical storm is defined as having sustained winds from 39 to 73 mph. If sustained winds exceed 73 mph, it is categorized a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered "Major" hurricanes. Wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (EEA and EOPSS, 2018).

When hurricanes and tropical storms occur, they will impact the entire planning area. All existing and future buildings including critical facilities and populations are at risk to the hurricane and tropical storm hazard (including critical facilities). Hurricane events have a large spatial extent and would potentially affect all of Tyngsborough's infrastructure and buildings. Impacts include water damage in buildings from building envelope failure, business interruption, loss of communications, and power failure. Flooding is a major concern as slow-moving hurricanes can discharge tremendous amounts of rain on an area.

The official hurricane season runs from June 1 to November 30. However, storms are more likely to occur in New England during August, September, and October (EEA and EOPSS, 2018). The Saffir/Simpson scale categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to provide an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on context (EEA and EOPSS, 2018). More information is included in Table 26.

Table 26. Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Potential Damage
1	74 – 95	Minimal: damage is primarily to shrubbery and trees, mobile homes, and some signs. No real damage is done to structures.
2	96 – 110	Moderate: some trees topple, some roof coverings are damaged, and major damage is done to mobile homes.
3	111 – 130	Extensive: large trees topple, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.
4	131 – 155	Extreme: extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	Catastrophic: roof damage is considerable and widespread, window and door damage are severe, there are extensive glass failures, and entire buildings could fail.

(EEA and EOPSS, 2018 based on information from NOAA)

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. Between 1851 and 2012, Massachusetts experienced 13 hurricanes and two named tropical storms. The most recent FEMA disaster declaration in Massachusetts due to a hurricane was Hurricane Sandy in 2012 (FEMA, 2018b). Hurricanes that have occurred in the region since 1938 are listed in Table 27. Four were Category 3 events.

Table 27. Hurricane Records for Eastern Massachusetts, 1938 to 2019

Hurricane Event	Date
Great New England Hurricane	September 21, 1938
Great Atlantic Hurricane	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol	August 31, 1954
Hurricane Edna	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Katrina	September 13, 2005
Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012
Hurricane Florence	September 18, 2018
Tropical Storm Dorian	September 7, 2019

(NOAA, 2020)

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Hurricane damage in Tyngsborough was estimated using a hurricane modeling software. Hazus Multi-Hazard (Hazus) is a GIS model developed by FEMA to estimate losses in a defined area due to a specified natural hazard. The Hazus hurricane model allows users to input specific parameters in order to model a defined hurricane magnitude, which is based on wind speed. The largest hurricane ever witnessed in Massachusetts was a Category 3 hurricane, which occurred in 1954. For the purpose of this analysis, in order to estimate potential damage, both a category 2 and a category 4 hurricane were modeled. Although there have been no recorded Category 4 hurricanes recorded in Massachusetts, storm was modeled to show the impact that could occur from an extreme scenario, something that could possibly happen in the future due to climate change.

In Massachusetts, the return period for a category 2 hurricane is approximately 0.01 percent, and for a category 4 hurricane it is approximately 0.005 percent. HAZUS models hurricanes based upon their return period. Therefore, a category 2 was modeled as a 100-year hurricane and a category 4 was modeled as a 500-year hurricane. In order to model each of these hurricanes, the study region must first be defined. The Town of Tyngsborough was outlined by the census tracts in the Town. The probabilistic scenario was used for Tyngsborough. This scenario considers the associated impact of thousands of storms that have a multitude of tracks and intensities. The output shows the potential impact that could occur in Tyngsborough if either a category 2 or a category 4 hurricane passed by. HAZUS is based on 2010 census data and 2014 dollars. The tables below show the estimated damage from both a category 2 and a category 4 hurricane in the municipality.

Table 28. Category 2 Hurricane Damage Potential

Land Use Type	Total # of Buildings	Total # of Buildings Damaged[1]	% of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	3,631	39	1%	$5,348,400
Commercial	272	3	1%	$79,100
Industrial	102	1	1%	$16,360
Others	48	1	2%	$16,600
TOTAL	4,053	44	1%	$5,460,460

[1]Numbers include Slight, Moderate, Extensive, and Total Damage
[2]Includes Building, Content, and Inventory

Table 29. Category 4 Hurricane Damage Potential

Land Use Type	Total # of Buildings	Total # of Buildings Damaged[1]	% of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	3,631	416	12%	$21,160,920
Commercial	272	24	9%	$758,300
Industrial	102	8	8%	$218,610
Others	48	4	8%	$160,340
TOTAL	4,053	452	11%	$22,298,170

[1]Numbers include Slight, Moderate, Extensive, and Total Damage
[2]Includes Building, Content, and Inventory

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Hurricanes are a Townwide hazard in Tyngsborough and are considered a medium frequency event. The average number of hurricane or tropical storm events is one every two years (EEA and EOPSS, 2018).

4.3.2 Tornadoes

A tornado is violently rotating column of air that extends from the base of a cloud to the ground that can be a mile or more wide. Tornadoes are the most violent of all atmospheric storms (EEA and EOPSS, 2018). According to the 2018 SHMCAP, the following are common factors in tornado formation:

- Very strong winds in the middle and upper levels of the atmosphere
- Clockwise turning of the wind with height
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e. 20 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground, with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

Tornadoes can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even form from little more than a rain shower if air is converging and spinning upward. The most common months for tornadoes to occur are June, July, and August. There are exceptions: The Great Barrington, Massachusetts, tornado in 1995 occurred in May; and the Windsor Locks, Connecticut, tornado in 1979 occurred in October (EEA and EOPSS, 2018).

The Fujita Tornado Scale measures tornado severity through estimated wind speed and damage. The National Weather Service began using the Enhanced Fujita-scale (EF-scale) in 2007, which led to increasingly accurate estimates of tornado severity. Table 30 provides more detailed information on the EF Scale.

Table 30. Enhanced Fujita Scale

Fujita Scale			**Derived**		**Operational EF Scale**	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gust (mph)
0	40 – 72	45 – 78	0	65 – 85	0	65 – 85
1	73 – 112	79 – 117	1	86 – 109	1	86 – 110
2	113 – 157	118 – 161	2	110 – 137	2	111 – 135
3	158 – 207	162 – 209	3	138 – 167	3	136 – 165
4	208 – 260	210 – 261	4	168 – 199	4	166 – 200
5	261– 318	262 – 317	5	200 – 234	5	Over 200

(MEMA and DCR, 2013)

Massachusetts averages 1.7 tornadoes per year. The most tornado-prone areas of the state are the central counties. Tornadoes are comparatively rare in eastern Massachusetts, although Middlesex County is considered an at-risk location (EEA and EOPSS, 2018). The most devastating tornado in Massachusetts in the history of recorded weather occurred in Worcester in 1953, it killed 94 people, injured more than 1,000, and caused more than $52 million in damages (more than $460 million in

current dollars). There have been 18 recorded tornados in Middlesex County since 1955. Over this period, a total of one fatality and six injuries have been reported (Lietz, 2019) (Table 31). Some more recent tornadoes in Massachusetts occurred in 2011 in Springfield, 2014 in Revere, and 2016 in Concord (Morrison 2014; Epstein 2016). Monson also experienced a tornado in 2011 and Yarmouth and Barnstable experienced tornadoes in 2019. The tornado on July 21, 1972 went through Tyngsborough along the Merrimack River and into North Chelmsford and over Robin Hill into South Chelmsford (NMCOG, 2015).

Tornadoes present a townwide hazard and the damages would depend on the track of the tornado. However, tornado damage could be high due to the prevalence of older construction and the density of development. Structures built before current building codes may be more vulnerable. Evacuation, sheltering, debris clearance, distribution of food and other supplies, search and rescue, and emergency fire and medical services may be required. Critical evacuation and transportation routes may be impassable due to downed trees and debris, and recovery efforts may be complicated by power outages.

Tornados are difficult to simulate well in climate models because of their small size when compared to other weather events. However, it is predicted that the frequency of tornados in eastern Massachusetts will rise in the future due to climate change.

Table 31. Tornado Records for Middlesex County

Date	Fujita	Fatalities	Injuries	Width	Length	Damage
10/24/1955	1	0	0	10	0.1	$500-$5000
6/19/1957	1	0	0	17	1	$5K-$50K
6/19/1957	1	0	0	100	0.5	$50-$500
7/11/1958	2	0	0	17	1.5	$50K-$500K
8/25/1958	2	0	0	50	1	$500-$5000
7/3/1961	0	0	0	10	0.5	$5K-$50K
7/18/1963	1	0	0	50	1	$5K-$50K
8/28/1965	2	0	0	10	2	$50K-$500K
7/11/1970	1	0	0	50	0.1	$5K-$50K
10/3/1970	3	1	0	60	35.4	$50K-$500K
7/1/1971	1	0	1	10	25.2	$5K-$50K
11/7/1971	1	0	0	10	0.1	$50-$500
7/21/1972	2	0	4	37	7.6	$500K-$5M
9/29/1974	3	0	1	33	0.1	$50K-$500K
7/18/1983	0	0	0	20	0.4	$50-$500K
9/27/1985	1	0	0	40	0.1	$50-$500K
8/7/1986	1	0	0	73	4	$50K-$500K
8/22/2016	1	0	0	400	.85	$10K

(Lietz, 2019)

4.3.3 Nor'easters

A nor'easter is characterized by large counterclockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, waves, and rain along the East Coast of North America. The term nor'easter refers to their strong northeasterly winds blowing in from the ocean. These weather events are among the season's most ferocious storms, often causing beach erosion, flooding, and structural damage (EEA and EOPSS, 2018).

Nor'easters generally occur in Tyngsborough on at least an annual basis, typically in late fall and early winter. Some years bring four or more nor'easter events. The storm radius is often as much as 100 miles and sustained wind speeds of 20 to 40 mph are common, with short-term gusts of up to 50 to 60 mph. Nor'easters are commonly accompanied by a storm surge equal to or greater than two feet. High surge and winds during a hurricane can last from 6 to 12 hours, while these conditions during a nor'easter can last from 12 hours to three days (EEA and EOPSS, 2018). Previous nor'easters events are listed in Table 32. The severe Coastal Storm in 1991 led to a federal disaster declaration.

Table 32. Nor'easter Events for Massachusetts, 1978 to 2019

Nor'easter Event	Date
Blizzard of 1978	February 1978
Severe Coastal Storm ("Perfect Storm")	October 1991
Great Nor'easter of 1992	December 1992
Blizzard, Nor'easter	January 2005
Coastal Storm, Nor'easter	October 2005
Severe Storms, Inland and Coastal Flooding	April 2007
Winter Storm and Nor'easter	January 2011
Severe Storm and Snowstorm	October 2011
Severe Winter Storm, Snowstorm, and Flooding	April 2013
Severe Winter Storm, Snowstorm, and Flooding	April 2015
Severe Winter Storm and Flooding	March 2018
Severe Winter Storm and Snowstorm	March 2018

(NOAA, 2018a)

Some of the historic events described in the "Flood-Related Hazards" section of this report were preceded by nor'easters, including the 1991 "Perfect Storm." The Blizzard of '78 was a notable storm. More recently, winter storms in 2015 and 2018 caused significant snowfall amounts.

The Town of Tyngsborough is vulnerable to high winds, snow, and extreme rain during nor'easters. These impacts can lead to property damage, downed trees, power service disruptions, surcharged drainage systems, and localized flooding. These conditions can impact evacuation and transportation routes and complicate emergency response efforts. Due to its inland location, Tyngsborough is not subject to the coastal hazards often associated with nor'easters.

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4.3.4 Thunderstorms and Related Wind Events

Thunderstorms can include lightning, strong winds, heavy rain, hail, and sometimes tornados. Thunderstorms typically last for about 30 minutes and can generate winds of up to 60 mph. Thunderstorms are considered high frequency events in Tyngsborough. Massachusetts experiences 20-30 thunderstorm days per year. Thunderstorms with little or no rainfall are rare in New England but have occurred (EEA and EOPSS, 2018).

Thunderstorms are typically less severe than other events discussed in this section. However, thunderstorms can cause local damage and are a town-wide risk in Tyngsborough. Winds associated with thunderstorms can knock down trees resulting in power outages and blocked evacuation and transportation routes. Extreme rain during thunderstorms can cause inland flooding around waterbodies or due to surcharged drainage systems. During periods of drought, lightning from thunderstorm cells can result in fire ignition.

NOAA's National Centers for Environmental Information offers thunderstorm data for Middlesex County, which includes Tyngsborough. Between 2008 and 2018, 278 thunderstorm events caused $3,208,000 in property damages. Three injuries and no deaths were reported. The severe thunderstorm on May 22, 2006 toppled trees in Tyngsborough, Chelmsford, and Lowell and left 5,000 residents without power. Wind gusts reached 45 mph.

Table 33. Previous Federal and State Disaster Declarations for Severe Storms

Disaster Name and Date of Event	Type of FEMA Assistance	Counties Under Declaration
Severe Storms/Flooding October 20-25, 1996	Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain and Flooding June 13-July 6, 1998	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms & Flooding March 5-April 16, 2001	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms and Flooding October 7-16, 2005	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storms and Flooding May 12-23, 2006	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	Middlesex, Essex, Suffolk
Severe Storm and Flooding March 12-April 26, 2010	Public Assistance; Individual & Households Program; Hazard Mitigation Grant Program	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester

Winds associated with thunderstorms can knock down trees resulting in power outages and blocked evacuation and transportation routes. Extreme rain during thunderstorms can cause inland flooding

around waterbodies or due to surcharged drainage systems. Thunderstorms are considered high frequency events in Tyngsborough.

4.3.5 Climate Change Impacts: Wind-Related Hazards

Tyngsborough's current 100-year wind speed is 110 mph. Climate change will likely increase the number of extreme wind events and their severity. Additionally, rising sea temperature could lengthen the hurricane season and fuel stronger hurricane events. Hurricanes have increased in intensity, frequency, and duration have since the early 1980s (Walsh and Wuebbles, 2014) This would result in greater losses due to increased flooding, associated building damages and business interruption impacts (Walsh and Wuebbles, 2014). The anticipated increase in frequency and intensity of severe thunderstorms may also increase the risk of tornadoes (EEA and EOPSS, 2018).

4.4 Winter Storms

Winter-storm events are atmospheric in nature and can impact the entire planning area. All current and future buildings and populations are considered to be at risk of winter storms, which have a variety of potential impacts. Heavy snow loads may cause roofs and trees to collapse leading to structural damage. Deaths and injury are also possible impacts. Additional impacts can include road closures, power outages, business interruption, business losses (i.e., due to road closures), hazardous driving conditions, frozen pipes, fires due to improper heating, and second-hand health impacts caused by shoveling (such as a heart attack). Public safety issues are also a concern, as streets and sidewalks can become difficult to pass. This issue may be especially difficult for vulnerable populations such as elderly people who may have trouble crossing at intersections due to large accumulations of snow. Impassable streets can also complicate emergency response efforts during an extreme event.

Winter storms are a potential town-wide hazard in Tyngsborough. These events can include wind, heavy snow, blizzards, and ice storms. Blizzards and ice storms in Massachusetts can range from an inconvenience, to extreme events that cause significant impacts and require a large-scale, coordinated response. There have been seven federal and state disaster declarations since 1996 in Middlesex County (Table 34).

Table 34. Previous Federal and State Disaster Declarations

Disaster Name and Date of Event	Type of FEMA Assistance	Counties Under Declaration
Blizzard January 7-13, 1996	No funding reported	All 14 Massachusetts Counties
Severe Winter Storm and Flooding December 11-18, 2008	Public Assistance; Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm and Snowstorm January 11-12, 2011	Public Assistance; Hazard Mitigation Grant Program	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, Suffolk

Table 34. Previous Federal and State Disaster Declarations

Disaster Name and Date of Event	Type of FEMA Assistance	Counties Under Declaration
Severe Storm and Snowstorm October 29-30, 2011	Public Assistance; Public Assistance Snow Removal; Hazard Mitigation Grant Program	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Worcester
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	Public Assistance; Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	Public Assistance; Hazard Mitigation Grant Program	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Snowstorm March 13-14, 2018 (FEMA, 2018b)	Public Assistance; Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester

Figure 17. Crash on Chestnut Road during December 2017 Snowstorm (Tyngsborough Police Department Twitter, 2017)

4.4.1 Heavy Snow and Blizzards

A blizzard is a winter snowstorm with sustained wind or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile. These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of the criteria. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero (EEA and EOPSS, 2018).

Winter storms include multiple risks, such as wind, ice, and heavy snow. The National Weather Service defines "heavy snow" as snowfall accumulating to 4" or more in 12 hours or less; or snowfall accumulating to 6" or more in 24 hours or less (NOAA, 2019b). Winter storms can be combined with the nor'easters discussed previously in the "Wind-Related Hazards" section.

There is no widely used scale to classify snowstorms. The Northeast Snowfall Impact Scale (NESIS), developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service (Kocin and Uccellini, 2004), characterizes and ranks high-impact northeast snowstorms. These storms have large areas of 10-inch snowfall accumulations and greater. NESIS has five

categories, as shown in Table 35. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus, NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact northeast snowstorms can have on the rest of the country in terms of transportation and economics. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The aerial distribution of snowfall and population information are combined in an equation that calculates a NESIS score, which varies from 1 for smaller storms to over 10 for extreme storms. The raw score is converted into one of the five NESIS categories. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers. NOAA began using the NESIS in 2005 to determine impact from snow events (MEMA and DCR, 2013).

Table 35. NESIS Categories

Category	NESIS	Value Description
1	1 – 2.499	Notable
2	2.5 – 3.99	Significant
3	4 – 5.99	Major
4	6 – 9.99	Crippling
5	10+	Extreme

(EEA and EOPSS, 2018)

The current winter snowfall record in Eastern Massachusetts is 108.6 inches during the 2014-2015 season ((NOAA, 2015). The town provides standard snow plowing operations and clearing snow has not posed any significant challenges. The "Blizzard of 1978" is a well-known winter storm that deposited more than three feet of snow and led to multiday closures of roads, businesses, and schools. Table 36 provides additional information on significant snow events.

Table 36. Severe Winter Storm Records for Massachusetts

Type of Event	Date
Blizzard	February 1978
Blizzard	March 1993
Blizzard	January 1996
Severe Snowstorm	March 2001
Severe Snowstorm	December 2003
Severe Snowstorm	January 2004
Severe Snowstorm	January 2005
Severe Snowstorm	April 2007
Severe Snowstorm	December 2010
Severe Snowstorm	January 2011
Blizzard	February 2013
Blizzard	January 2015
Severe Snowstorm	March 2018

(NOAA, 2019a)

NOAA's National Centers for Environmental Information Storm Events Database provide information for blizzards, winter weather, heavy snow, and winter storms. There were 250 winter events between 2000 and 2019 in Middlesex County totaling $2,059,000 dollars of damage. The greatest damage was during this time frame was a storm in 2011 causing $926,000 of damage. Most of the electric customers (99%) were out of electricity during a snowstorm in October 2011 (NMCOG, 2015). In March 2018, Tyngsborough experienced 21 inches of snowfall in a single storm (NOAA, 2020).

During Tyngsborough's MVP Workshop in October 2019, participants discussed past examples of severe winter weather. Participants discussed the opportunity for additional snow maintenance personnel and equipment, as well as more hazard snow removal at Town buildings. Participants discussed how the snow removal procedures could be updated, and adherence to the procedures could be more strictly enforced. Backup power sources are imperative to the Town in the event of power outages due to severe winter weather.

Blizzards are classified as high frequency events in Tyngsborough. As defined by the *2013 Massachusetts State Hazard Mitigation Plan*, this hazard can occur more than once in five years (a greater than 20% chance of occurring each year). High-impact snowstorms occur more frequently at approximately the rate of once per year (EEA and EOPSS, 2018).

4.4.2 Ice Storms

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects creating ice build-ups of ¼ inch or more that can cause severe damage. An ice storm warning, now included in the criterion for a winter storm warning, is for severe icing. This is issued when ½ inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the weighing down of power lines and trees. Icy roads can also complicate emergency response efforts during an extreme event. Ice storms are classified as medium frequency events in Tyngsborough. Ice storms impact the Commonwealth on at least an annual basis.

Sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. Sleet differs from hail: sleet is a wintertime phenomenon, while hail usually falls during thunderstorms in the spring and summer (EEA and EOPSS, 2018).

NOAA's National Centers for Environmental Information Storm Events Database offers data on hail events, ice storms and sleet Middlesex County. There were 131 hail events, three ice storms, and no reported sleet hazards between 2000 and 2019. No deaths or injuries were reported. Over $6.2 million dollars in damages were incurred.

4.4.3 Climate Change Impacts: Winter Storms

There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated during the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain (EEA and EOPSS, 2018).

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Climate projections indicate that climate change will result in more precipitation during the winter in the Northeast (EEA, 2018a). This trend may result in more frequent and/or more severe winter storms.

4.5 Geological Hazards

Geologic hazards can include earthquakes, landslides, sinkholes, and subsidence. town officials did not identify any local areas that were previously recorded as being vulnerable to geologic hazards.

4.5.1 Earthquakes

An earthquake is the vibration, sometimes violent, of the earth's surface that follows a release of energy in the Earth's crust due to fault fracture and movement. The magnitude or extent of an earthquake is a seismograph-measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the size of earthquakes. The Richter scale is the most widely known scale that measures earthquake magnitude. It has no upper limit and is not a direct indication of damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can have the same magnitude as an earthquake in a remote area that causes no damage. Table 37 summarizes Richter scale magnitudes and corresponding earthquake effects (EEA and EOPSS, 2018).

Table 37. Richter Scale and Effects

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally, not felt, but recorded
3.5- 5.4	Often felt, but rarely causes damage
Under 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 km across where people live.
7.0- 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred meters across.

(Louie, 1996)

Earthquakes occur in New England, albeit infrequently as compared to other parts of the country. The first recorded earthquake was noted by the Plymouth Pilgrims and other early settlers in 1638. Of the over 5,000 earthquakes recorded in the Northeast Earthquake Catalog through 2008, 1,530 occurred within the boundaries of the six New England States, with 366 earthquakes recorded for Massachusetts between 1627 and 2008. The probability of a magnitude 5.0 or greater earthquake centered in New England is about 10-15% in a 10-year period (EEA and EOPSS, 2018). A summary of historic earthquakes in the Boston area is included in Table 37.

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Table 38. Historical Earthquakes in Boston or Surrounding Area, 1727-2012

Location	Date	Magnitude
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA - Cape Ann	2/10/1728	NA
MA - Cape Ann	3/30/1729	NA
MA - Cape Ann	12/9/1729	NA
MA - Cape Ann	2/20/1730	NA
MA - Cape Ann	3/9/1730	NA
MA - Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA - Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6
MA - Off Cape Cod	11/23/1755	NA
MA - Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA
MA - Offshore	1/2/1785	5.4
MA - Wareham/Taunton	12/25/1800	NA
MA - Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA - Brewster	8/8/1847	4.2
MA - Boxford	5/12/1880	NA
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA - Cape Ann	1/7/1925	4
MA - Nantucket	10/25/1965	NA
MA - Boston	12/27/1974	2.3
VA - Mineral	8/23/2011	5.8
MA - Nantucket	4/12/2012	4.5
ME - Hollis	10/17/2012	4.0
MA – Newburyport	2/20/2013	2.3
NH – Contoocook	10/11/2013	2.6
MA – Freetown	1/9/2014	2.0
MA – Bliss Corner	2/11/2014	2.2
MA – off Northshore	8/18/2014	2.0
CT - Deep River Center	8/14/2014	2.7
CT – Wauregan	1/12/2015	3.3
CT – Wauregan	1/13/2015	2.6

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Table 38. Historical Earthquakes in Boston or Surrounding Area, 1727-2012

Location	Date	Magnitude
RI – Newport	2/3/2015	2.0
NH – Epsom	8/2/2015	2.2
NH – Contoocook	3/21/2016	2.8
MA – Rockport Coast	6/1/2016	2.2
NH – Bedford	2/11/2017	2.2
NH – East Kingston	2/15/2018	2.7
ME – Cape Neddick	7/16/2018	2.1
MA – Nantucket	8/18/2018	2.4
MA – Templeton	12/21/2018	2.1
MA – Gardner	12/23/2018	2.2
RI – Charlestown	3/1/2019	2.3
MA – Rockport	4/27/2019	2.1
MA – North Plymouth	12/3/2019	2.1

(USGS, 2020)

Ground shaking or ground motion is the primary cause of earthquake damage to manmade structures. Ground motion from earthquakes is amplified by soft soils and reduced by hard rock. Ground motion.is measured by maximum peak horizontal acceleration expressed as a percentage of gravity (%g). Peak ground acceleration in the state ranges from 10 %g to 20 %g, with a 2% probability of exceedance in 50 years (Figure 18). Tyngsborough is located in an area with a PGA of 16 %g to 18 %g with a 2% probability of exceedance in 50 years. This is the fourth/fifth highest zone in the state: in other words, a moderate area of earthquake risk. Compared to the rest of the United States, Massachusetts overall has a low risk of earthquakes.

No earthquake epicenters have been recorded within Tyngsborough. Although new construction under the most recent building codes generally will be built to seismic standards, much of the development in the Town pre-dates the current building code. If an earthquake occurs, the entire region, not just the Town, would face significant challenges. Earthquakes often trigger fires. The water distribution system may be disrupted, thus posing a risk for public health and safety.

A serious earthquake in Massachusetts is possible. These events can strike without warning and can have a devastating impact on infrastructure and buildings constructed prior to earthquake resistant design considerations.

All existing and future buildings and populations are at risk to an earthquake hazard. Impacts from earthquakes can be from slight to moderate building damage, to catastrophic damage and fatalities, depending on the severity of the earthquake event. Events may cause minor damage such as cracked plaster and chimneys, or broken windows, or major damage resulting in building collapse. Based on the 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (EEA and EOPSS), the degree of exposure depends on many factors, including the building's age, construction type, soil type under the structures, and the proximity to the fault location. Furthermore,

the time of day exposes different sectors of the community to the hazard. Earthquakes can lead to business interruptions, loss of utilities and road closures which may isolate populations. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction. (Liquefaction is the phenomenon that occurs when the strength and stiffness of a soil is reduced by earthquake).

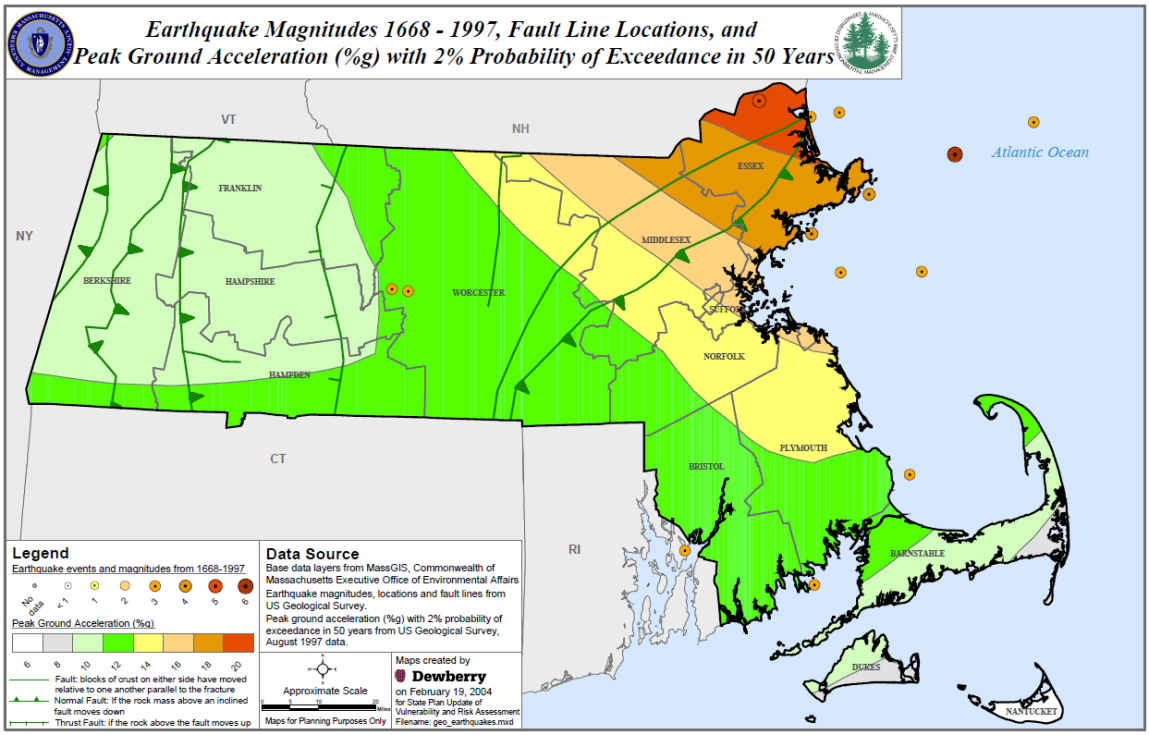

Figure 18. State of Massachusetts Earthquake Probability Map (EEA and EOPSS, 2018)

Potential earthquake damage was modeled for Tyngsborough. Hazus Multi-Hazard (Hazus) is a GIS model developed by FEMA to estimate losses in a defined area due to a specified natural hazard. The Hazus earthquake model allows users to input specific parameters in order to model a defined earthquake magnitude, with the epicenter located at the center of the municipality. In this analysis, two earthquakes were modeled: a magnitude 5.0 and a magnitude 7.0 earthquake. While large earthquakes are rare in Massachusetts, there was a magnitude 5.0 earthquake recorded in 1963. There is a possibility for larger scale earthquakes to occur in Massachusetts at some point, therefore a magnitude 7.0 earthquake was modeled as well to demonstrate the damage that could occur.

In order to model each of these earthquakes, the study region must first be defined. The Town of Tyngsborough was outlined by the census tracts in the Town. The arbitrary event scenario was used, which allows the user to input the magnitude, depth, with, and epicenter of the earthquake. This must be done for each earthquake magnitude chosen. The output shows the potential impact that could occur in Tyngsborough if either a magnitude 5.0 or a magnitude 7.0 earthquake occurred with the epicenter located in the center of the Town. HAZUS is based on 2010 census data and 2014 dollars. The tables below show the estimated damage from both a magnitude 5.0 and a magnitude 7.0 earthquake in the municipality.

Table 39. Magnitude 5.0 Earthquake Damage

Land Use Type	Total # of Buildings	# of Buildings Damaged	% of Buildings Damaged[1]	Value of Building Damage[2]
Residential	3,631	1,714	47%	$118,518,700
Commercial	272	211	78%	$46,534,000
Industrial	102	81	79%	$15,118,600
Others	48	36	75%	$11,513,000
TOTAL	4,053	2,042	50%	$191,684.300

[1]Numbers include Slight, Moderate, Extensive, and Total Damage
[2]Includes Building, Content, and Inventory

Table 40. Magnitude 7.0 Earthquake Damage

Land Use Type	Total # of Buildings	# of Buildings Damaged	% of Buildings Damaged[1]	Value of Building Damage[2]
Residential	3,631	3,622	99%	$1,026,414,500
Commercial	272	272	100%	$291,339,800
Industrial	102	102	100%	$92,431,900
Others	48	48	100%	$73,498,300
TOTAL	4,053	4,044	99%	$1,483,684,500

[1]Numbers include Slight, Moderate, Extensive, and Total Damage
[2]Includes Building, Content, and Inventory

In addition to the infrastructural damage, HAZUS also calculated the potential social impact of a magnitude 5.0 and magnitude 7.0 earthquake on the community. This is shown as monetary value of business interruption loss of wages, capital related loss, rental and relocation costs. It also estimates displaced households, persons seeking temporary public shelter, and casualties. The full HAZUS earthquake global risk report can be found in the Appendix D.

Earthquakes are classified as a low-frequency event in Tyngsborough. As defined by the *2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan*, the probability of a magnitude 5.0 or greater earthquake centered in New England is about 10-15% in a 10-year period.

4.5.2 Landslides

Landslide include a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity, acting on an over steepened slope, is the primary reason for a landslide, there are other contributing factors. These contributing factors can include erosion by rivers or ocean waves over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; earthquake created stresses that make weak slopes fail; excess weight from accumulation of rain or snow; and stockpiling of rock or ore from waste piles or man-made structures (USGS, 2019).

Landslides occur throughout the United States, causing an estimated $1 billion in damages and 25-50 deaths each year. Any area composed of very weak or fractured materials resting on a steep slope will likely experience landslides. Although the physical cause of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of land-

use management regulations can reduce landslide hazards (USGS, 2019). Landslides can damage buildings and infrastructure and cause sedimentation of water bodies. Landslide intensity can be measured in terms of destructiveness, as demonstrated by Table 41.

Table 41. Landslide Volume and Velocity

Estimate Volume (m^3)	Expected Landslide Velocity		
	Fast moving (rock fall)	Rapid moving (debris flow)	Slow moving (slide)
<0.001	Slight intensity	--	--
<0.5	Medium intensity	--	--
>0.5	High intensity	---	--
<500	High intensity	Slight intensity	--
500-10,000	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000	--	Very high intensity	High intensity
>>500,000	--	--	Very high intensity

(Cardinali et al., 2002)

All of Tyngsborough is classified as having a low risk for landslides. No significant landslides have been recorded for Tyngsborough or Middlesex County (Appendix B of EEA and EOPSS, 2018). Rather, local officials indicate that there are occasionally localized issues of erosion during construction, as a result of development, or as a result of clearing vegetation. Landslides are classified as low frequency events in Tyngsborough. These events can occur once in 50 to 100 years (i.e., 1% to 2% chance of occurring each year).

4.6 Fire-Related Hazards

Fire risk is influenced by type of fuel, terrain, and weather. Strong winds can exacerbate extreme fire conditions, especially wind events that persist for long periods, or ones with significant sustained wind speeds that quickly promote fire spread through the movement of embers or exposure within tree crowns. Fires can spread quickly into developed areas.

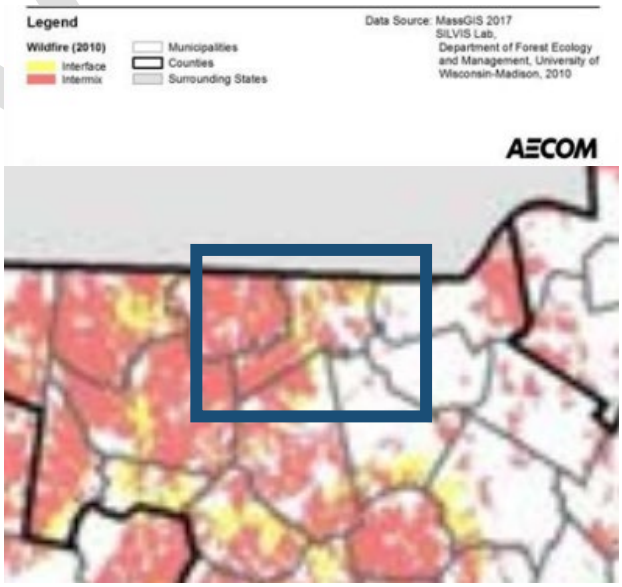

Figure 19. Interface and Intermix Areas (MA EOEEA and EOPSS, 2018)

Tyngsborough is most susceptible to brushfire compared to a wildfire (or fire with a larger impact area). Brushfires and wildfires occur in the vegetative wildland, including grass, shrub, leaf litter, and forested-tree fuels. Fires can be caused by natural events or human activity, which then can spread quickly, igniting brush, trees,

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and homes (MEMA and DCR, 2013). The State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPPS, 2018) states:

> The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface…. Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated.

Tyngsborough has many intermix and a few interface areas, which are more vulnerable to fire hazards (Figure 19). The Dracut-Lowell-Tyngsborough State Forest, managed by the Massachusetts Department of Conservation and Recreation, was also viewed as a more at-risk area in Tyngsborough according to the core team.

Tyngsborough experienced between 51 and 100 recordable fires between 2001 and 2009 that resulted in 10 to 99 burned acres. Anecdotally, the number of brushfires has decreased, except for small brushfires deep in the woods. The Town just started using a tracking system in 2018. No brushfires with considerable acreage damaged have occurred in the last five years in memory (Town of Tyngsborough Core Team, 2020). Causes of these fires are due to human carelessness, such as juvenile activity. Approximately 84% of brushfires are caused by humans (Balch et al., 2017). Lightning can also be a culprit, igniting a fire when striking dry tinder on the forest floor.

Brush fires can lead to property damage and even death. Individuals whose homes or workplaces are located in brushfire hazard zones are more vulnerable to this hazard. The most vulnerable members of this population are those who would be unable to evacuate quickly, including those over the age of 65, households with young children under the age of 5, people with mobility limitations, and people with low socioeconomic status (EEA and EOPSS, 2018). Secondary effects from brushfire include contamination of waterways; destroyed power, gas, water, and broadband lines. Brush fires can also contribute to flooding as they strip slopes of vegetation, thereby exposing them to greater amounts of runoff which may cause soil erosion and ultimately the chance of flooding. Additionally, subsequent rains can worsen erosion because brushfires burn ground vegetation and ground cover.

4.7 Extreme Temperatures

Extreme temperatures are considered a town-wide hazard in Tyngsborough. These events can include both temperatures over and under seasonal averages. These extreme temperature events can range from brief to lengthy.

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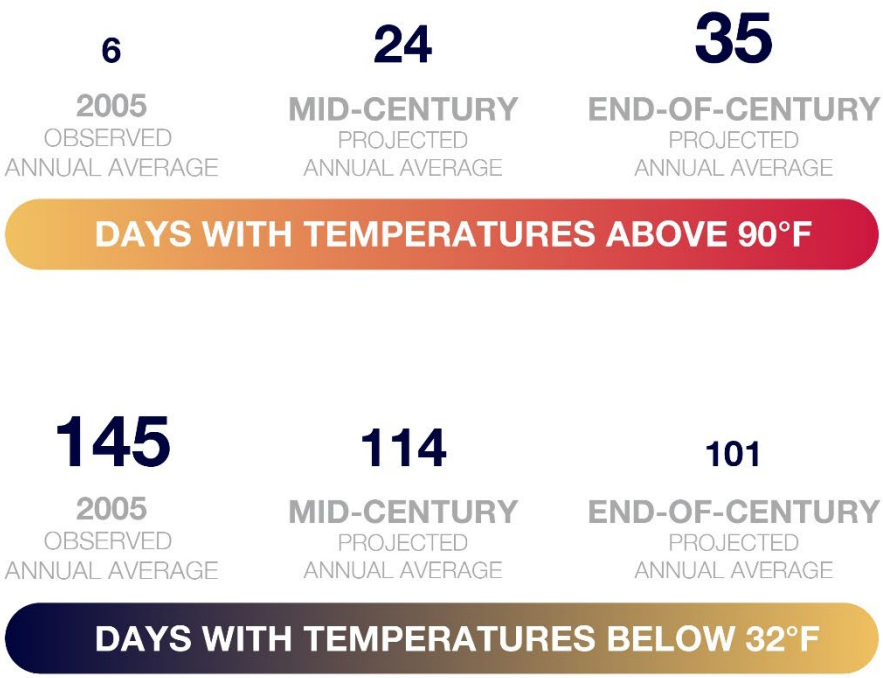

Figure 20. Anticipated Temperature Changes (Weston & Sampson based on EEA, 2018)

The Massachusetts has four clearly defined seasons. Extreme temperatures fall outside of the ranges average experienced during these seasons. Boston's average winter temperature, from December to February, is 32.2°F. Boston's average summer temperature, from June to August, is 73.8°F (NOAA, 2018b).

4.7.1 Extreme Cold

Extremely cold temperatures are measured using the Wind Chill Temperature Index provided by the National Weather Service (NWS). The updated index was implemented in 2001and helps explain the impact of cold temperatures on unexposed skin. Figure 21, below, provides more information.

Extremely cold temperatures can create dangerous conditions for homeless populations, stranded travelers, and residents without sufficient insulation or heat. The homeless, the elderly, and people with disabilities are often most vulnerable. In Tyngsborough, 11.2% of the population are over 65 years old and 7.2% percent of the population has a disability (US Census, 2018). Cold weather events can also have significant health impacts such as frostbite and hypothermia. Furthermore, power outages during cold weather may result in inappropriate use of combustion heaters, cooking appliances, and generators in poorly ventilated areas which can lead to increased risk of carbon monoxide poisoning.

NOAA's National Centers for Environmental Information Storm Events Database provides data for extreme cold events. Between 2000 and 2018, Middlesex County experienced three extreme cold and will chill events, which caused no deaths, injuries, or property damage.

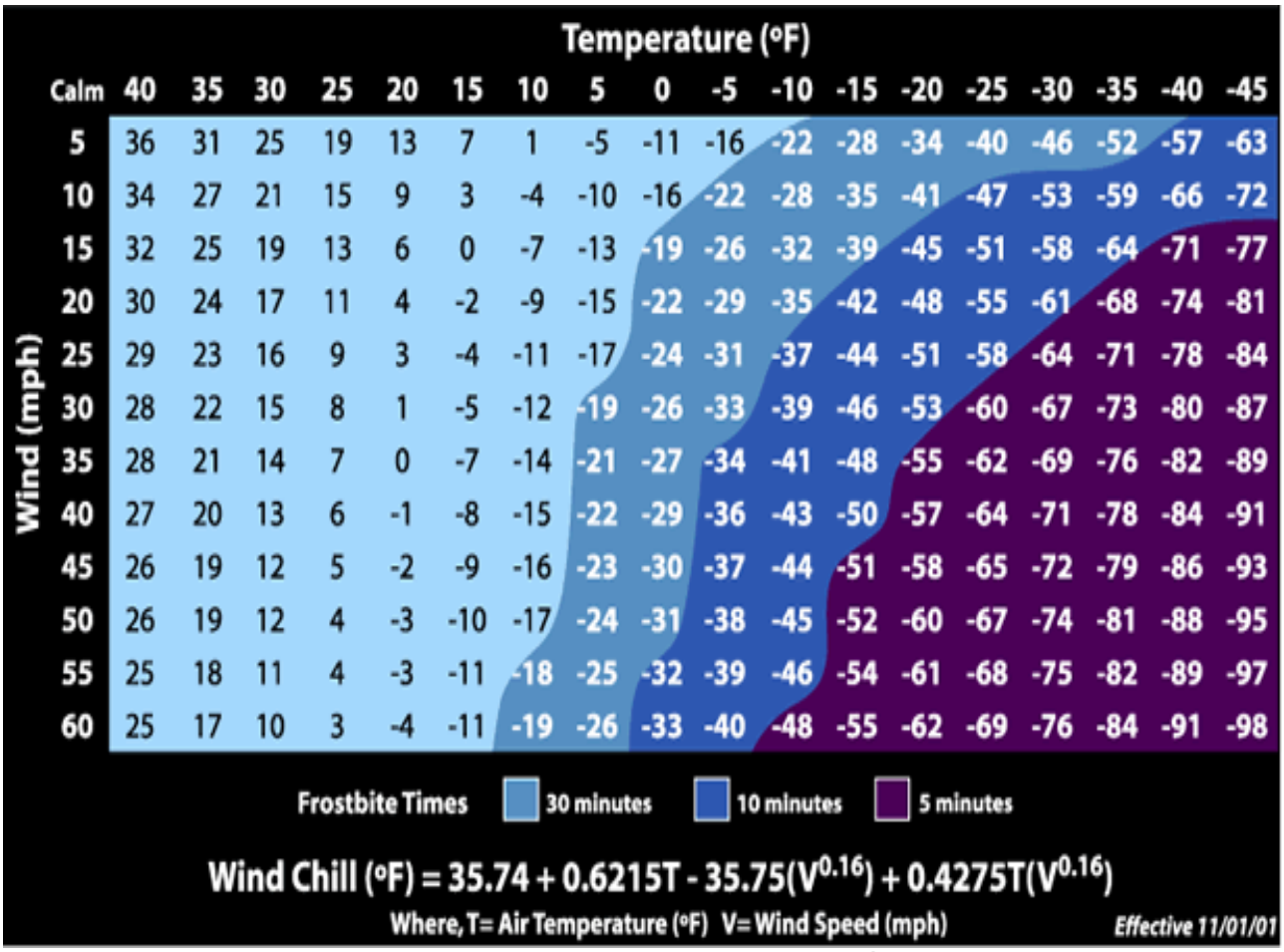

Figure 21. Windchill Temperature Index and Frostbite Risk (National Weather Service)

4.7.2 Extreme Heat

Increased temperatures will impact all locations within Tyngsborough. Projected heat days and heat waves can have an increased impact in densely settled urban areas. These can become "heat islands" as dark-colored asphalt and roofs store the heat from the sun. According to the Centers for Disease Control and Prevention, the populations most vulnerable to extreme heat impacts include the following:

- People over the age of 65 (e.g., with limited mobility),
- Children under the age of five,
- Individuals with pre-existing medical conditions that impair heat tolerance,
- Low-income individuals who cannot afford proper cooling,
- Individuals with respiratory conditions,
- The general public who may overexert themselves during extreme heat events.

Homeless people are increasingly vulnerable to extreme heat. The capacity of homeless shelters is typically limited. Impacts from heat stress can exacerbate pre-existing respiratory and cardiovascular conditions.

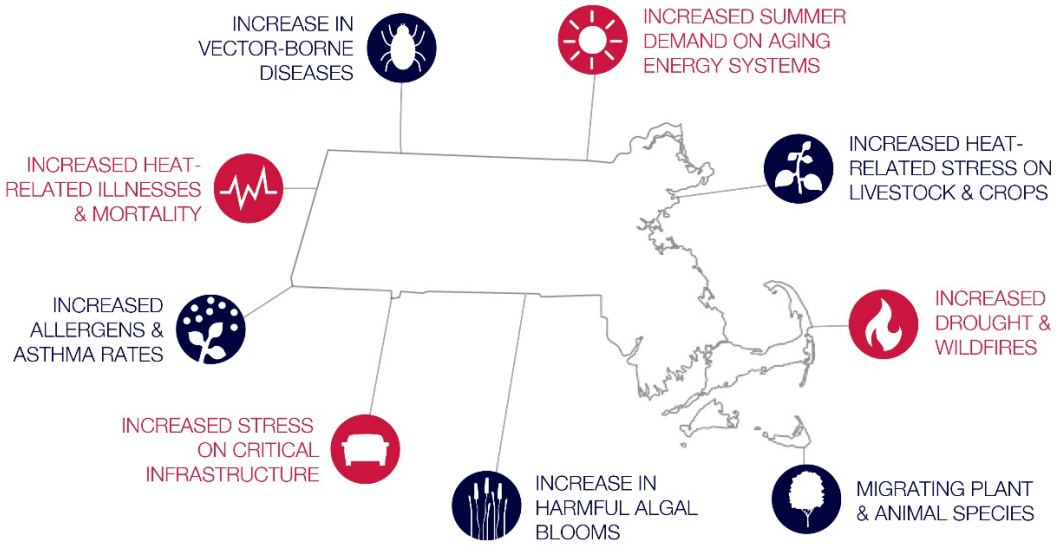

Figure 22: Potential Impacts from Increasing Temperatures (Weston & Sampson based on EEA, 2018)

The NWS issues a Heat Advisory when the Heat Index (Figure 23) is forecast to reach 100-104˚ F for two or more hours (https://www.weather.gov/bgm/heat). The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105˚+F for two or more hours. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. In Boston, over 50 people die each year due to heat-related illnesses. From 1979-2016, excessive heat exposure caused in excess of 9,000 deaths in the United States (EEA and EOPSS, 2018). During this period,

	Temperature (°F)																
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.

Figure 23. Heat Index Chart (NOAA, n.d.)

more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Based on Figure 24, compiled by the Massachusetts Department of Public Health Bureau of Environmental Health (MA DPH 2019), there is at least one population vulnerability measure in each Census Tract (2010). The population vulnerability measures include low income, minimal English proficiency, people of color, and elderly. Tyngsborough has a population density of less than 1,270 per square mile.

On July 6, 2013, a postal worker in Massachusetts collapsed and died as the Heat Index reached 100°F (EEA and EOPSS, 2018). Because most heat-related deaths occur during the summer, people should be aware of who is at greatest risk and what actions can be taken to prevent a heat-related illness or death. The populations at greater risk are the elderly, children, and people with certain medical conditions, such as heart disease. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. Some behaviors also put people at greater risk drinking alcohol, taking part in strenuous outdoor physical activities in hot weather, and taking medications that impair the body's ability to regulate its temperature or that inhibit perspiration (EEA and EOPSS, 2018).

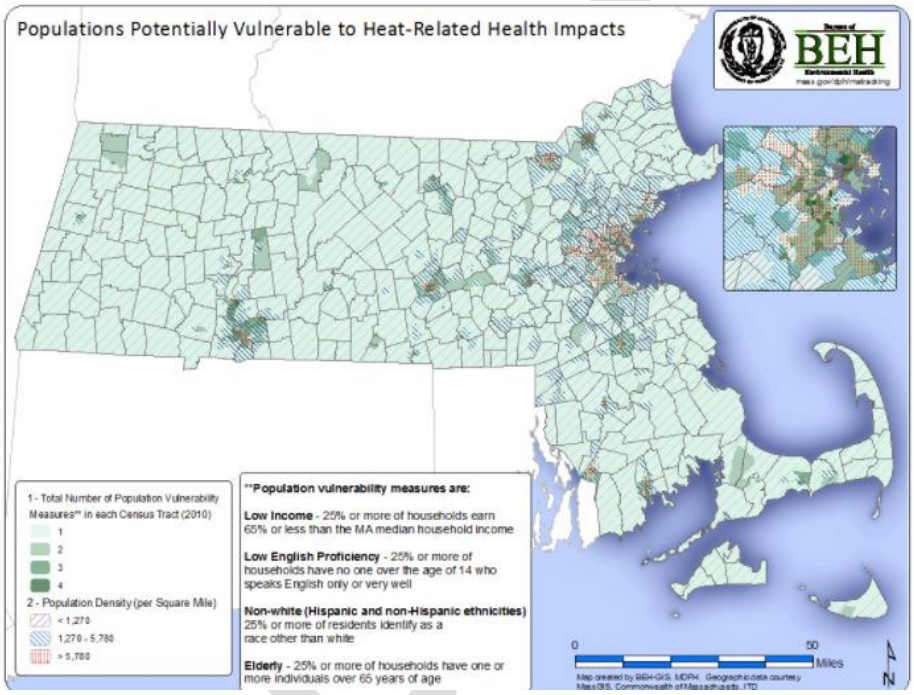

Figure 24. Populations Potentially Vulnerable to Heat Related Health Impacts (Massachusetts Department of Public Health, Bureau of Environmental Health, 2019)

Increased temperatures can lead to a longer growing season, which in turn leads to a longer pollen season. Warmer weather can also support the migration of invasive species and lead to an increase in vector-borne diseases. Increasing temperatures can also worsen air pollution, which can lead to negative health impacts such as respiratory problems.

The Town of Tyngsborough does not collect data on heat occurrences. The best available local data are for Middlesex County, through the National Environmental Information Center. NOAA's National Centers for Environmental Information Storm Events Database provides data on excessive heat.

Between 1998 and 2018, Middlesex County experienced three extreme heat days, which did not result in injury or property damage. One event did result in a single death in 2013.

Extreme temperatures are classified as medium frequency events. According to the *2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (EEA and EOPSS, 2018), between four and five heat waves (3 or more consecutive days of 90˚F+ temperatures) occur annually in Massachusetts.

4.7.3 Climate Change Impacts: Extreme Temperatures

Between 1961 and 1990, Boston experienced an average of one day per year in excess of 100°F. That could increase to six days per year by 2070, and 24 days per year by 2099. Under these conditions by the end of the century, Massachusetts's climate would more closely resemble that of Maryland or the Carolinas (Figure 25). These changes in temperature would also have a detrimental impact on air quality and public health concerns including asthma and other respiratory conditions (Frumhoff et al., 2007).

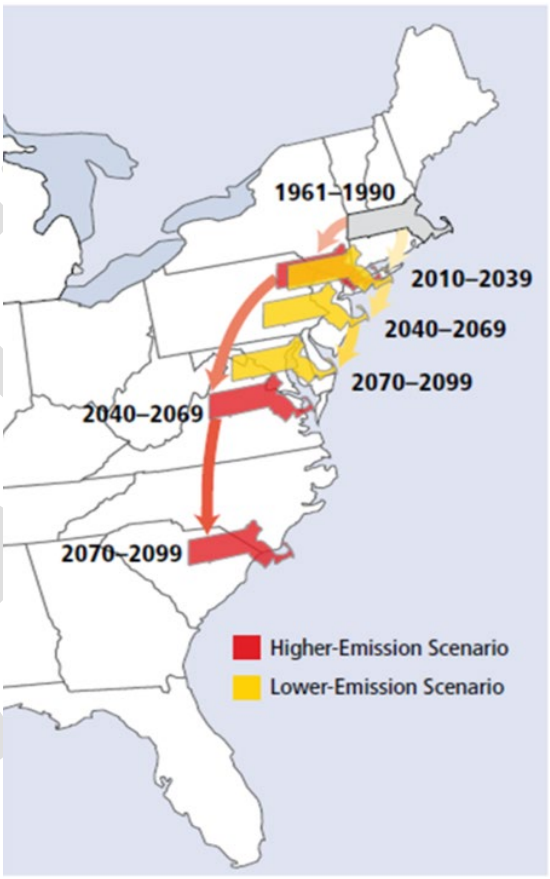

Figure 25. Massachusetts Extreme Heat Scenarios. ***(Frumhoff et al., 2007)***

4.8 Drought

Drought is an extended period of deficient precipitation. Drought conditions occur in virtually all climatic zones, yet its characteristics vary significantly from one region to another since it is relative to the normal precipitation in that region. Agriculture, the water supply, aquatic ecosystems, wildlife, and the economy are vulnerable to the impacts of drought (EEA and EOPSS, 2018).

Average annual precipitation in Boston is 53.32 inches per year, with approximately two to five-inch average amounts for each month of the year (NOAA, 2019c). Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of precipitation they receive. In accordance with the Massachusetts Drought Management Plan (Massachusetts Water Resource Commission, 2019), the Drought Management Task Force will make recommendations to the Secretary of Energy & Environmental Affairs about the location and severity of drought in the Commonwealth. The Drought Management Plan divides the state into six regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape and islands. Tyngsborough is located within the Northeast region (EEA and EOPSS, 2018). In a proposed update to the Drought Management Plan, which is expected to be

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finalized in 2019, a seventh region, representing the Islands alone, has been proposed (Massachusetts Water Resources Commission, 2019).

Five levels of drought have been developed to characterize drought severity: Normal, Advisory, Watch, Warning, and Emergency; these correspond to Level 0 – Normal, Level 1 - Mild Drought, Level 2 - Significant Drought, Level 3 - Critical Drought (was Warning), and Level 4 - Emergency Drought (was Emergency), respectively, of the Drought Management Plan update. The drought levels are based on the severity of drought conditions and their impacts on natural resources and public water supplies.

The Drought Management Plan specifies the agency response and interagency coordination and communication corresponding to the various drought levels. During normal conditions, data are routinely collected and distributed. There is heightened vigilance with additional data collection during an advisory, and increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which use of emergency supplies become necessary or in which the Governor may exercise his authority to require mandatory water restrictions or (EEA and EOPSS, 2018).

A variety of drought indices are available to assess the various impacts of dry conditions. The Commonwealth uses a multi-index system to determine the severity of a drought or extended period of dry conditions. A determination of drought level is based on seven indices: Standardized Precipitation Index, Precipitation (percent of normal), Crop Moisture Index, Keetch-Byram Drought Index (KBDI), Groundwater levels, Stream flow levels, and Index Reservoir levels.

Drought level is determined monthly based on the number of indices which have reached a given drought level. A majority of the indices would need to be triggered in a region in order for a drought designation to move to a more severe level. Drought levels are declared on a regional basis for each of the six regions in Massachusetts. Drought levels may also be made county by county or be watershed specific. The end of a drought is determined by precipitation and groundwater levels since these have the greatest long-term impact on streamflow, water supply, reservoir levels, soil moisture and potential for forest fires (EEA and EOPSS, 2018). Figure 26 illustrates weeks of extreme drought between 2001 and 2019. statewide drought levels in Massachusetts from 1850 to 2017. Table 42 summarizes all recorded droughts in Massachusetts's history between 1879 and 2017

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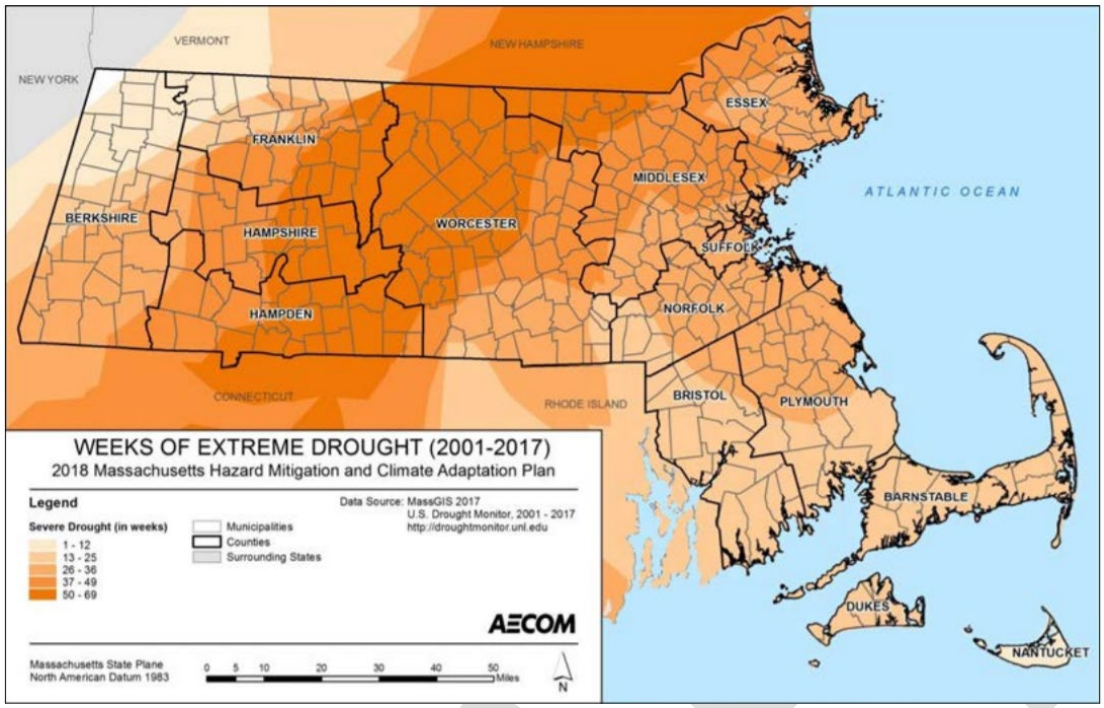

Figure 26. Weeks of Severe Drought (2001 - 2017)

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There are five drought emergencies on record in Massachusetts: 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought is considered the most severe Massachusetts drought in modern times, given its length. On a monthly basis over the 162-year period of record, there is a one percent chance of being in a Drought Emergency (EEA and EOPSS, 2018).

Table 42. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (yrs)	Remarks
1879 to 1883	–	–	–
1908 to 1912	–	–	–
1929 to 1932	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
1939 to 1944	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957 to 1959	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961 to 1969	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.

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Table 42. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (yrs)	Remarks
1980 to 1983	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985 to 1988	Housatonic River Basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.
1995	–	–	Based on statewide average precipitation.
1998 to 1999	–	–	Based on statewide average precipitation.
2001 to 2003	Statewide	–	Level 2 drought (out of 4 levels) was reached statewide for several months.
2007 to 2008	Statewide except West and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2010	Connecticut River Valley, Central and Northeast regions	–	Level 1 drought (out of 4 levels)
2014	Southeast and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2016 to 2017	Statewide	–	Level 3 drought (out of 4 levels).

(EEA and EOPSS, 2018)

Drought Warning levels not associated with Drought Emergencies would have occurred in 1894, 1915, 1930,1985, 2016, and 2017. On a monthly basis over the 162-year period of record, there is a 2% chance of being in a drought Warning level (DCR, 2017b).

drought watches not associated with higher levels of drought generally would have occurred three to four times per decade between 1850 and 1950. The drought emergency declarations dominated the 1960s. There were no Drought Watches or above in the 1970s. In the 1980s, there was a lengthy Drought Watch level of precipitation between 1980 and 1981, followed by a Drought Warning in 1985. A frequency of drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. There were six drought watches in Massachusetts in 2002, five drought watches in 2016, and two drought watches in 2017 (DCR 2017b, 1). Figure 27 presents an example of drought conditions in the six drought regions.

Drought is a potential town-wide hazard in Tyngsborough. As noted previously, temperature is projected to increase and may lead to exacerbated drought conditions especially in summer and fall months. Droughts can also increase fire risk: fires can be caused by lightning, and a 2014 study found that the frequency of lightning strikes could increase by more than 10% for every degree

Celsius of warming (EEA and EOPSS, 2018). A long-term drought could lead to impacts to Tyngsborough's wetlands and streams, and to the Merrimack River. In a drought emergency affecting the water supply, water-use restrictions could be implemented in Tyngsborough, which could result in loss of landscaped areas and business revenues depending on the length of the water use restriction.

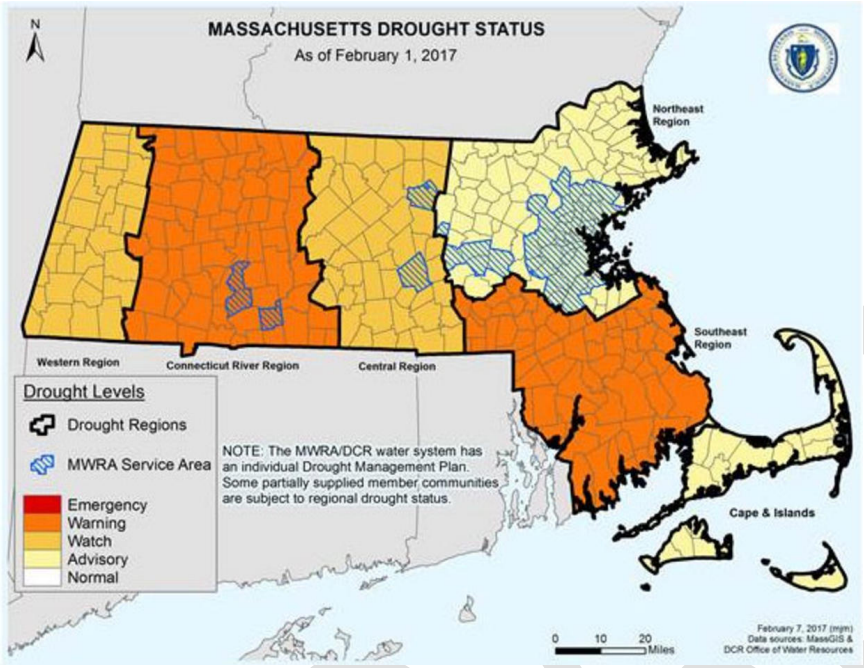

Figure 27. Massachusetts Drought Status, February 2017 *(DCR, 2017b)*

Droughts are classified as a low-frequency, natural-hazard event. As defined by the *2013 Massachusetts State Hazard Mitigation Plan*, these events can occur between once in 50 years to once in 100 years (a 1% to 2% chance of occurring per year).

4.8.1 Climate Change Impacts: Drought

Under climate change, drought conditions will be exacerbated with projected increasing air temperatures and changes in precipitation. Between 1970 and 2000, the median number of consecutive dry fall days in Massachusetts was 11.4 days. This is in comparison to a projected median of 13.5 consecutive days by the end of the century (EEA, 2018a).

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5.0 EXISTING MITIGATION MEASURES

The Town of Tyngsborough is already doing measures to mitigate local hazards. Chapter 5 documents the Town's current operations and discusses potential improvements. The *Local Mitigation Planning Handbook* categorizes hazard mitigation measures into four types as displayed in Table 43 (FEMA, 2013). Town of Tyngsborough uses many of these tools, which are presented by hazard type.

Table 43. FEMA's Types of Mitigation

Mitigation Category	Description	Examples
Local Plans and Regulations	These actions include government authorities, policies, or codes that influence the way land and buildings are developed and built.	• Comprehensive plans • Land use ordinances • Subdivision regulations • Development review regulations • Building codes and enforcement • NFIP Community Rating System • Capital improvement plans • Open space preservation • Stormwater management regulations and master plans
Structure and Infrastructure Projects	These actions involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. This could apply to public or private structures as well as critical facilities and infrastructure. This type of action also involves projects to construct manmade structures to reduce the impact of hazards.	• Acquisitions and elevations of structures in flood prone areas • Utility undergrounding • Structural retrofits • Floodwalls and retaining walls • Detention and retention structures • Culverts • Safe rooms
Natural Systems Protection	These are actions that minimize damage and losses and preserve or restore the functions of natural systems.	• Sediment and erosion control • Stream corridor restoration • Forest management • Conservation easements • Wetland restoration and preservation

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Table 43. FEMA's Types of Mitigation

Mitigation Category	Description	Examples
Education and Awareness Programs	These are actions to inform and educate citizens, elected officials, and property owners about hazards and potential ways to mitigate them. A greater understanding and awareness of hazards and risk among local officials, stakeholders, and the public is more likely to lead to direct actions.	• 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

Table adapted from Local Mitigation Planning Handbook (FEMA, 2013).

5.1 Existing Flood-Related Mitigation Measures

Tyngsborough employs a number of practices to help minimize potential flooding, reduce impacts from flooding, and to proactively maintain existing drainage infrastructure. Existing townwide mitigation measures include the following:

Participation in the NFIP – Tyngsborough participates in the NFIP (FEMA, 2018c). The NFIP is a Federal program administered by FEMA enabling property owners in participating communities to purchase insurance as a protection against flood loss in exchange for State and community floodplain management regulations that reduce future flood damage. NFIP offers flood insurance to communities that comply with the minimum standards for floodplain management.

NFIP uses CRS to award communities that go beyond the minimum standards with lower flood insurance premiums for property owners. The incentives are awarded upon a credit system for various activities. Points are awarded to communities that prepare, adopt, implement, and update a comprehensive flood hazard mitigation plan using a standard planning process. Tyngsborough is not currently enrolled in the CRS Program (as of May 2019) (FEMA, 2019c).

Tyngsborough participates in NFIP with 50 policies in force as of June 30, 2019 (DCR, 2020). FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at https://www.fema.gov/policy-claim-statistics-flood-insurance

The Town complies with the NFIP by enforcing floodplain regulations, maintaining up-to-date floodplain maps, and providing information to property owners and builders regarding floodplains and building requirements. The FEMA flood maps for the Town were last updated in 2010.

Street sweeping – The Town performs street sweeping twice per year on all roads.

Catch basin cleaning – The Town clears debris from its catch basins annually and on an as-needed basis. Mapping of the catch basin and outfall system is in progress. There are approximately 1,430 catch basins.

Ongoing Drainage Improvement Program – The Public Works Department provides maintenance to culverts, drainage pipes, and other drainage infrastructure on an as-needed basis.

Stormwater System and Outfalls Mapped in GIS – The Town has developed a drainage system inventory and integrated the data into the Town's GIS. The inventory is being updated with improved methods starting in high priority areas.

Illicit Discharge Detection and Elimination Program Implementation –The Town's written illicit discharge detection and elimination (IDDE) Program was developed with guidance from the Central Massachusetts Stormwater Coalition and will implemented over the next few years. The Town started sampling outfalls for water quality and has delienated flows into impaired waterbodies.

Zoning Regulations – Zoning is intended to protect public health and safety through the regulation of land use. The Tyngsborough Zoning Bylaw includes a Floodplain District (Section 2.13.00). The Town's Floodplain Overlay District (Zoning Bylaw Section 2.13.00) is defined by the 100-year floodplain as designated by FEMA. The Floodplain Overlay District regulates certain activities within a flood zone.

Massachusetts Stormwater Regulations – These apply everywhere in the Commonwealth and are regulated by the Conservation Commission.

Tyngsborough Stormwater Management Regulations – The Town has a Stormwater Management Bylaw (2007) and more recently updated Stormwater Regulations (2019. The regulations partially match the requirements set forth in by the municipal separate storm sewer systems (MS4) permit requirements. The Town is planning to further align the MS4 permit with the Stormwater Regulations through the support of the Conservation Commission. The subdivision provisions in the regulations require that the quantity of runoff shall be less than or equal to the predevelopment condition. The stormwater system must be designed for the 25-year storm event.

Prevention of Sewer Backflow – The Town is completing an infiltration and inflow study which will reduce volume of water in the sewer system and reduce water treatment costs. All sewer pump stations are continuously monitored for any problems and have backup generators at all pump stations. The Town also has a Sewer Overflow Plan.

Wetlands Protection Act – The Tyngsborough Conservation Commission administers the state's Wetlands Protection Act (Chapter 131, Section 40 MGL) to protect resource areas in and around wetlands, including land subject to flooding.

Wetlands Protection Bylaw – The Town's Wetlands Protection Bylaw prohibits disturbance of any wetland or abutting land.

Tyngsborough Open Space and Recreation Plan (OSRP) – Tyngsborough updated its open space and recreation plan. The Town has many conservation areas and recreation spaces, and the *Open Space and Recreation Plan* aims to maintain, promote use, and increase the number of these spaces. The Town integrated hazard mitigation considerations in this update by including a section on chronic flooding, repetitive loss structures, anticipated climate change impacts, and mapping visualizing the floodplain extent and environmental justice populations.

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5.2 Existing Dam Mitigation Measures

DCR Dam Safety Regulations – All jurisdictional dams are subject to the Division of Conservation and Recreation's dam safety regulations (302 CMR 10.00). The dams must be inspected regularly, and reports filed with the DCR Office of Dam Safety. The Town communicates with the DCR Office of Dam Safety to confirm regular maintenance is performed to make sure the dams in Tyngsborough are safe and in good working order.

Permits Required for Construction – State law requires a permit for the construction of a dam.

Upper Flint Pond Dam Removal – The Dam is currently undergoing improvements and reconstruction through DCR to improve safety.

5.3 Existing Wind-Related Mitigation Measures

Massachusetts State Building Code – The Town enforces the Massachusetts State Building Code whose provisions are generally adequate to protect against most wind damage. The code's provisions are the most cost-effective mitigation measure against tornados and other wind-related events given the extremely low probability of occurrence. If a tornado or other wind-related events were to occur, the potential for severe damages would be extremely high.

Tree Maintenance by the Town – The Town has a tree warden who maintains street trees and numerous trees on public grounds, historic sites, conservation areas, park areas, and cemeteries. The Tree Warden works with National Grid to maintain trees near utility lines.

Tree Maintenance by Energy Utility National Grid – Utilities trim trees along the power lines twice a year. Preventative maintenance of trees along the power lines coming from Westford has recently been implemented.

5.4 Existing Winter-Related Mitigation Measures

Snow Removal Requirements in the General Code –Tyngsborough Town By-Law, Article 38 states, "No person, other than an employee acting for or in behalf of the Town, shall by himself or herself or through his/her agents, servants or employees, in any manner place or deposit or cause to be placed or deposited any snow, other than incidental amounts thereof, on any public sidewalk, street or way which has been previously cleared of snow by the Town.

Snow-Plowing Operations – The Public Works Department performs snowplowing as well as deicing (e.g., sanding and salting).

5.5 Existing Fire-Related Mitigation Measures

Open Burning Permits Required – The Town allows controlled open burning in accordance with state regulations, but a permit is required from the Fire Department for each day of intended burning. The Fire Department is working towards an online permit application process. Burning is only allowed during the burning season, typically January through May each year. The resident must notify the Fire Department for each day they intend to burn.

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Fire Department Review of Proposed Development – The Fire Department reviews site plans for compliance with site access, water supply needs, and other applicable regulations within their jurisdiction. New housing developments are required to have water cisterns for firefighting when outside of the range of hydrant coverage.

Public Education – The Fire Department provides fire education twice a year at schools in Tyngsborough, and once a month to seniors. The Fire Department distributes educational materials through social media as well.

Firefighting Water Supplies – The Town has hydrant coverage for at least 40% of the Town. New housing The Town has several surface waterbodies that can be used for water supplies for fighting fires.

Statewide Fire Mobilization Plan – The Commonwealth has a fire mobilization plan for brush fires as well as a separate plan for Tyngsborough's Fire District, District 6.

5.6 Extreme Temperature Hazard Mitigation Measures

Local Emergency Planning Committee (LEPC) – Under the Emergency Planning and Community Right to Know Act of 1986, communities are required to establish Local Emergency Planning Committees to develop a response plan for chemical emergencies. In accordance with this legislation, the Town of Tyngsborough has identified locations where hazardous materials are stored, used, and transported.

Massachusetts State Building Code – The Town enforces the Massachusetts State Building Code whose provisions are generally adequate to protect against most wind damage. The code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur, the potential for severe damages would be extremely high.

Tree Maintenance by the Town – The Town has a Tree Warden who maintains street trees and numerous trees on public grounds, historic sites, conservation areas, park areas, and cemeteries. The Tree Warden works with National Grid to maintain trees near utility lines.

Tree Maintenance by Energy Utility National Grid – Utilities trim trees along the power lines twice a year. Preventative maintenance of trees along the power lines coming from Westford has recently been implemented.

Emergency Shelters – The High School and Elementary School would serve as shelters in the event of a disaster. The Greater Lowell Vocational High School and Council on Aging also have shelter capabilities.

5.7 Geologic Mitigation Measures

Massachusetts State Building Code – The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake." This section goes on to state that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, is not economically achievable for most buildings.

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Section 1612.2.5 establishes seismic hazard exposure groups and assigns all buildings to one of these groups according to Table 1612.2.5. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities which are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

5.8 Multi-Hazard Mitigation Measures

Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to all the hazards discussed in this plan.

Emergency Preparedness Committee – Under the *Emergency Planning and Community Right to Know Act of 1986,* communities are required to establish Local Emergency Planning Committees to develop a response plan for chemical emergencies. In accordance with this legislation, the Town of Tyngsborough has identified locations where hazardous materials are stored, used, and transported.

Public Education – Emergency Preparedness public education is available on the Town's website and social media, via the Fire Department, Police Department, and the Emergency Management Department.

Rave Mobile Safety System– The Town uses a Rave Mobile Safety system, or Reverse 911, that automatically calls all residents and businesses to communicate emergency information. Residents may update their Rave Mobile Safety information on the Town website.

Emergency Shelters – The High School and Elementary School would serve as shelters in the event of a disaster. The Greater Lowell Vocational High School and Council on Aging also have shelter capabilities.

Multi-Department Review of Developments – Multiple Town departments, such as Planning, Zoning, Health, Public Works, Engineering, Fire, Police, Emergency Management and Conservation, thoroughly review all subdivision and site plans prior to approval.

Communications Systems – The Town of Tyngsborough has communication plans and backup infrastructure in place for public safety communications. The Town utilizes a Reverse 911 system to communicate with residents.

Backup Generators – In the event of power outages due to downed limbs, the Town of Tyngsborough does have backup systems in place for public safety communications, shelters, and pumping stations.

Buried Utilities – The Subdivision Rules and Regulations state that all utilities shall be underground in accordance with specifications outlined in the planning board's typical roadway cross section.

Massachusetts State Building Code – The *Massachusetts State Building Code* contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.

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Upper Merrimack Valley Medical Reserve Corps (MRC) – The Town of Tyngsborough is served by the Upper Merrimack Valley MRC volunteer program that can help provide critical services during emergencies. The Upper Merrimack Valley MRC is administered through the Town of Westford's Health Department.

FEMA Deployment – FEMA can deploy vehicles in the case of an emergency.

Green Community Designation – Tyngsborough has been designated as a Green Community by the Department of Energy Resources (DOER). The Town is working toward improving energy efficiency and reducing greenhouse gas emissions.

Tree Maintenance by the Town – The Town has a Tree Warden who maintains street trees and numerous trees on public grounds, historic sites, conservation areas, park areas, and cemeteries. The Tree Warden works with National Grid to maintain trees near utility lines.

Tree Maintenance by Energy Utility National Grid – Utilities trim trees along the power lines twice a year. Preventative maintenance of trees along the power lines coming from Westford has recently been implemented.

Ongoing Operation and Maintenance – The Town annually budgets funds to continue the operation and maintenance of public roadways, bridges, stormwater systems, and more.

5.9 Compilation of Mitigation Measures

The Town of Tyngsborough has numerous existing hazard mitigation and preparedness measures already in place in Tyngsborough as described in the previous sections. Table 44 provides a summary of these resources, where the measures are applied and if any improvements could be made.

Table 44. Tyngsborough Mitigation Measures and Improvements

	Mitigation Measures	Area Covered	Recommended Improvements
MULTIPLE HAZARDS	Comprehensive Emergency Management Plan (CEMP)	Townwide	Every three years with annual training
	Emergency Preparedness Committee	Townwide	None currently
	Public Education	Townwide	Continue to expand outreach, especially on social media
	Rave Mobile Emergency Communication System	Townwide	None currently
	Emergency Shelters	Townwide	Expand outreach to public
	Multi-Department Review of Developments	Townwide	None currently
	Communications Equipment	Townwide	None currently

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Table 44. Tyngsborough Mitigation Measures and Improvements

	Mitigation Measures	Area Covered	Recommended Improvements
	Backup Generators	Shelters, Pump Stations, Communication Infrastructure	Expand to other critical facilities
	Buried Utilities	New Developments	Possible expand to redevelopments or large-scale roadway construction
	Massachusetts State Building Code	Townwide	None currently
	Upper Merrimack Medical Reserve Corps	Regional	None currently
	FEMA Deployment	Statewide	Outside of local authority
	Green Community Designation	Townwide	None currently
	Tree Maintenance by the Town	Townwide	Expand education about private tree trimming benefits and expand clean up staff after wind events
	Tree Maintenance by Electric Utilities (National Grid)	Townwide	Further maintenance of trees along power lines would be beneficial
	Ongoing Operation and Maintenance	Town-wide	Increase staff dedicated to culvert cleaning after storms increase funding and staff capacity for roadway and drainage.
FLOOD HAZARDS	Participation in the NFIP. The Town actively enforces the floodplain regulations.	Areas identified on the FIRM maps	Encourage all eligible homeowners to obtain insurance. Participate in NFIP Training offered by the MEMA and FEMA to address flood hazard planning and management.
	Street sweeping	Townwide	None currently
	Catch basin cleaning	Townwide	None currently
	Ongoing Drainage Improvement Program	Townwide	Continue current improvements
	Stormwater System and Outfalls Mapped in GIS	Townwide	Still in progress
	IDDE Program Implementation	Townwide	Continue implementing plan and sampling at outfalls.

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Table 44. Tyngsborough Mitigation Measures and Improvements

	Mitigation Measures	Area Covered	Recommended Improvements
	Zoning Regulations– Floodplain Overlay District	Townwide	Improve to capture future flood events under climate change scenarios and update FEMA flood maps
	Subdivision Regulations require runoff to be less than or equal to pre-development conditions	Townwide	None currently
	Massachusetts Stormwater Regulations	Conservation Commission jurisdictional areas	Currently being updated
	Tyngsborough Stormwater Management Bylaw and Regulations	Townwide	Update in accordance with State amendments and incorporate climate change.
	Sewer Backflow Prevention	Townwide	None currently
	Wetlands Protection Act	Wetland Resource Areas	None currently
	Wetlands Protection Bylaw	Wetland Resource Areas	None currently
	Tyngsborough Open Space and Recreation Plan	Townwide	The Plan is currently being updated
	Review and New Developments	Townwide	Development of new climate resilient design guidelines
	Public Education on Stormwater	Townwide	Continue to update and inform the public
	NPDES Phase II Stormwater Program	Townwide	Continue implementation
DAM HAZARDS	DCR Dam Safety Regulations	Specific Sites	Outside of local authority
	Permits Required for Construction	Townwide	None currently
	Upper Flint Pond Dam Removal	Upper Flint Pond Dam	Continue implementation
WIND HAZARDS	Addressed in multiple hazard section		

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Table 44. Tyngsborough Mitigation Measures and Improvements

	Mitigation Measures	Area Covered	Recommended Improvements
WINTER HAZARDS	Snow-Plowing and Deicing Operations	Townwide	None currently
	Snow Removal Requirements in the General Code	Townwide	None currently
BRUSH FIRE HAZARDS	Open Burning Permits Required	Townwide	None currently
	Fire Department Review of Proposal Developments	Townwide	None currently
	Public Education	Townwide	None currently
	Firefighting Water Supplies	Townwide	Identify high risk fire areas and ensure and document nearby water access
	Statewide Fire Mobilization Plan	State-wide	None currently
EXTREME HAZARDS	Addressed in Multiple Hazard Section of Table		
GEOLOGIC HAZARDS	Addressed in Multiple Hazard Section of Table		

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5.10 Mitigation Capabilities and Local Capacity for Implementation

Under the Massachusetts system of Home Rule, the Town of Tyngsborough is authorized to adopt, and from time to time, amend certain local bylaws and regulations that support the Town's authority to mitigate natural hazards. These include the Zoning Ordinance, Stormwater Ordinance, Subdivision and Site Plan Review Regulations, Wetlands Ordinance, Health Regulations, Public Works regulations, and local enforcement of the State Building Code. Local Ordinances may be amended by the Town Board of Selectman to improve the Town's authority, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission. The Town of Tyngsborough has recognized

several existing mitigation measures that require implementation or improvements and has the capacity based on these Home Rule powers within its local boards and departments to address them. The Town also has the authority to expand on and improve the existing policies and programs listed above.

The Tyngsborough Planning Board and Board of Selectmen are the two primary Town entities responsible for regulating development in town. Feedback to both boards was ensured through the participation of the Town Manager and the Town Planner/Director of Economic Development on the local hazard planning team. In addition, NMCOG, the State-designated regional planning authority for Tyngsborough, works with all agencies that regulate development in its region, including the municipal entities listed above and state agencies, such as Department of Conservation and Recreation and MassDOT.

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6.0 STATUS OF MITIGATION MEASURES FROM THE 2015 DRAFT PLAN

6.1 Implementation Progress on the Previous Plan

The Tyngsborough core team was interviewed to update the mitigation measures identified in the 2015 Northern Middlesex Region Hazard Mitigation Plan. The core team provide updates on the progress of each measure. Incomplete measures were evaluated, and some will be carried forward into the 2020 HM-MVP Plan. The decision on whether to delete or retain a particular measure was based on the core team's assessment of the continued relevance or effectiveness of the measure and whether the deferral of action on the measure was due to the inability of the Town to take action on the measure. Table 45 summarizes the status of the mitigation measures.

Table 45. 2020 Status of Mitigation Measures from the 2015 Draft Plan

Mitigation Measure	2020 Status	To be Included in 2020 Plan
Work with MassDOT to mitigate flooding problems along Pawtucket Blvd (Route 113)	Not Completed	Yes
Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current	Underway – Communications with DCR are open and ongoing, especially with the Flint Pond Dam repairs	Yes
Participate in NFIP Training offered by the MEMA and FEMA to address flood hazard planning and management	Not Completed – Town Engineer did attend a training on the FEMA BCA Toolkit	Yes
Require use of elevation certificate for new buildings	Completed	No
Incorporate Hazard Mitigation planning into subdivision regulations, Master Plan and Open Space and Recreation Plan Update	In Progress – The Town of Tyngsborough is currently updating the Master Plan, updated the Open Space and Recreation Plan, and has taken steps to implement findings from the Hazard Mitigation Planning process. The 2018 Open Space and Recreation Plan Update included a section on chronic flooding, repetitive loss structures, anticipated climate change impacts, and mapping visualizing the floodplain extent and environmental justice populations. A Land Use Technical Paper shared as an interim update on the forthcoming Master Plan includes information on the floodplain district, the Flood Insurance Rate Map	Yes

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Table 45. 2020 Status of Mitigation Measures from the 2015 Draft Plan

Mitigation Measure	2020 Status	To be Included in 2020 Plan
	(FIRM), and FEMA special flood hazard areas. The Master Plan also contains a chapter on climate resiliency and incorporates actions from the HM-MVP.	
Correct flooding problems on the access road to the elementary school through culvert installation	Underway– Primarily resolved	Yes
Correct flooding problems on Sherburne Avenue	Underway	Yes
Correct flooding problems on Westford Road	Underway	Yes
Distribute educational information to residents and businesses on protecting life and property from severe storms	Underway – Emergency Manager primarily communicates with the public through social media	Yes
Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold winter storm events	Underway – Emergency Manager primarily communicates with the public through social media	Yes
Ensure that administrators of schools, businesses, medical facilities, and municipal buildings have a shelter plan in the event of a tornado warning		
Address areas of severe icing on roadways by delineating the limits of the ROW for tree removal to allow greater solar access	Not Completed – Most of the severe icing on roadways has been determined to be from underground springs	No
Work with cable and communication companies and the electric utility to develop a tree trimming program for above ground utility lines	Underway – The tree warden works closely with National Grid, which trims trees biannually, focusing on the lines coming from the power source in Westford	Yes

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Table 45. 2020 Status of Mitigation Measures from the 2015 Draft Plan

Mitigation Measure	2020 Status	To be Included in 2020 Plan
Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse	Not Completed	Yes
Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Not Completed	Yes
Evaluate public buildings and critical facilities for the potential to withstand high winds	Not Completed	Yes
Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Underway	Yes
Develop an inventory of public buildings that do not currently meet seismic standards	Not Completed	No

As indicated in Table 45, the Town is nearing completion of several mitigation measures including correcting flooding problems at the Elementary School access road through installation of a culvert and updating the Town's Master Plan and Open Space a Recreation Plan to include hazard mitigation. Others will be included in the implementation strategy described in Chapter 7.

Several mitigation measures were identified and prioritized in this plan. These include continuing to collaborate with the electric company to perform hazard tree removal near utility lines, increase public awareness and educate residents on natural hazards and hazard mitigation, and correct flooding problems in Tyngsborough.

The Town did not have a planner from 2006 to 2016, and the role was filled part-time by the full-time Conservation Director between 2016 and 2018. For that reason, there has been limited development of additional planning mechanisms by the Town since the completion of the 2015 Plan. As the Town moves forward into the next five-year plan implementation period hazard mitigation will be incorporated into the Town's capital planning. Limited staffing and financial resources are the biggest challenges the Town faces in implementing the mitigations measure identified in this plan. The plan is intended to assist the Town in prioritizing the proposed measures, which will provide guidance on how to best allocate any available grant or funding opportunities.

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7.0 HAZARD MITIGATION STRATEGY

7.1 Identification of Hazard Mitigation and Climate Adaptation Strategies

The Town developed a list of priority hazard mitigation and climate adaptation strategies through multifaceted approach. Strategies were discussed and developed upon review of the:

- Community profile, including the Town's strengths and vulnerabilities.
- Hazard and climate change risk assessment.
- Existing measures.
- Progress on the previous plan.
- Input from stakeholders.

Stakeholders were engaged through core team, the CRB Workshop, and the public input session. Any additional action items from the CRB Workshop that were not integrated into the final list of action items prioritized by the core team are available in Appendix B. Table 46 represents the Town's recommended hazard mitigation and climate adaptation measures and implementation roadmap. The estimated cost, timeframe, and implementation responsibility were developed for the road map, but along with the core team's prioritization based upon the societal benefit and feasibility. A description of the categories in Table 46 is identified below.

Priority – Designation of high, medium, or low priority was based on overall potential benefits and feasibility. A high priority action is very likely to have political and public support. The necessary maintenance and continued operation following the project is feasible. A medium priority action may have some political and public support. Necessary maintenance may be feasible once the project is complete. A low priority action may not have political and public support for implementation or the necessary maintenance support following the project.

Mitigation Action – A brief description of each mitigation measure that was identified in this plan.

Implementation Responsibility – Most mitigation measures will require a multi-department approach where several Town departments share responsibility. The designation of implementation responsibility in the table was assigned based on general knowledge of the responsibilities of each municipal department. The lead department for each action item is bolded.

Timeframe – The timeframe designates the most likely initial start time of the project. The timeframes represented below are assigned based on the complexity of the measure, the overall priority of the measure and at what stage of design and/or funding has been attained. The identification of time frames is not meant to prevent a community from actively seeking out and taking advantage of funding opportunities as they arise. Projects that involve maintenance or do not have a definitive end date are classified as Ongoing.

- Less than 1 year
- 1-3 years
- 3-5 years
- 5-10 years
- More than 10 years
- Ongoing

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Estimated Cost – Cost are provided for each mitigation measures. In some cases, costs are provided for different phases of the project. All cost data would need to be updated at the time of design and construction and is only provided as an estimate. Costs are represented as follows:

- $ = less than $10,000
- $$ =$10,000 to $100,000
- $$$ =$100,000-$500,000
- $$$$ = more than $500,000

Potential Finding Sources – Sources of funding are identified in Table 46 and further summarized in Table 47. The "Potential Funding Sources" column in Table 47 focuses on projects that would be competitive for each funding source. The Town's General Fund is considered a potential funding source unless the Town can pursue external funding.

While acronyms are used in Table 46, the full names of potential funding sources can be found in Table 47. An additional description of municipal funding is available in Section 7.2.

Hazard Icon Legend:


Heavy precipitation and flooding


Severe snow, ice, extreme cold


Severe thunderstorms, wind, nor'easters, tornado


Extreme heat, drought, brushfire


All hazards

Table 46. High Priority Action Items

Priority& Hazard	Mitigation Action	Implementation Responsibility	Timeframe	Cost	Potential Funding Sources
High 	Install backup power in additional critical facilities (including Greater Lowell Vocational High School, Senior Center, Town Hall, and other municipal buildings) and invest in renewable energy systems for redundancy	**Buildings,** Emergency/ Fire, School	1-3 years	$$ per facility	FEMA BRIC, EEA MVP, Green Comm-unities
High 	Provide wellness checks for vulnerable citizens	**Health** and Emergency/ Fire	Less than 1 year	$	Senior SAFE, Healthy Comm-unities

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Table 46. High Priority Action Items

Priority& Hazard	Mitigation Action	Implementation Responsibility	Timeframe	Cost	Potential Funding Sources
High 	Right size and replace culverts; focus preliminary efforts on Westford Road, the road to the elementary school, Sherburne Ave, and Dunstable Road	Highway and Engineering	1-3 years per culvert	$$$ per culvert	DOT Ch 90, EEA MVP, FEMA BRIC, MADER Culvert Program
High 	Work with cable, communication and the electric utility companies to increase proactive tree management above and beyond current tree trimming program for above-ground utility lines	Highway, State Agencies, and Utility Companies	1-3 years	$	Utility Company
High 	Implement climate resilience action items in the recently updated Open Space and Recreation Plan and the Master Plan	Conservation and Planning	3-5 years	Varied	EEA MVP
High 	Conduct a stormwater infrastructure assessment to identify opportunities to utilize best management practices on municipal property	Engineering	1-3 years	$$	CWA S604b, EEA MVP
High 	Ensure that administrators of schools, businesses, medical facilities, and municipal buildings have a shelter plan in the event of a tornado warning.	Schools, Emergency/Fire	Less than 1 year	$	MEMA, SAFE
High 	Implement improvements identified in Ch. 5, Table 43 to expand existing initiatives and municipal service capacity	All Departments	Ongoing	Varies	Multiple
High 	Assess and inventory stream crossings, such as culverts and bridges; prioritize/rank these assets based on vulnerability	Conservation and Engineering	1-3 years	$$	Municipal Small Bridge, EEA MVP, MADER Culvert

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Table 46. High Priority Action Items

Priority& Hazard	Mitigation Action	Implementation Responsibility	Timeframe	Cost	Potential Funding Sources
High 	Identify problem areas with poor drainage, icing issues, and gaps in the stormwater system. Identify potential strategies to address these issues	**Engineering,** Highway, Emergency/Fire	1-3 years	$$	EEA MVP, FEMA BRIC
Medium 	Build an updated public safety complex or center fire station on the west side of the Merrimack River	**Emergency/ Fire** and State Agencies	3-5 years	$$$$	MEMA EMGP
Medium 	Build a new satellite police station or facility on the east side of the Merrimack River	**Emergency/ Fire**	5-10 years	$$$$	MEMA EMGP
Medium 	Increase capacity for snow removal, identify locations for snow storage, and develop residential snow removal policies, evaluate most vulnerable roofs an develop plans to clear roofs of excessive snow accumulations to prevent collapse	**Highway**, Buildings	1-3 years	$	EEA MVP
Medium 	Update regulations related to stormwater management, including subdivision regulations, to encourage or require best management practices and climate resilience	**Planning** and Conservation	1-3 years	$$	EEA MVP, EEA Planning Assistance
Medium 	Increase education and outreach efforts related to public safety and climate resilience	Conservation, **Emergency/Fire**, State Agencies	Less than 1 year, Ongoing	$ up to $$	SAFE, EEA MVP, Healthy Comm-unities
Low 	Work with DCR Office of Dam Safety to ensure all dam inspections are current and develop regional collaborations to assess dams and design strategies. Complete dam reconstructions	**Conservation**, Engineering, and State Agencies	1-3 years	$$$$	EEA Dam and Seawall Program

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Table 46. High Priority Action Items

Priority& Hazard	Mitigation Action	Implementation Responsibility	Timeframe	Cost	Potential Funding Sources
Low 	Update regulations to require increased energy resilience in redevelopment	Conservation and Engineering	1-3 years	$	EEA MVP, EEA Planning Assistance, Green Comm-unities
Low 	Collaborate with the State to conduct a stormwater assessment on State-owned roads, assess undersized culverts, and complete retrofits for the stormwater system. Work with MassDOT to mitigate flooding on Pawtucket Blvd (113)	Highway, Engineering, State Agencies	1-3 years	$$	Ch 90, DER Culvert Program, EEA MVP, FEMA BRIC
Low 	Conserve, create, or rehabilitate parks and open space to provide climate resilient benefits, such as cooling, flood storage, and stormwater management	Planning and Conservation	1-3 years	$$$	Land Grant Program, MassTrails, Land and Water Conser-vation Fund, MET, PARC
Low 	Improve water supply reliability by investing in Tyngsborough owned water sources and developing water conservation signage. Develop a program to connect private wells user to public supply	Engineering	3-5 years	$$ for initial assess ment	DWSRF, Land Purchase: EEA Drinking Water Program, Water Management Act Grant, DWSP
Low 	Improve municipal building infrastructure including insulation, energy efficiency, ability to withstand snow loads, and cool roofs	Buildings and Engineering	3-5 years	$$$ per building	Green Comm-unities, EEA MVP, FEMA BRIC

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7.2 Potential Funding Sources

The identification of potential funding sources in is preliminary and may vary depending on numerous factors. These factors include, but are not limited to, if a mitigation measure is conceptual or has been studied, evaluated, or designed. In most cases, the measure will require an assemblage of funding sources. The funding sources identified are not a guarantee that a specific project will be eligible for or receive funding. Upon adoption of this plan, the local representatives responsible for implementation should begin to explore the funding sources in more detail. Funding source could include the following:

Traditional funding sources within the Town of Tyngsborough such as funding from the operating and capital budgets may be able to cover some of the cost. State revolving funds and other no or low interest loans may also be of interest. There is a great variety of grant funding available for Massachusetts municipalities, both through the state and federal governments. A full list of funding opportunities can be found on the Community Grant Finder webpage. The Community Grant finder provides a streamlined interface where municipalities can easily learn about grant opportunities. Specific funding opportunities related to Action Items developed by Tyngsborough are listed in Table 47.

Table 46 in the previous section identifies potential funding sources for each action item. However, combining several actions items into a single grant proposal may make an application more competitive, depending on the grant's criteria. Therefore, Table 47 below outlines more information on potential funding sources, to assist the Town in matching grants with appropriate project types.

Table 47. Potential Grant Funding Sources

Source	Grant (Hyperlinked)	Description of Funding
Massachusetts Emergency Management Agency (MEMA)	Flood Mitigation Assistance (FMA) Grant Program	Implements cost-effective measures that reduce or eliminate the long-term risk of flood damage
	Hazard Mitigation Grant Program	Provides funding after a disaster to significantly reduce or permanently eliminate future risk to lives and property from natural hazards
	Building Resilience Infrastructure and Communities (BRIC) Grant Program	Provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event
	Emergency Management Performance Grant (EMPG)	Reimbursable grant program to assist local emergency management departments to build and maintain an all-hazards emergency preparedness system
	Public Assistance Program	The state reimburses governments and other applicants for disaster related costs

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Table 47. Potential Grant Funding Sources

Source	Grant (Hyperlinked)	Description of Funding
Department of Energy and Resources (DOER)	Green Communities Designation & Grant Program	Grant for qualifying communities to implement energy efficiency measures, construct renewable energy projects, or pursue other avenues to reduce fossil fuel energy consumption.
Department of Conservation and Recreation (DCR)	Community Forest Grant Program	Funding to establish community forests
Division of Ecological Restoration (DER)	Culvert Replacement Municipal Assistance Grant Program	Grant to replace undersized, perched, and/or degraded culverts located in an area of high ecological value
Department of Environmental Protection (DEP)	604b Grant Program	Water quality assessment and management planning
	MS4 Grant Program	Meeting the requirements of the 2016 MS4 permit and reduce stormwater pollution through partnerships
	Water Management Act Grant	Funds planning projects to identify implementation actions to improve ecological conditions, conservation projects, and drought resiliency planning, and withdrawal mitigation projects that increase porosity and water quality.
	Drinking Water Supply Protection (DWSP) Grant Program	Financial assistance for protection of existing DEP-approved public drinking water supplies, protection of planned future public drinking water supplies, and protection of planned future public drinking water supplies.
Executive Office of Energy and Environmental Affairs (EEA)	Dam and Seawall Program	Grants for the repair or removal of dams, seawalls, and levees
	Drinking Water Supply Protection Grant Program	Financial assistance to public water systems and municipal water departments for the purchase of land or interests in land

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Table 47. Potential Grant Funding Sources

Source	Grant (Hyperlinked)	Description of Funding
	Land Use Planning Grants	Support effort to plan, regulate, and act to conserve and develop land consistent with the Massachusetts' Sustainable Development Principles
	LAND Grant Program	Helps cities and towns acquire land for conservation and passive recreation
	Federal Land & Water Conservation Fund	Funding for the acquisition, development, and renovation of parks, trails, and conservation areas.
	MassTrails Program	Trail protection, construction, and stewardship projects
	MVP Program	Provides support in implanting climate change resiliency priority projects
	Massachusetts Environmental Trust (MET)	Grants to support projects that protect and restore natural resources, including dam removal
Department of Fire Services	Senior SAFE	Supports fire and life safety education for seniors
	Student Awareness of Fire Education (S.A.F.E.)	Grants for local fire departments to teach fire and life safety to schools
MA Department of Transportation (DOT)	Chapter 90 Program	Reimbursable grants on approved projects
	Community Transit Grant Program	Funding to the transportation and mobility needs of seniors and people with disabilities
	Complete Streets Funding Program	Technical assistance and construction funding
	Municipal Small Bridge Program	Funding for small bridge replacement, preservation, and rehab projects
Division of Conservation Services	Massachusetts Land and Water Conservation Fund Grant Program	Provides 50% of the total project cost for the acquisition, development, and renovation, of parks, trails, and conservation areas
	Local Acquisitions for Natural Diversity (LAND) Grant Program	Helps cities and towns acquire land for conservation and passive recreation
	Parkland Acquisitions and Renovations for	Assists municipalities in acquiring and developing land for park and outdoor

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Table 47. Potential Grant Funding Sources

Source	Grant (Hyperlinked)	Description of Funding
	Communities (PARC) Grant Program	recreation purposes. Can be used to acquire parkland, build a new park, or renovate an existing park.
US Economic Development Administration	Disaster Supplemental Funding	Funding available to communities impacted by natural disasters and flooding
US Department of Agriculture	Watershed and Flood Prevention Operations Program	Helps municipalities protect and restore watersheds
	Emergency Watershed Protection Program	Funds to help communities quickly address serious and long-lasting damages to infrastructure and the land
	Regional Conservation Partnership Program	NRCS seeks to co-invest with partners to implement projects that demonstrate innovative solutions
U.S. Department of the Interior	Land and Water Conservation Fund	Secures public access, improves recreational opportunities, and preserves ecosystem benefits for local communities (multiple funding options)
US Environmental Protection Agency	Healthy Communities Grant Program	Reduce environmental risk to protect and improve human health and the quality of life
	Drinking Water State Revolving Fund (DWSRF)	Loans provided to municipalities to assist with infrastructure projects needed improve drinking water source, distribution, and treatment

7.3 Regional Partnerships

Mitigating natural hazards is not confined to a local issue, especially in Tyngsborough. Many of the community's utilities and critical infrastructure are dependent or interconnected with surrounding communities. Tyngsborough will benefit from making a concerted effort to partner with neighboring towns and cities to find mutually beneficial partnerships and support systems.

In addition, the drainage systems that service communities are often complex systems of storm drains, roadway drainage infrastructure, pump stations, dams, and other facilities owned and operated by a wide variety of agencies including the Massachusetts Department of Transportation (MassDOT) and the Department of Conservation and Recreation (DCR). The planning, construction, operation, and maintenance of these structures are integral to hazard mitigation efforts of communities. These agencies are the town's regional partners in hazard mitigation efforts. Mitigation measures for the following regional issues should be considered as Tyngsborough develops its own local plan. These agencies also operate under the same constraints as communities do including budgetary and staffing limitations. And as all communities do, they must make decisions about numerous competing priorities. In order to implement many of these mitigation measures, all parties will need to work together towards a mutually beneficial solution.

8.0 PLAN ADOPTION AND MAINTENANCE

8.1 Plan Adoption

The 2020 Tyngsborough HM-MVP Plan was adopted by the Board of Selectmen on December 14, 2020. See Appendix E for documentation. The plan was approved by FEMA on December 23, 2020 for a five-year period that will expire on December 22, 2025.

8.2 Plan Implementation

The time frame, responsible department, and funding mechanisms in Table 46 and 47 layout out an action plan for the core team to implement. The core team will be held accountable through the tracking mechanisms explained in the following section. The HM-MVP Plan will also inform future planning and budgeting processes.

8.3 Plan Maintenance

8.3.1 Tracking Progress and Updates

FEMA's initial approval of this plan is valid for five years. During that time, the Town will need to continue to track progress, document hazards, and identify future mitigation efforts. The core team, co-coordinated by the Planning Department and Fire Department, will meet annually in November or on an as-needed basis, whichever is most frequent, to monitor plan implementation. The core team will be amended as needed. The co-coordinators of core team will also prepare and distribute instruction on how to collaborate to keep the plan current every two years. The co-coordinators wills utilize a series of shared spreadsheets be made available to all core team members and any other interested local stakeholders. The spreadsheet and discussion about the spreadsheet will assist in determining any necessary changes or revisions to the plan that may be needed. In addition, it will help provide information on progress and accomplishments for implementation and any new hazards or problem areas that have been identified since the plan drafting. The information collected through the survey will be used to formulate a report and/or addendum to the plan.

8.3.2 Continuing Public Participation

The adopted plan will be posted on the Town's website. The posting of the plan on the Town's web site will provide a mechanism for citizen feedback, such as an e-mail address for interested parties to send comments. The Town will encourage local participation whenever possible during the next five-year planning cycle and. The core team will incorporate engagement into the implementation of the priority action items. All updates to the plan, including implementation progress, will be placed on the Town's web site. All public meetings related to the HM-MVP Plan will be publicly noticed in accordance with town and state open meeting laws.

8.3.3 Integration of the Plans with Other Planning Initiatives

Upon approval of the 2020 Tyngsborough HM-MVP Plan by FEMA, the core team will make the plan available to all interested parties and all departments with an implementation responsibility. The group will initiate a discussion with those various departments regarding how the plan can be integrated into their ongoing work. At a minimum, the plan will be reviewed and discussed with the following departments and the Town Administrator's Office:

Public Works Department	Fire Department/Emergency Management	Parks and Recreation
Planning		Board of Health
Conservation Commission	Police Department	Buildings

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Appropriate sections of the HM-MVP Plan will be integrated into other plans, policies, and documents as those are updated and renewed, including the Master Plan, Open Space and Recreation Plan, Comprehensive Emergency Management Plan, and Capital Investment Program. For example, the forthcoming Master Plan includes information on the floodplain district, the Flood Insurance Rate Map (FIRM), and FEMA special flood hazard areas. The Master Plan also contains a chapter on climate resiliency and incorporates actions from the HM-MVP. Coordination with the Northern Middlesex Council of Governments, land conservation organizations and watershed groups will be required for successful implementation and continued updating.

8.4 Process of Updating

By maintaining the 2020 HM-MVP Plan, the Town will have a competitive application when applying to FEMA for funding to update the plan. Once the resources have been secured to update the plan, the core team will need to determine whether to undertake the update itself or hire a consultant. If the core team decides to update the plan itself, the group will need to review the current FEMA hazard mitigation plan guidelines for any change in the requirements. The Tyngsborough HM-MVP Plan Update will be forwarded to MEMA for review and to FEMA for ultimate approval. The core team will begin drafting the full update of the plan in four years. This will help the Town avoid a lapse in its approved plan status and grant eligibility when the current plan expires at the end of year five.

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Appendix A – Core Team Materials

Municipal Vulnerability Preparedness Planning Grant and Hazard Mitigation Planning Grant Update

Core Team Meeting
Town Hall Conference Room
Wednesday, September 11, 2019
1:00 pm – 2:30 pm

Introductions	5 minutes
Project Overview	15 minutes
Core Team Role	2 minutes
Data Sources	3 minutes
Goal Setting and Endorsement	15 minutes
Community Resilience Building Workshop and Review of Materials	35 minutes
Workshop Participants	10 minutes
Wrap Up and Next Steps	5 minutes

TOWN OF TYNGSBOROUGH

Core Team Meeting

Wednesday, September 11, 2019

Photo: Lake Mascuppic. Photo by the Town of Tyngsborough, Twitter, 2017.

1

WELCOME CORE TEAM

Eric Salerno	Patrick Sands
Danielle Mucciarone	Richard Howe
Justin Sultzbach	Kathy Cayer
Matt Hanson	Kerri Oun
Wes Russell	Jim Hustins

Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018.

2

CORE TEAM

ROLE

- Confirm framework for process
- Provide data and local expertise
- Participate in the stakeholder workshop
- Finalize priority actions for the final report

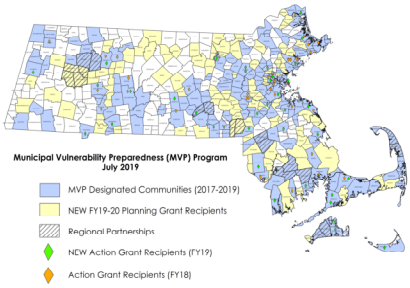
TODAY'S OBJECTIVES

- Review Process
- Set Goals
- Prepare for Stakeholder Meeting

3

3

MUNICIPAL VULNERABILITY PREPAREDNESS PROGRAM (MVP)



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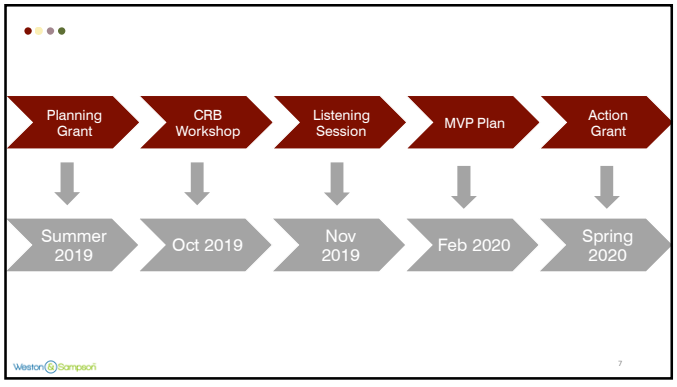

7

MVP PLANNING GRANT COMPONENT

HAZARD MITIGATION PLAN UPDATE

- Aligns with MVP Process
- Extended hazard profiles and vulnerability assessment
- Update to previous mitigation measures table

RESILIENCE MASTER PLAN CHAPTER

- Builds on HMP-MVP work
- Incorporates stormwater
- Develop alongside current master planning process

8

WORKSHOP OUTLINE

PRESENTATION:
- Overview of Science & Data
- Characterization of Hazards

- BREAK -

INDIVIDUAL TABLES:
- Identify Community Features

- LUNCH -

INDIVIDUAL TABLES:
- Identify and Prioritize Actions

- BREAK -

LARGE GROUP DISCUSSION:
- Determine Overall Priority Actions

Photo: Old Town Hall. Photo by John Phelan, 2010.

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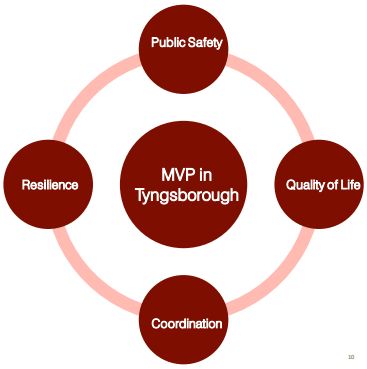
MVP GOALS IN TYNGSBOROUGH



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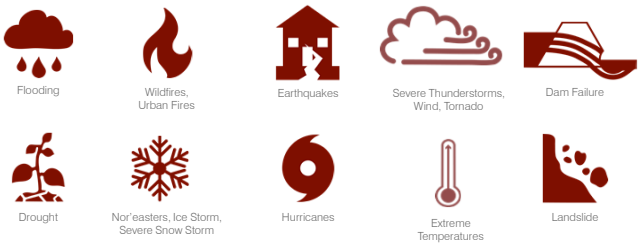
HAZARDS IN TYNGSBOROUGH



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EXTREME TEMPERATURES

WARMER ANNUAL AIR TEMPERATURES
UP 0.5°F PER DECADE SINCE 1970, ON AVERAGE

WARMER WINTERS
UP 1.3°F PER DECADE SINCE 1970, ON AVERAGE

12

EXTREME TEMPERATURES IN MASSACHUSETTS

2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
6	24	35

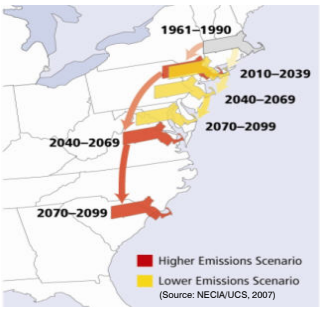
DAYS WITH TEMPERATURES ABOVE 90°F

2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
145	114	101

DAYS WITH TEMPERATURES BELOW 32°F

13

(Source: UCSUSA "Confronting Climate Change in the U.S. Northeast")



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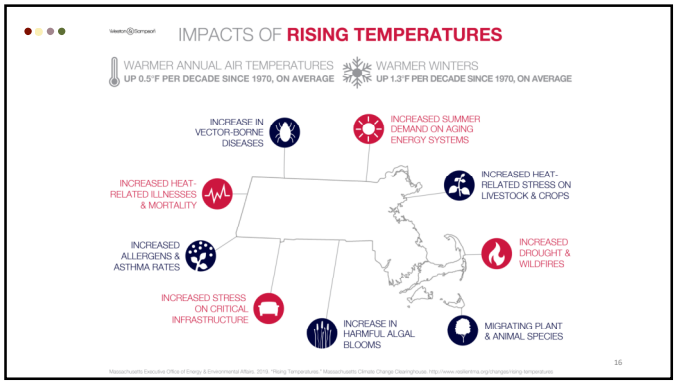

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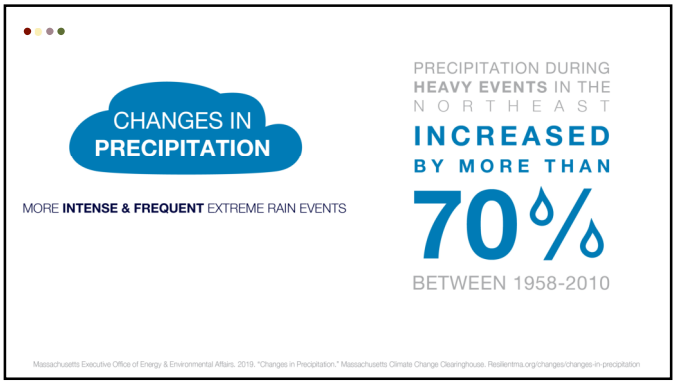

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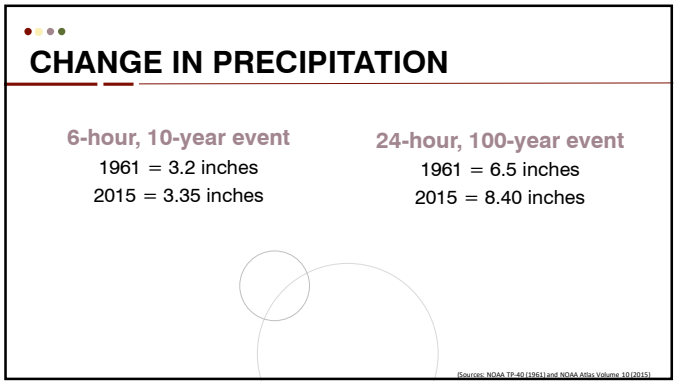

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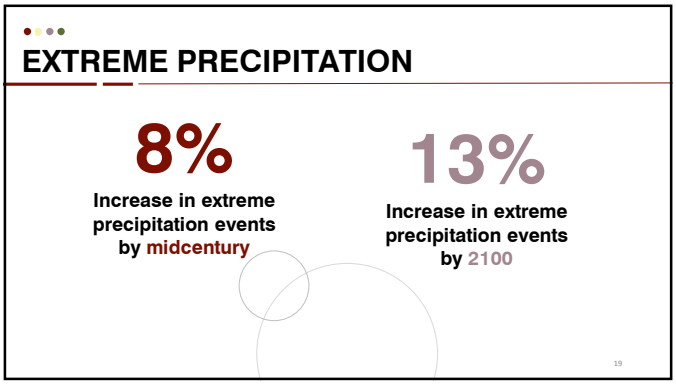

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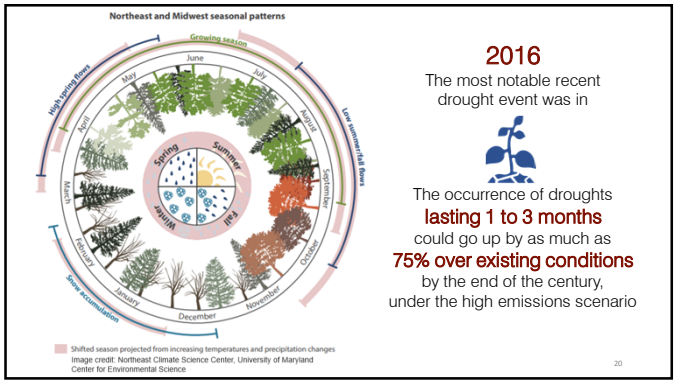

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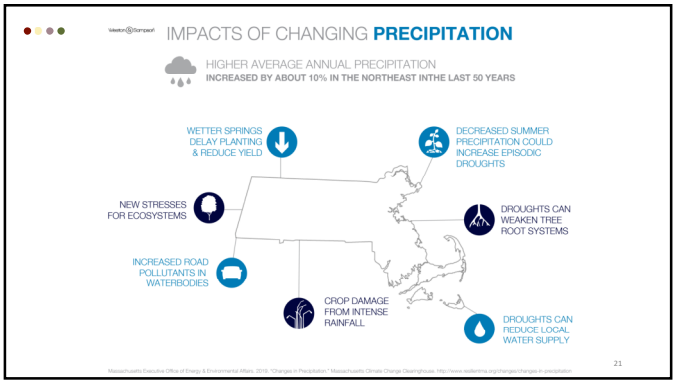

21

WINTER STORMS

The blizzard of 2013 left nearly **400,000 Massachusetts residents without power**

"Heavy blizzards are among the **most costly and disruptive** weather events for Massachusetts communities."

23

23

FLOODING

ZONE	ANNUAL CHANCE	FLOODPLAIN
A, AE, A1-A30	1% ANNUAL CHANCE	100-YEAR FLOODPLAIN
X	0.2% ANNUAL CHANCE	500-YEAR FLOODPLAIN

"By 2050, Boston could experience the current 100- year riverine flood every two to three years on average"

24

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Flood Prone Areas

Access road to the Tyngsborough Elementary School

Route 113 near Vesper Country Club

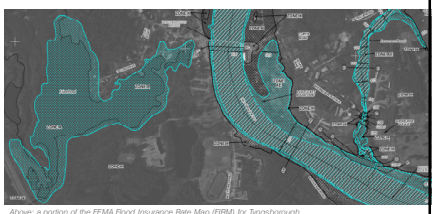
Vicinity of Bridgeview Circle

Riverbend Road

River Road

Red Gate Road

Larson Avenue



Above: a portion of the FEMA Flood Insurance Rate Map (FIRM) for Tyngsborough

REPETITIVE FLOOD LOSS STRUCTURES

- Defined as an NFIP-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978.[1]
- Tyngsborough has **8** repetitive loss structures. All are residential structures.[2]
- As of May 2013, the NFIP paid out **$2,129,486** for **16 claims.**[2]

[1] Federal Emergency Management Agency (FEMA). 2019. "Definitions." Accessed August 29, 2019. Fema.gov/national-flood-insurance-program/definitions#R

[2] Northern Middlesex Council of Governments. 2013. Hazard Mitigation Plan for the Northern Middlesex Region. 11th

25

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STORMWATER FLOODING

Areas with:

- Poor drainage
- High amounts of impervious surface
- Undersized culverts

26

26

EROSION

Caused by riverine flow & stormwater

Increased precipitation, including winter rains, could increase erosion

Drier soils will reduce resistance to erosion

(Source: MA Climate Change Adaptation Report, 2011)

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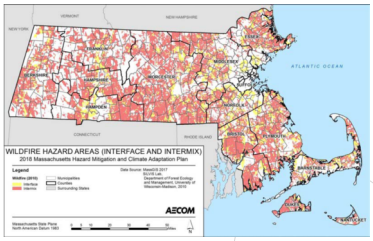
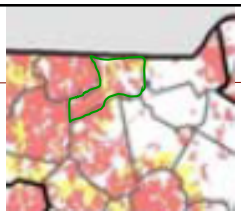
WILDFIRE





206+

brush fires were reported in the Town of Tyngsborough over a 3-year period .

28

28

HURRICANES AND EARTHQUAKES

HURRICANE

Irene
was the most recently identified hurricane according the last HMP

Upward trend in North Atlantic hurricane activity since 1970

Nor'easters along the Atlantic coast are increasing in frequency and intensity

EARTHQUAKE

30-40
Earthquakes occur in New England each year, although most are not felt.

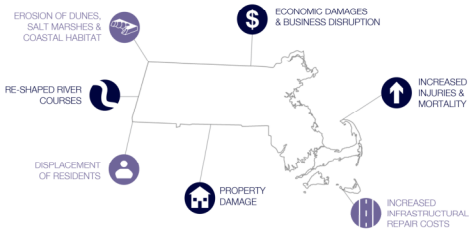
Source: Climate Science Special Report, Fourth National Climate Assessment (NCA4), Volume prepared by the U.S. Global Change Research Program (USGCRP)Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 159-160.

29

29

IMPACTS OF EXTREME WEATHER

STORMS ARE BECOMING MORE INTENSE AND DAMAGING



Massachusetts Executive Office of Energy & Environmental Affairs. 2015. "Extreme Weather." Massachusetts Climate Change Clearinghouse. http://www.resilientma.org/changes/extreme-weather

30

30

HAZARD POTENTIAL OF DAMS

Table 58: Hazard Classification of Tyngsborough Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Lower Flint Pond Dam	Lower Flint Pond	Low	450	10/13/2007	10/13/2012
Locust Pond Dam	Locust Pond	Significant	100	NA	NA
Masquppic Lake Dam	Masquppic Lake	Non-jurisdictional	NA	NA	NA
Upper Flint Pond Dam	Upper Flint Pond	Significant	0	10/13/07	10/13/2012
Cow Pond Brook Dam	Cow Pond Brook	Significant	100	6/26/2007	6/26/2012

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety

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As an FYI: Boston Sea Level Rise Projections (ft)

Increased coastal flooding

Permanently inundated low-lying coastal areas

Increased shoreline erosion

Emission Scenario	2030	2050	2070	2100
Intermediate	0.7	1.4	2.3	4.0
Intermediate-High	0.8	1.7	2.9	5.0
High	1.2	2.4	4.2	7.6
Extreme	1.4	3.1	5.4	10.2

(Source: Northeast Climate Adaption Science Center)

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RISK MATRIX

Photo: March 2018 snowstorm. Photo by the Town of Tyngsborough, Twitter, 2018.

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RISK MATRIX

Community Resilience Building Risk Matrix — www.CommunityResilienceBuilding.com

Top Priority Hazards (tornado, flood, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership: Y or S	Priority	Time
Infrastructural				
Societal				
Environmental				

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RISK MATRIX: HAZARDS

Community Resilience Building Risk Matrix — www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Priority H - M - L	Time Short Long Ongoing
Infrastructural					
Societal					
Environmental					

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IDENTIFY HAZARDS

Photo: Snowstorm. Photo by the Town of Tyngsborough, Twitter, 2017.

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Hazards in Tyngsborough

Hazard	Frequency- (Weight factor 2)	Severity- (Weight factor 5)	Extent of Impact – (Weight factor=10)	Probability- (weight factor 7)	Total Score
Flood	3x2=6	1x5=5	3x10=30	3x7=21	62
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	52
Urban Fire	1x2=2	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x2=6	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	2x2=4	1x5=5	2x10=20	2x7=14	43

Weston & Sampson — Source: Northern Middlesex Council of Governments, 2015, "Hazard Mitigation Plan for the Northern Middlesex Region," 198.

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Natural Hazards in TYNGSBOROUGH

CHOOSE 4 FOR THE MVP ACTION PLAN

- Flooding
- Wildfires, Urban Fires
- Earthquakes
- Severe Thunderstorms, Wind, Tornado
- Dam Failure
- Drought
- Nor'easters, Ice Storm, Severe Snow Storm
- Hurricanes
- Extreme Temperatures
- Landslide

Weston & Sampson — Source: Northern Middlesex Council of Governments, 2015, "Hazard Mitigation Plan for the Northern Middlesex Region," 198.

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15 MINUTE BREAK!

Photo: Crash on Chestnut Road during December 2017 Snowstorm. Photo by Tyngsborough Police Department, Twitter, 2017.

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RISK MATRIX: HAZARDS

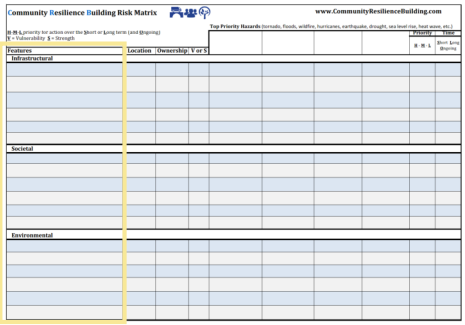
Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

				Priority H - M - L	Time Short Long Ongoing

40

40

RISK MATRIX: FEATURES


Community Resilience Building Risk Matrix
www.CommunityResilienceBuilding.com
Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)
Priority
Time
H M L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength
Features
Location
Ownership
V or S
Infrastructural
Societal
Environmental

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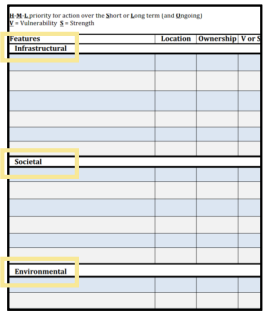
RISK MATRIX: FEATURES


H M L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength
Features
Location
Ownership
V or S
Infrastructural
Societal
Environmental

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RISK MATRIX: FEATURES

FEATURES	LOCATION	OWNERSHIP	VULNERABILITY OR STRENGTH
Infrastructural	Town wide	State	Vulnerability
Societal	Multi- vs. Single-neighborhood	Town	Strength
Environmental	Specific location	Private	Both
		Shared	

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FEATURES IN TYNGSBOROUGH


Photo: Memorial Day Parade. Photo by the Tyngsborough Police Department Twitter, 2019.

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INFRASTRUCTURAL FEATURES

Police Department
Photo by the Tyngsborough Police Department


Fire Department
Photo by the Tyngsborough Fire Department


Wastewater Treatment & Collection


Dams
Lake Massuppic. Photo by the Town of Tyngsborough.


Roadways
Photo by the Town of Tyngsborough


Water Supply

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45

INFRASTRUCTURAL FEATURES

30% of the Town is serviced by public drinking water

70% is served by on-site private wells

3 *water districts that operate*

5 *distribution systems which access various supply sources in neighboring communities*

25% of the Town is covered by the public sewer system

75% of the Town is supported by on-site septic systems

Source: Northern Middlesex Council of Governments, 2018, "Hazard Mitigation Plan for the Northern Middlesex Region," 124.

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INFRASTRUCTURAL FEATURES
CRITICAL FACILITIES

Table 56: Emergency Operations Center, Health Care Facilities and Shelters – Tyngsborough

Facility Types	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Centers	Fire Station (Primary)	26 Kendall Road				No	Yes
	Police Station (Alternate)	20 Westford Road				No	Yes
	Town Hall (Alternate)	25 Dunstable Lane				No	Yes
Health and Medical Facilities	None						
Shelters	Tyngsborough High School	50 Norris Road			100	Yes	Yes
	Tyngsborough Elementary School	205 Westford Road			100	Yes	Yes
	Greater Lowell Vocational High School	230 Pawtucket Boulevard			700	Yes	Yes

Source: Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region," 155.

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SOCIETAL FEATURES

Population
2010: 11,287 residents
2018: 12,418 residents
Age
Under 18 years: 21%
65+ years: 9.8%
Education
Bachelor's degree or higher: 45.8%
Additional Information
Median household income: $101,303
Persons in poverty: 7.1%
With a disability: 6.5%
Language other than English spoken at home: 11.6%

Source: U.S. Census Bureau, 2019

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SOCIETAL FEATURES

SCHOOL SYSTEM
- 2,300 students are enrolled in the public school system
- Public school system includes **3** elementary schools and **1** junior/senior high school
- Other schools include:
  - Greater Lowell Technical High School
  - Academy of Notre Dam
  - Innovation Academy

Source: Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region," 154.

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SOCIETAL FEATURES

66 public safety personnel, including:

23 uniformed police officers

40 on-call fire fighters

Source: Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region," 155.

50

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ENVIRONMENTAL FEATURES

Forest

Trails

Perennial Streams in Tyngsborough[1]
- Bridge Meadow Brook
- Lawrence Brook
- Limit Brook
- Scarlett Brook
- Locus Brook

1. Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region," 157.

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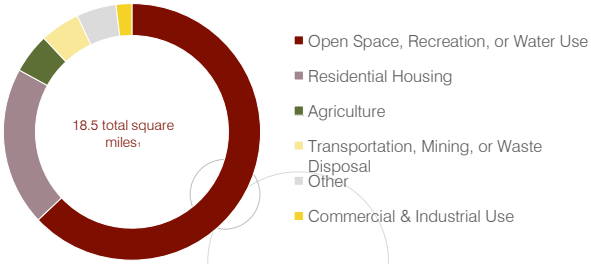
Tyngsborough's Land Use



1. Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region," 154.

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DATA RESOURCES

In Tyngsborough and Massachusetts

- Massachusetts Climate Change Projections (NECSC, 2018)
- Hazard Mitigation Plan for the Northern Middlesex Region, 2015 Update
- Massachusetts Climate Change Adaptation Report (MA EEA, 2011)
- Tyngsborough Open Space & Recreation Plan, 2009
- Input from Municipal Officials

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EXISTING HAZARD PROTECTION

- Maintained compliance with the National Flood Insurance Program
- Enforced the town's floodplain bylaw
- Enforced the erosion control and stormwater management standards with the town's subdivision regulations
- Implemented BMPs within the town's Stormwater Management Plan
- Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act
- Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)
- Enforced the town's Stormwater Management Bylaw
- Rehabilitation of the Tyngsborough Bridge (opened in 2012)
- Drainage work completed through the Pawtucket Blvd. relocation project
- Participated in conversations with private dam owners to check on the status of Dam Safety Orders
- Tree removal for electric reliability-Implemented in Winter 2012-2013 –hazard trees are inspected and removed
- Procured a Portable 100kVA Backup Generator for Sewer Pump stations
- Implemented CodeRED emergency notification system
- Amended the floodplain bylaw in May 2012 to satisfy 44 CFR, Section 60.3

Weston & Sampson Source:

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LUNCH

Photo: Town Beach at Lake Mascuppic. Photo by the Town of Tyngsborough, 2017, Twitter.

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ADAPTATION STRATEGIES

Photo: Conditions on Westford Road during a March 2018 snowstorm. Photo by the Town of Tyngsborough, Twitter, 2018.

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15 MINUTE BREAK!

Photo: Tree down on Willowdale and Westland Road. Photo by the Town of Tyngsborough, 2017, Twitter.

82

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DEFINE COMMUNITY ACTIONS

Photo: Tyngsborough Council on Aging (169 Westford Road). Photo by the Tyngsborough Police Department, Twitter, 2017.

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IDENTIFY PRIORITY ACTIONS

Photo: Police cars on Westford Road. Photo by the Town of Tyngsborough, 2017, Twitter.

84

WRAP-UP & CLOSING REMARKS

Photo: Traffic lights out at the intersection of Westford/Swan Road and Old Boone Hill. Photo by the Town of Tyngsborough, 2017, Twitter.

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THANK YOU

Weston & Sampson

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Municipal Vulnerability Preparedness Planning Grant and
Hazard Mitigation Planning Grant Update

Core Team Meeting
Town Hall Conference Room
Wednesday, September 11, 2019
1:00 pm – 2:30 pm

Introductions 5 minutes

Project Overview 15 minutes

1. MVP Program Overview
    a. Brief Introduction to Climate Change in Tyngsborough
    b. MVP Planning Process
    c. MVP Action Grants
        i. Senate Bill 10 could unlink MVP Action Grants from the fiscal year.
    d. Hazard Mitigation Plan Overlap
        i. FEMA requires an updated HMP every 5 years
        ii. The Town is interested in including a list of infrastructural assets with their anticipated lifespans. This will help inform the timeline for action items and the distribution of funding.
        iii. HMP requires Core Team endorsement of goals
        iv. There are opportunities to combine the public outreach required for both MVP and HMP
    e. Master Plan Chapter
        i. The plan will look forward 5-years
        ii. There are opportunities to align the Master Plan with the Town's MS4 requirements
        iii. The inclusion of resilience in this plan will help introduce the issues of stormwater management to the Board.
        iv. The inclusion of resilience-related goals will help make the case for allocating future budget towards resiliency projects.

Core Team Role 2 minutes

1. Develop/approve list of stakeholders
2. Active participants in the Community Resilience Building Workshop
3. Promote the listening session/attend listening session
4. Inform community priorities/Determine how decisions from Workshop will be used

Data Sources 3 minutes

1. Interviews with municipal officials
2. Applicable reports and materials
    a. Hazard Mitigation Plan Update (2015)
    b. Open Space and Recreation (2009) and update
        i. Danielle Mucciarone is close to finalizing an updated Open Space and Recreation plan.
    c. Master Plan (2004, being updated now)
    d. Critical assets and infrastructure
        i. The Town is in the middle of an infrastructure study.

e. Demographics
f. The Town can provide updated land use percentages.
g.

3. Ask:
    a. Other ongoing efforts?
    b. Local hazards/experiences to highlight?
        i. Flooding
        ii. Drought
        iii. Snow and Nor'easters, although the action items associated with this hazard may rely heavily on National Grid.
    c. Is data available on the projected impact of climate change on relative humidity?
    d. The Core Team is looking for more information on how dam hazard classifications are determined. Additionally, it may be helpful to include a definition for "non-jurisdictional" dams on the PowerPoint slide and ownership.
        i.

W&S Action Item: Review materials and incorporate into Workshop and Report(s)
Tyngsborough Action Item: Identify and provide any additional resources

Goal Setting and Endorsement 15 minutes

1. Large group activity on what a successful hazard mitigation and climate preparedness plan means to them.
2. Presentation of goals and large group discussion on how to incorporate comments. Feedback included:
    a. Streamline the original goals to remove redundancy
    b. Make the goals more specific to Tyngsborough. They currently read as general goals that could apply to any municipality in the region.
    c. Include goals related to both residents and residences.
    d. Include goals related to specific regulations that need to be updated or enforced.
    e. Include goals related to climate change-related diseases and health issues and other emerging issues.
    f. Clarify that the goals do not need to include Action Items – those will be addressed later in the reports.

Community Resilience Building Workshop and Review of Materials 35 minutes

1. MVP Risk Matrix
    g. Discuss hazards and key features (infrastructure, society, environment)
        i. Updates will be made to the Upper Flint Pond dam next year. The Town is working with US Fish & Wildlife on this project.
        ii. The protection of historic records was identified as a vulnerability of concern.
2. Review map of key resources/assets/hazards
3. Prioritization Process MVP Key Actions
4. Workshop Schedule
    h. Options include one 8-hour or two 4-hour meetings, weekday or weekend, day or evening
    i. An 8-hour workshop during the day of October 30th was tentatively identified as preferable
5. Presentation Feedback

W&S Action Item: Finalize Workshop materials based on Core Team input
Tyngsborough Action Item: Help to fill mapping and PowerPoint gaps

Workshop Participants — 10 minutes

1. Respond to a list of workshop invitees

W&S Action Item: Draft invitation to stakeholders
Tyngsborough Action Item: Finalize list of invitees; send invitation and track RSVPs, assign participants to tables

Initial additions suggested for the draft list of invitees (additional feedback pending):

- Ask each Board to send a representative, which does not have to be the Chair
- Water District
- Faith-based groups
- Private schools (not just a representative from the public schools)
- Regional hospital
- MassDOT
- National Grid?
- Relationships related to water and sewer in Lowell and Chelmsford

Wrap Up and Next Steps — 5 minutes

1. Confirm draft schedule

Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Wednesday, Sept 11, 2019 1:00 pm – 2:30 pm

Name	Sign-in with an X or Signature
Eric Salerno	X
Danielle Mucciarone	
Justin Sultzbach	X
Matt Hanson	X
Wes Russell	X
Patrick Sands	
Richard Howe	
Kathy Cayer	Kathy Cayer / Paul Provencher
Kerri Oun	
Jim Hustins	X
Michelle Rowden	

Weston & Sampson

Appendix B – Workshop Materials

TOWN OF TYNGSBOROUGH

Municipal Vulnerability Preparedness Planning Grant Project

Community Resilience Building Workshop

Old Town Hall, 10 Kendall Road
Wednesday, October 30, 2019
8:30 am – 4:30 pm

8:30 am – 8:45 am	Registration and Refreshments
8:45 am – 9:00 am	Welcome and Introductions
9:00 am – 9:15 am	MVP Workshop Purpose and Overview
9:15 am – 10:00 am	Data Resources and Overview of Science
	Risk Matrix
10:00 am – 10:15 am	Large Group Exercise #1
10:15 am – 10:30 am	BREAK
10:30 am – 10:50 am	Small Group Exercise #1
10:50 am – 11:10 am	Small Group Exercise #2
11:10 am – 11:30 am	Small Group Exercise #3
11:30 am – 12:00 pm	MVP Community Actions
12:00 pm – 1:00 pm	Lunch
1:00 pm – 1:45 pm	Small Group Exercise #4
1:45 pm – 2:30 pm	Small Group Exercise #5
2:30 pm – 3:00 pm	Small Group Exercise #6
3:00 pm – 3:15 pm	BREAK
3:15 pm – 4:15 pm	Large Group Exercise #2
4:15 pm – 4:30 pm	Wrap-up and Closing Remarks

TOWN OF TYNGSBOROUGH

Community Resilience Building Workshop

Wednesday, October 30th, 2019

Weston & Sampson Photo: Lake Mascuppic. Photo by the Town of Tyngsborough, Twitter, 2017. 1

1

WELCOME CORE TEAM

Eric Salerno	Patrick Sands
Danielle Mucciarone	Richard Howe
Justin Sultzbach	Kathy Cayer
Matt Hanson	Kerri Oun
Wes Russell	Jim Hustins

Weston & Sampson Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018. 2

2

WELCOME W&S

Amanda Kohn
Deanna Lambert
Lydia Kifner
Adria Boynton

Weston & Sampson Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018. 4

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WELCOME PARTICIPANTS

Your name
Organization/Relationship to Tyngsborough
Favorite thing about Tyngsborough

Weston & Sampson Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018. 5

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WORKSHOP OUTLINE

PRESENTATION:
- Overview of Science & Data
- Characterization of Hazards

- BREAK -

INDIVIDUAL TABLES:
- Identify Community Features

- LUNCH -

INDIVIDUAL TABLES:
- Identify and Prioritize Actions

- BREAK -

LARGE GROUP DISCUSSION:
- Determine Overall Priority Actions

Photo: Old Town Hall. Photo by John Phelan, 2010. 6

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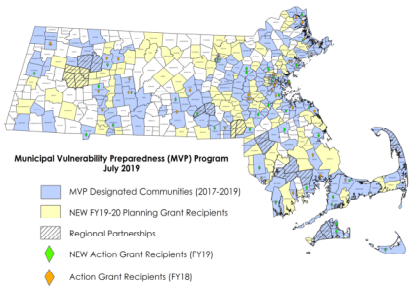
MUNICIPAL VULNERABILITY PREPAREDNESS PROGRAM (MVP)



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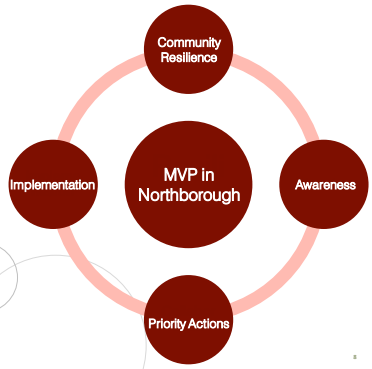
7

MVP IN TYNGSBOROUGH

- Increase resilience of community
- Raise awareness of climate threats
- Identify priority actions to move forward
- Create implementation pathways



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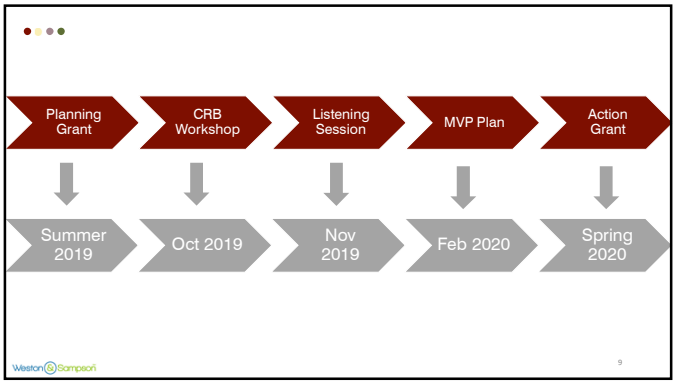

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MVP PLANNING GRANT COMPONENT

HAZARD MITIGATION PLAN UPDATE

- Aligns with MVP Process
- Extended hazard profiles and vulnerability assessment
- Update to previous mitigation measures table

RESILIENCE MASTER PLAN CHAPTER

- Builds on HMP-MVP work
- Incorporates stormwater
- Develop alongside current master planning process

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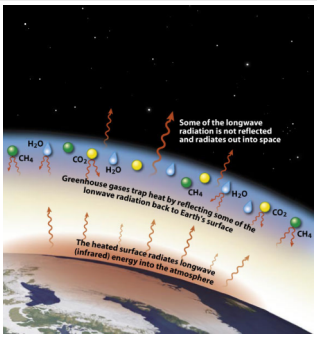
GREENHOUSE GASES (GHG)

- Naturally occurring
- Act as a blanket
- Examples: carbon dioxide and methane

Climate mitigation ensures there is less to adapt to and is a key component of our community's resilience

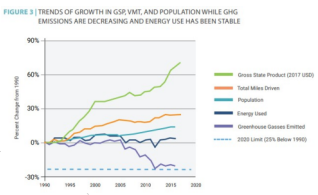


Smithsonian Environmental Research Center. "Too Much of a Good Thing."
http://forces.si.edu/atmosphere/02_04_07.html

11

MASSACHUSETTS GHG GOALS

- Established by the Global Warming Solutions Act (GWSA) of 2008
- 25% reduction in GHG emissions by 2020
- 80% reduction in GHG emissions by 2050
- 1990 is the baseline year



Source: Commonwealth of Massachusetts. 2019. "Global Warming Solutions Act 10-year Progress Report." 10.

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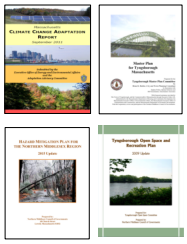
DATA RESOURCES



In Tyngsborough and Massachusetts

- Massachusetts Climate Change Projections (NECSC, 2018)
- Massachusetts Climate Change Adaptation Report (MA EEA, 2011)
- Input from Municipal Officials
- Hazard Mitigation Plan for the Northern Middlesex Region Update, 2015
- Tyngsborough Master Plan, 2004
- Tyngsborough Open Space and Recreation Plan, 2009

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HAZARDS IN TYNGSBOROUGH

Flooding
Wildfires, Urban Fires
Earthquakes
Severe Thunderstorms, Wind, Tornado
Dam Failure
Drought
Nor'easters, Ice Storm, Severe Snow Storm
Hurricanes
Extreme Temperatures
Landslide

Weston & Sampson

Source: Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 156.

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EXTREME TEMPERATURES

WARMER ANNUAL AIR TEMPERATURES
UP 0.5°F PER DECADE SINCE 1970, ON AVERAGE

WARMER WINTERS
UP 1.3°F PER DECADE SINCE 1970, ON AVERAGE

15

15

EXTREME TEMPERATURES IN MASSACHUSETTS

2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
6	24	35

DAYS WITH TEMPERATURES ABOVE 90°F

2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
145	114	101

DAYS WITH TEMPERATURES BELOW 32°F

Massachusetts Executive Office of Energy & Environmental Affairs. 2019. "ResilientMA Datagraphic." Massachusetts Climate Change Clearinghouse. Resilientma.org/datagraphic/?c=Temp/state/h90/AAN/MA/. Notes: 1961-century projected annual averages use a 2040-2069 time range. End-of-century project annual averages use a 2080-2097 time range.

16

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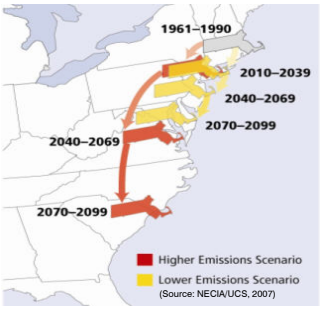
(Source: UCSUSA "Confronting Climate Change in the U.S. Northeast")



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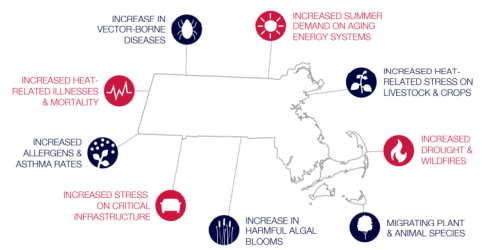
IMPACTS OF RISING TEMPERATURES

WARMER ANNUAL AIR TEMPERATURES **UP 0.5°F PER DECADE SINCE 1970, ON AVERAGE**
WARMER WINTERS **UP 1.3°F PER DECADE SINCE 1970, ON AVERAGE**



Massachusetts Executive Office of Energy & Environmental Affairs. 2019. "Rising Temperatures." Massachusetts Climate Change Clearinghouse. http://www.resilientma.org/changes/rising-temperatures

19

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CHANGES IN PRECIPITATION

MORE **INTENSE & FREQUENT** EXTREME RAIN EVENTS

PRECIPITATION DURING **HEAVY EVENTS** IN THE NORTHEAST **INCREASED BY MORE THAN 70%** BETWEEN 1958-2010

Massachusetts Executive Office of Energy & Environmental Affairs. 2019. "Changes in Precipitation." Massachusetts Climate Change Clearinghouse. Resilientma.org/changes/changes-in-precipitation

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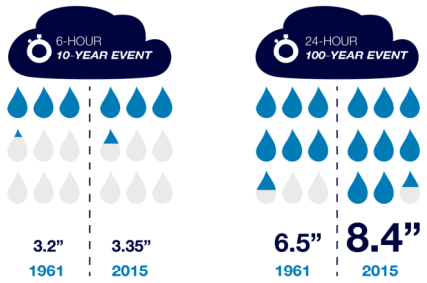
20

CHANGES IN **PRECIPITATION**



21

EXTREME PRECIPITATION

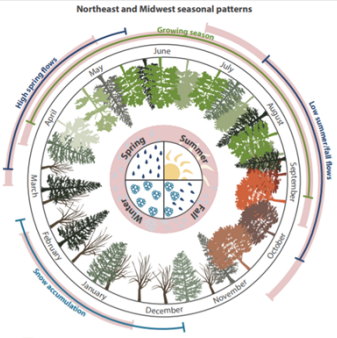
8%

Increase in extreme precipitation events by midcentury

13%

Increase in extreme precipitation events by 2100

22



2016

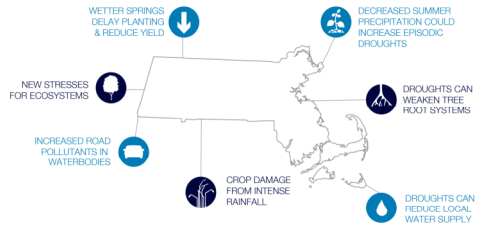
The most notable recent drought event was in

The occurrence of droughts **lasting 1 to 3 months** could go up by as much as **75% over existing conditions** by the end of the century, under the high emissions scenario

23

IMPACTS OF CHANGING **PRECIPITATION**

HIGHER AVERAGE ANNUAL PRECIPITATION
INCREASED BY ABOUT 10% IN THE NORTHEAST INTHE LAST 50 YEARS



24

WINTER STORMS

The blizzard of 2013 left nearly **400,000 Massachusetts residents without power**

"Heavy blizzards are among the **most costly and disruptive** weather events for Massachusetts communities."

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FLOODING

ZONE	ANNUAL CHANCE	FLOODPLAIN
A, AE, A1-A30	1% ANNUAL CHANCE	100-YEAR FLOODPLAIN
X	0.2% ANNUAL CHANCE	500-YEAR FLOODPLAIN

"By 2050, Boston could experience the current 100- year riverine flood every two to three years on average"

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Flood Prone Areas

Access road to the Tyngsborough Elementary School

Route 113 near Vesper Country Club

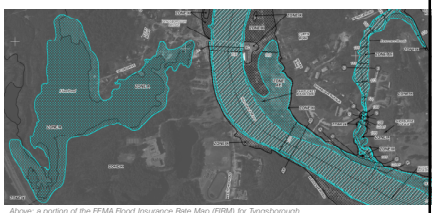
Vicinity of Bridgeview Circle

Riverbend Road

River Road

Red Gate Road

Larson Avenue



Above: a portion of the FEMA Flood Insurance Rate Map (FIRM) for Tyngsborough

REPETITIVE FLOOD LOSS STRUCTURES

- Defined as an NFIP-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978.[1]
- Tyngsborough has **8** repetitive loss structures. All are residential structures.[2]
- As of May 2013, the NFIP paid out **$2,129,486** for **16 claims.**[2]

[1] Federal Emergency Management Agency (FEMA). 2019. "Definitions." Accessed August 29, 2019. fema.gov/national-flood-insurance-program/definitions#R
[2] Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 158.

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STORMWATER FLOODING

Areas with:

- Poor drainage
- High amounts of impervious surface
- Undersized culverts

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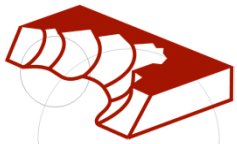
EROSION

Caused by riverine flow & stormwater

Increased precipitation, including winter rains, could increase erosion

Drier soils will reduce resistance to erosion



(Source: MA Climate Change Adaptation Report, 2011)

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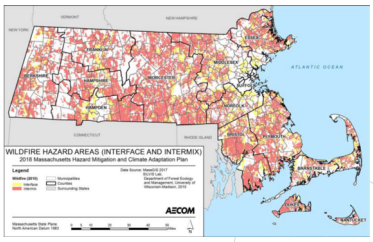
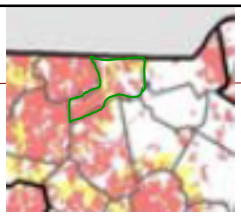
30

WILDFIRE





206

brush fires were reported in the Town of Tyngsborough over a 3-year period .

31

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HURRICANES AND EARTHQUAKES

HURRICANE

Irene

was the most recently identified hurricane according the last HMP

Upward trend in North Atlantic hurricane activity since 1970

Nor'easters along the Atlantic coast are increasing in frequency and intensity

EARTHQUAKE

30-40

Earthquakes occur in New England each year, although most are not felt.

Source: Climate Science Special Report, Fourth National Climate Assessment (NCA4). Volume prepared by the U.S. Global Change Research Program (USGCRP)Northern Middlesex Council of Governments 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 159-160.

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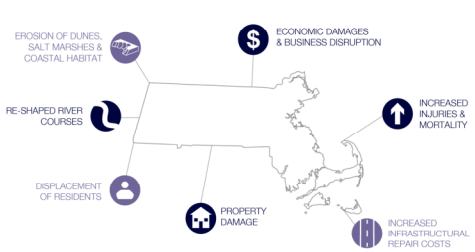
IMPACTS OF EXTREME WEATHER

STORMS ARE BECOMING MORE INTENSE AND DAMAGING



Massachusetts Executive Office of Energy & Environmental Affairs. 2019. "Extreme Weather." Massachusetts Climate Change Clearinghouse. http://www.resilientma.org/changes/extreme-weather

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HAZARD POTENTIAL OF DAMS

Table 58: Hazard Classification of Tyngsborough Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Lower Flint Pond Dam	Lower Flint Pond	Low	450	10/13/2007	10/13/2012
Locust Pond Dam	Locust Pond	Significant	100	NA	NA
Masquppic Lake Dam	Masquppic Lake	Non-jurisdictional	NA	NA	NA
Upper Flint Pond Dam	Upper Flint Pond	Significant	0	10/13/07	10/13/2012
Cow Pond Brook Dam	Cow Pond Brook	Significant	100	6/26/2007	6/26/2012

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety

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As an FYI: Boston Sea Level Rise Projections (ft)

Increased coastal flooding

Permanently inundated low-lying coastal areas

Increased shoreline erosion

Emission Scenario	2030	2050	2070	2100
Intermediate	0.7	1.4	2.3	4.0
Intermediate-High	0.8	1.7	2.9	5.0
High	1.2	2.4	4.2	7.6
Extreme	1.4	3.1	5.4	10.2

(Source: Northeast Climate Adaption Science Center)

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RISK MATRIX

Photo: March 2018 snowstorm. Photo by the Town of Tyngsborough, Twitter, 2018.

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RISK MATRIX

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Top Priority Hazards					Priority H-M-L	Time Short Long Ongoing
Infrastructural										
Societal										
Environmental										

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RISK MATRIX: HAZARDS

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Priority H-M-L	Time Short Long Ongoing
Infrastructural					
Societal					
Environmental					

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RISK MATRIX: HAZARDS

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

				Priority H-M-L	Time Short Long Ongoing

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IDENTIFY HAZARDS

Photo: Snowstorm. Photo by the Town of Tyngsborough, Twitter, 2017.

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Hazards in Tyngsborough

Hazard	Frequency- (Weight factor 2)	Severity- (Weight factor 5)	Extent of Impact – (Weight factor=10)	Probability- (weight factor 7)	Total Score
Flood	3x2=6	1x5=5	3x10=30	3x7=21	62
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	52
Urban Fire	1x2=2	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	2x2=4	1x5=5	2x10=20	2x7=14	43

Source: Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 156.

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HAZARD FOCUS FOR TODAY

CHOOSE 4 FOR THE MVP ACTION PLAN

Recommended by Core Team and Hazard Profiles

Extreme Temperatures and Drought

Severe Thunderstorms, Wind, Tornado

Wildfires, Urban Fires

Nor'easters, Ice Storm, Severe Snow Storm

Flooding

Hurricanes

Source: Northern Middlesex Council of Governments, 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 156.

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15 MINUTE BREAK!

Photo: Crash on Chestnut Road during December 2017 Snowstorm. Photo by Tyngsborough Police Department, Twitter, 2017.

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RISK MATRIX: FEATURES

Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.com

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Features	Location	Ownership	V or S	Priority	Time (Short, Long, Ongoing)
Infrastructural					
Societal					
Environmental					

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44

RISK MATRIX: FEATURES

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Features	Location	Ownership	V or S
Infrastructural			
Societal			
Environmental			

45

45

RISK MATRIX: FEATURES

FEATURES	LOCATION	OWNERSHIP	VULNERABILITY OR STRENGTH
Infrastructural	Town wide	State	Vulnerability
Societal	Multi- vs. Single-neighborhood	Town	Strength
Environmental	Specific location	Private	Both
		Shared	

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FEATURES IN TYNGSBOROUGH

Photo: Memorial Day Parade. Photo by the Tyngsborough Police Department Twitter, 2019.

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INFRASTRUCTURAL FEATURES

Police Department

Photo by the Tyngsborough Police Department

Fire Department

Photo by the Tyngsborough Fire Department

Wastewater Treatment & Collection

Dams

Lake Mascopic. Photo by the Town of Tyngsborough.

Roadways

Photo by the Town of Tyngsborough

Water Supply

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INFRASTRUCTURAL FEATURES

30% of the Town is serviced by public drinking water

70% is served by on-site private wells

3 *water districts that operate*

5 *distribution systems which access various supply sources in neighboring communities*

40% of the Town is covered by the public sewer system

60% of the Town is supported by on-site septic systems

Source: Northern Middlesex Council of Governments, 2018, "Hazard Mitigation Plan for the Northern Middlesex Region," 154. Sewer Administrator

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INFRASTRUCTURAL FEATURES

CRITICAL FACILITIES

Table 56: Emergency Operations Center, Health Care Facilities and Shelters – Tyngsborough

Facility Types	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Centers	Fire Station (Primary)	26 Kendall Road				No	Yes
	Police Station (Alternate)	20 Westford Road				No	Yes
	Town Hall (Alternate)	25 Dayants Lane				No	Yes
Health and Medical Facilities	None						
Shelters	Tyngsborough High School	50 Norris Road			100	Yes	Yes
	Tyngsborough Elementary School	205 Westford Road			100	Yes	Yes
	Greater Lowell Vocational High School	250 Pawtucket Boulevard			300	Yes	Yes

Source: Northern Middlesex Council of Governments, 2015, "Hazard Mitigation Plan for the Northern Middlesex Region," 155.

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SOCIETAL FEATURES

Population	
2010: 11,287 residents	
2018: 12,418 residents	
Age	
Under 18 years: 21%	
65+ years: 9.8%	
Education	
Bachelor's degree or higher: 45.8%	
Additional Information	
Median household income: $101,303	
Persons in poverty: 7.1%	
With a disability: 6.5%	
Language other than English spoken at home: 11.6%	

Source: U.S. Census Bureau, 2019

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SOCIETAL FEATURES

SCHOOL SYSTEM

- 2,300 students are enrolled in the public school system
- Public school system includes **3** elementary schools and **1** junior/senior high school
- Other schools include:
  - Greater Lowell Technical High School
  - Academy of Notre Dame
  - Innovation Academy

Source: Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 154.

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SOCIETAL FEATURES

66 public safety personnel, including:

23 uniformed police officers

40 on-call fire fighters

Source: Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 155.

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ENVIRONMENTAL FEATURES

Forest

Trails

Perennial Streams in Tyngsborough[1]

- Bridge Meadow Brook
- Lawrence Brook
- Limit Brook
- Scarlett Brook
- Locus Brook

1. Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 157.

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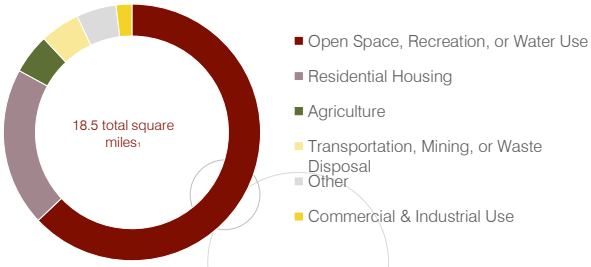
Tyngsborough's Land Use



Weston & Sampson

1. Northern Middlesex Council of Governments. 2015. "Hazard Mitigation Plan for the Northern Middlesex Region." 154.

55

55

LUNCH

Photo: Town Beach at Lake Mascuppic. Photo by the Town of Tyngsborough. 2017. Twitter.

56

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ADAPTATION STRATEGIES

Photo: Conditions on Westford Road during a March 2018 snowstorm. Photo by the Town of Tyngsborough. Twitter. 2018.

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EXISTING HAZARD PROTECTION

- Maintained compliance with the National Flood Insurance Program
- Enforced the town's floodplain bylaw
- Enforced the erosion control and stormwater management standards with the town's subdivision regulations
- Implemented BMPs within the town's Stormwater Management Plan
- Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act
- Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)
- Enforced the town's Stormwater Management Bylaw
- Rehabilitation of the Tyngsborough Bridge
- Drainage work completed through the Pawtucket Blvd
- Participated in conversations with private dam owners to check on the status of Dam Safety Orders
- Tree removal for electric reliability-Implemented in Winter 2012-2013 –hazard trees are inspected and removed
- Procured a Portable 100kVA Backup Generator for Sewer Pump stations
- Implemented CodeRED emergency notification system
- Amended the floodplain bylaw in May 2012 to satisfy 44 CFR, Section 60.3
- Open Space Plan Update
- I/I Study
- Culvert replacements

Weston & Sampson Source:

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COMMUNITY ACTIONS

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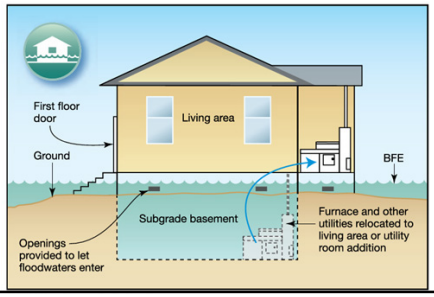
WET FLOODPROOFING



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RAISED BUILDINGS

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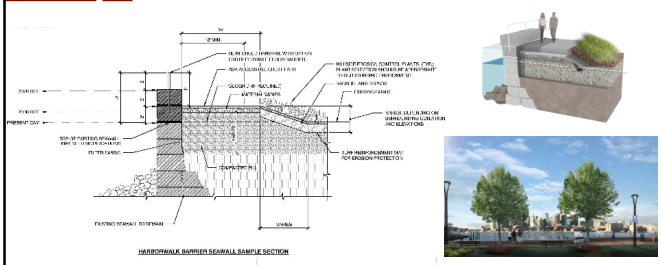
FLOOD WALLS



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DEPLOYABLE FLOOD BARRIER

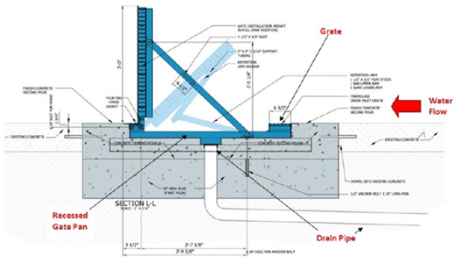

FIGURE 1 | A FloodBreak barrier gate diagram

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PREVENTING SEWER BACKFLOW

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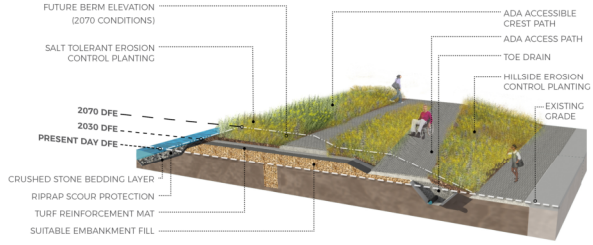
VEGETATED BERM



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65

MULTI-PURPOSE FLOOD STORAGE

66

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LOW IMPACT DEVELOPMENT (LID)

67

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POROUS ASPHALT & PERMEABLE PAVERS

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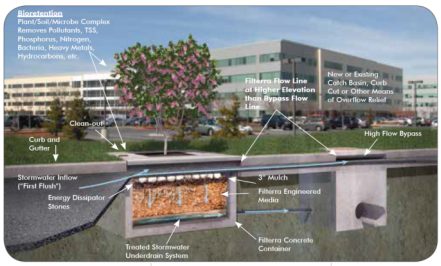
STREET TREES & TREE BOX FILTERS



69

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STREET TREES & TREE BOX FILTERS

Rain Garden in a median strip of a townhouse project. Please note the depressed curb and grate inlet structure

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STORMWATER DETENTION & RETENTION

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CULVERT WIDENING TO IMPROVE HABITAT & FLOW

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CLOUDBURST STREETS

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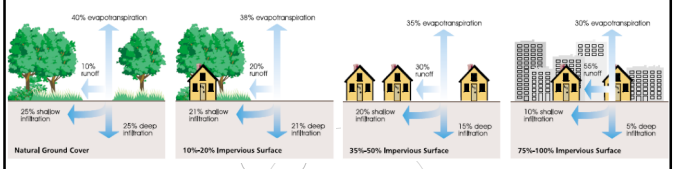
REDUCE IMPERVIOUS AREAS



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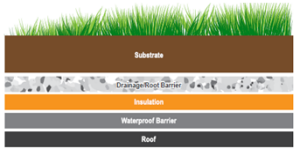
GREEN ROOFS



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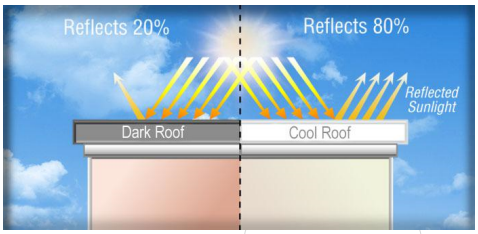
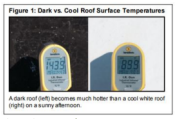
COOL ROOFS



Source: Heat Island Group at Lawrence Berkeley National Laboratory



A dark roof (left) becomes much hotter than a cool white roof (right) on a sunny afternoon.

Source: U.S. Department of Energy Guidelines for Selecting Cool Roofs

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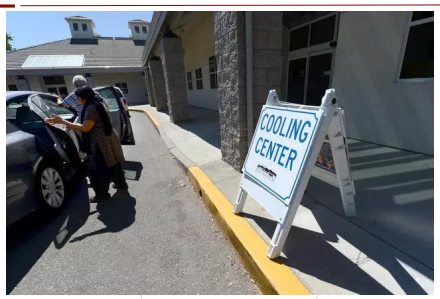
COOLING CENTERS



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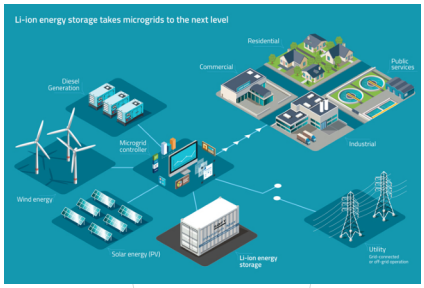
RENEWABLE MICRO-GRIDS



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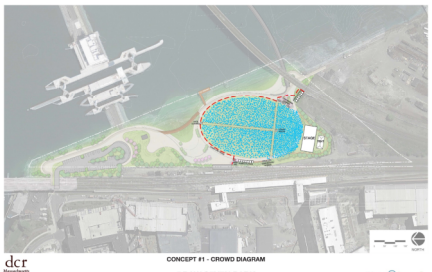
LANDSCAPE DESIGN TO ACCOMMODATE WATER



CONCEPT #1 - CROWD DIAGRAM

DRAW SEVEN PARK

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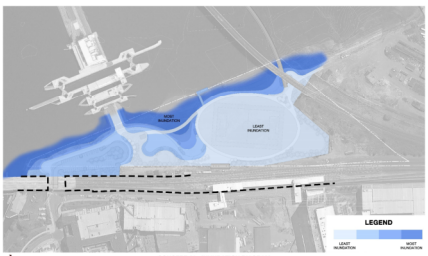
LANDSCAPE DESIGN TO ACCOMMODATE WATER



CONCEPT #1 - INUNDATION DIAGRAM

DRAW SEVEN PARK

80

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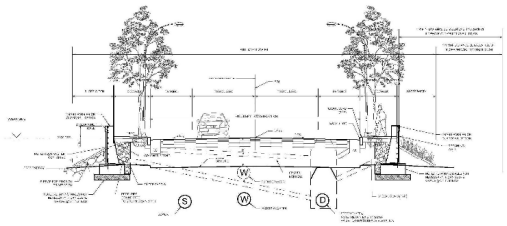
RAISED ROADWAYS



SAMPLE SECTION

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RETROFITTED FLOODPROOF DOORWAYS

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RE-EVALUATE LOCAL REGULATIONS & POLICIES

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15 MINUTE BREAK!

Photo: Tree down on Willowdale and Westland Road. Photo by the Town of Tyngsborough, 2017, Twitter.

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DEFINE COMMUNITY ACTIONS

Photo: Tyngsborough Council on Aging (169 Westford Road). Photo by the Tyngsborough Police Department, Twitter, 2017.

85

IDENTIFY PRIORITY ACTIONS

Photo: Police cars on Westford Road. Photo by the Town of Tyngsborough, 2017, Twitter.

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WRAP-UP & CLOSING REMARKS

Photo: Traffic light out at the intersection of Westford/Swan Road and Old Bone Hill. Photo by the Town of Tyngsborough, 2017, Twitter.

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Stakeholders Invited to Attend Tyngsborough's Community Resilience Building Workshop

Attend ?	Name	Title	Affiliation
√	Eric Salerno	Town Planner	Town of Tyngsborough
√	Danielle Mucciarone	Conservation Director	Town of Tyngsborough
√	Justin Sultzbach	Assistant Town Administrator	Town of Tyngsborough
	Matt Hanson	Town Administrator	Town of Tyngsborough
√	Wes Russell	Fire Chief and Emergency Management Director	Town of Tyngsborough
	Pat Sands	Assistant Fire Chief	Town of Tyngsborough
	Richard D. Howe	Police Chief	Town of Tyngsborough
√	Kathy Cayer	Sewer Administrator	Town of Tyngsborough
√	Kerri Oun	Health Agent	Town of Tyngsborough
√	Jim Hustins	Highway Lead Foreman	Town of Tyngsborough
√	Paul Provencher	Senior Sewer Foreman	Town of Tyngsborough
√	Jake Zwicker	Town Engineer	Town of Tyngsborough
	Hillari Wennerstrom	Elected Board Member, Chair	Board of Selectmen
	David Robson	Elected Board Member, Vice-Chair	Board of Selectmen
	Richard Reault	Elected Board Member, Clerk	Board of Selectmen
	Steven Nocco	Elected Board Member	Board of Selectmen
√	Ronald Keohane	Elected Board Member	Board of Selectmen
	Steve Brogan	Media Director	Town of Tyngsborough
	Paul Winchester	Commission on Disability, Chair	Town of Tyngsborough
	Brian Martin	Conservation Commission, Chair	Town of Tyngsborough
	Chaz Doughty	Conservation Commission, Planning Board, Master Plan	Town of Tyngsborough
	Mary Jo Tatseos	Council on Aging, Chair	Town of Tyngsborough
√	Dale Thompson	Water District Superintendent	Tyngsborough Water District
	Warren Allgrove	Historical Commission, Chair	Town of Tyngsborough
	Warren Allgrove	Master Planning Committee	Town of Tyngsborough
	Kimberly O'Brien	Planning Board, Chair	Town of Tyngsborough
	Adriana Gioumbakis	Zoning Board of Appeals, Chair	Town of Tyngsborough
	Anthony Tinnirella/Rob Mullin	Capital Asset Management Committee, School Committee	Town of Tyngsborough
√	Billy Crawford	Finance Committee, Chair	Town of Tyngsborough
√	Liz Antanavica	Sustainability Committee, Chair	Town of Tyngsborough
	Michael Cassella	Assistant Emergency Management Director	Town of Tyngsborough

√	Paul Welcome	Building Commissioner	Town of Tyngsborough
	Alison Page	Recreation Director	Town of Tyngsborough
	Dave Robson Sr.	Animal Control Officer, Planning Board	Town of Tyngsborough
	Michael Flanagan	Superintendent of Schools	Tyngsborough Public Schools
	Barbara Roche	Senior Center Director	Tyngsborough Senior Center
√	Steve Coughlin		Tyngsborough Public Schools
	Chris Dery	Veteran's Agent	Tyngsborough Office of Veteran Services
	Melinda Theide	Housing Authority Executive Director	Tyngsborough Housing Authority
			Tyngsborough-Dunstable Historical Society
√	Sue Arthur	Library Director	Tyngsborough Public Library
	Greg Orpen	Head of School	Innovation Academy Charter School
	John O'Brien	President	Notre Dame Academy School
	Dr. Vittoria Pacifico	Head of School	Notre Dame Academy School
	Sheila Perrault	Board of Health Chair	Town of Tyngsborough
√	Chad Graves		Innovation Academy Charter School
	Susan Silvia		Highway Division
	Dean Tran	State Senator, Worcester and Middlesex	Massachusetts Senate
	Mary Gail	Legislative Aid	Representative Garry
	Lori Trahan	Congresswoman, 3rd District	US House of Representatives
	Colleen Garry	State Representative, 36th Middlesex District	Massachusetts House of Representatives
	Eileen Duff	Governor's Councilor, District 5	MA Governor's Council
	Elise Simons	Environmental Planner	U.S. Environmental Protection Agency
	Katelyn Rainville	Representative	Army Corps of Engineers
	Eric Worrall	Northeast Regional Director	MA Department of Environmental Protection
	Priscilla Geigis or Dan Driscoll	Deputy Commissioner for Conservation and Resource Stewardship	DCR
	Sarah White	Hazard Mitigation Unit Supervisor	MEMA
	Jeff Zukowski	Hazard Mitigation Planner	MEMA

	John Macone	Interim Director, Outreach Specialist	Merrimack River Watershed Council
	Ray Stinson	District 4, Middlesex County Contact	MassDOT
	Cecelia Lynch	VP of Patient Care Services	Lowell General
	Melissa Owens	National Grid Gas District 4 Contact (as of 2018)	National Grid
	Sandra Annis	National Grid Electric District 4 Contact (as of 2018)	National Grid
√	Susan Griffin		National Grid
√	Alicia Geilen	Environmental Planner	Northern Middlesex Council of Governments
	Jay Reynolds	Sewer Superintendent	Town of Dracut
	Betsy Ware	Director of Community Development	Town of Dracut
	Gary Persichetti	Director of Public Works	Town of Chelmsford
	Steve Jahnle	Asst. Dir. Of Public Works	Town of Chelmsford
	Evan Belansky	Community Development Director	Town of Chelmsford
	Mark Young	Lowell Water Executive Director	City of Lowell
	Mike Stuer	Lowell Water Engineering Manager	City of Lowell
	George Rose or Paul Lachance	Dep. Directors of Emergency Management	City of Lowell
	Rebecca Cheney	Town Planner	Town of Westford
	Jake Voelker	Assistant Town Administrator	Town of Dunstable
	Justin Kates	Director of Emergency Management	City of Nashua, NH
	Steve Malizia	Town Administrator	Town of Hudson, NH
	Brian Groth	Town Planner	Town of Hudson, NH
	Jess Forrence	Public Works Director	Town of Hudson, NH
√	Michelle Rowden	MVP Program Regional Coordinator	EEA

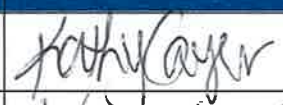
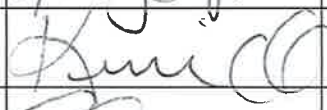
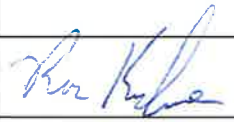
√ indicates invitee also attended the Workshop

Municipal Vulnerability Preparedness Planning Grant Project
Wednesday, October 30th, 8:30-4:30

Name	Title	Organization	Email	Signature	Table
Adria Boynton	Architect	Weston & Sampson	BoyntonA@wseinc.cpm		
Alicia Geilen	Environmental Planner	Northern Middlesex Council of Governments	ageilen@nmcog.org		2
Alison Page	Recreation Director	Town of Tyngsborough	apage@tyngsboroughma.gov		3
Amanda Kohn	Sustainability Planner II	Weston & Sampson	Kohn.Amanda@wseinc.com		
Billy Crawford	Finance Committee, Chair	Town of Tyngsborough	massatusets@live.com		3
Chad Graves		Innovation Academy Charter School	cgraves@innovationcharter.org		2
Dale Thompson	Water District Superintendent	Tyngsborough Water District	info@tyngsboroughwater.org		1
Danielle Mucciarone	Conservation Director	Town of Tyngsborough	dmucciarone@tyngsboroughma.gov		1
Deanna Lambert	Engineer	Weston & Sampson	LambertD@wseinc.com		
Eric Salerno	Town Planner	Town of Tyngsborough	esalerno@tyngsboroughma.gov		1
Jake Zwicker	Town Engineer	Town of Tyngsborough	jzwicker@tyngsboroughma.gov		3
Jeff		MEMA			3
Jim Hustins	Highway Lead Foreman	Town of Tyngsborough	jhustins@tyngsboroughma.gov		3
Justin Sultzbach	Assistant Town Administrator	Town of Tyngsborough	jsultzbach@tyngsboroughma.gov		3

Weston & Sampson

Municipal Vulnerability Preparedness Planning Grant Project
Wednesday, October 30th, 8:30-4:30

Name	Title	Organization	Email	Signature	
Kathy Cayer	Sewer Administrator	Town of Tyngsborough	kcayer@tyngsboroughma.gov		1
Kerri Oun	Health Agent	Town of Tyngsborough	koun@tyngsboroughma.gov		2
Liz Antanavica	Sustainability Committee, Chair	Town of Tyngsborough	eantanavica@gmail.com		2
Lydia Kifner	Engineer	Weston & Sampson	kifnerl@wseinc.com		
Mary Gail	Legislative Aid	Representative Garry			2
Matt Hanson	Town Administrator	Town of Tyngsborough	mhanson@tyngsboroughma.gov		2
Pat Sands	Assistant Fire Chief	Town of Tyngsborough	psands@tyngsboroughma.gov		1
Paul Provencher	Senior Sewer Foreman	Town of Tyngsborough	pprovencher@tyngsboroughma.gov		1
Paul Winchester	Commission on Disability, Chair	Town of Tyngsborough	ada@tyngsboroughma.gov		2
Richard D. Howe	Police Chief	Town of Tyngsborough	rhowe@tyngsboroughma.gov		3
Ronald Keohane	Elected Board Member	Board of Selectmen	rkeohane@tyngsboroughma.gov		1
Steve Brogan	Media Director	Town of Tyngsborough	sbrogan@tyngsboroughma.gov	NOT AVAILABLE	3
Sue Arthur	Library Director	Tyngsborough Public Library	sarthur@tynglib.org		2
Susan Silvia		Highway Division	ssilvia@tyngsboroughma.gov		1

Municipal Vulnerability Preparedness Planning Grant Project
Wednesday, October 30th, 8:30-4:30

Name	Title	Organization	Email	Signature	
Wes Russell	Fire Chief and Emergency Management Director	Town of Tyngsborough	wrussell@tyngsboroughma.gov		2
Steve Coughlan	TPS Building Grounds	Tyngsborough Public Schools	stephen.coughlan@tyngsboroughps.org		2
Paul Welcome		Town			1
Michelle Lewis	EEA				
Susan Griffin	NGRID				3

Weston & Sampson

Tyngsborough MVP Stakeholder Workshop Notes
October 30, 2019

Opening Remarks from Michelle, EEA:

- Think about long-term goals
- Keep your perspective broad and diverse
- You're here to look at future conditions
- Think big, everything goes on the table
- Examples of similar towns' action grant projects include:
    - Detailed risk assessments
    - Culvert work: assessing locations of undersized culverts, and assessing how much larger the culverts should be
    - Updating bylaws and zoning ordinances to integrate resilience

Participant Introductions: Favorite Aspects of Tyngsborough

- Small community
- Short commuter
- Working with the community
- Unique challenges presented by the river running through the middle of town
- Water resources in town, including the river and ponds
- Green spaces, open spaces
- Community groups and volunteers
- People support each other
- Town staff is committed
- The river is a beautiful background to the Town
- Residents are proud of, and committed to, the Town
- Small town atmosphere
- The new Sustainability Committee
- Tyngsborough is the little engine that could. Everyone chips in.

Workshop Attendees' Comments on Climate Hazards and Adaptation Actions:

- Tyngsborough has so many trees
    - They're a vulnerability and a strength
    - It's important to maintain the trees and plant hardy species
    - Trees can soak up stormwater and mitigate the urban heat island effect
- The Northern Middlesex Council of Governments (NMCOG) drafted a tree retention bylaw for the Town, to encourage the retention of trees on the sites of new development
- Forestry management principles: there are grants that the town could apply for
- Invasive species on Town-owned properties: a possible action could be an invasive species removal plan
- CPC and CPA funding from the State has reportedly been reduced over time
- Question: do outside agencies like the National Grid get involved?
  Answer: Susan is a National Grid attendee today

- Senate Bill 10 will setup funding for MVP, the Greenhouse Gas group, and to implement actions in the SHMCAP. This bill will unlink the funding from the fiscal year and make the funding more certain, because it won't have to be approved each year.
- The proposed excise tax on the sale of properties would be a sustainable funding source.
    - The CPA fund was also reportedly an excise tax
- Comment: you can include assessments, studies, and inventories as proposed action items. You don't need to have all the answers today

Overview from Susan, National Grid:

- National Grid manages electric and natural gas
- Climate change is an accepted fact within the organization. Employees are first responders.
- They're seeing storms that are more intense for shorter periods of time, like microbursts that last 12 hours but cause damage that takes 3 days to restore.
- They're doing a hazard mitigation tree program: removing trees threatening the grid
- In Tyngsborough, the power comes from Westford and Chelmsford stations
- National Grid is investing millions in tree management
    - There are some conflicts because communities consider tree lined streets to be part of their landscape
    - National Grid says that power lines and forests can't cohabitate
- National Grid is spending $3.5 million on tree trimming
- "Ground to Sky" pilot program involves removing trees in Westford
- National Grid is spending $2 million on storm hardening, which includes installing taller, fatter poles
- Question: are underground lines possible?
    - Answer: dry trees can cause fires. PG&E is shutting off the entire grid during outages. During outages, National Grid considers life support customers (including hospice care and critical facilities that are increasingly in residential areas)
    - Focused on storm hardening, redundancy, and the resilience of the grid
    - Linemen/women need to get down a manhole to service underground wires (so those wires can't be put down the middle of a roadway). They can't be installed along the side of the road either because that's where the trees are
    - Moving wires underground is cost prohibitive
- Question: if electric wires are moved underground, is there an advantage to working with the company that deals with both gas and electric lines? Because gas lines are already underground?
    - Answer: They're two different parts of the organization. We don't share information.
- The MassSurcharge program can affix additional costs to utility bills, which funds moving utilities underground. Chelmsford is participating.
- Question: Maybe in the short-term, you have to cut down trees to move lines underground. But after doing so, you can replant. Currently, when National Grid clear-cuts trees 10 feet around their poles, they don't re-plant and we get ponding in those areas because the vegetation is removed.
    - Answer: undergrounding would increase rates across communities, which would impact low income areas disproportionally

- The MVP program favors collaborations between communities and organizations. It may be possible for Tyngsborough to work with Susan on a tree management plan

Selection of Four Climate Hazards:

- The Core Team recommended three hazards
- Comment: historically, those three hazards cause the most significant impacts
- Hurricanes are not a problem here
- The Town has more brush fires now than 20 years ago. Hotter, drier summers and falls will have an impact
- There are complaints about downed trees after wind storms
- There is concern over viruses, ticks (EEE, etc.).
- Wildlife is a feature of Tyngsborough
- Final four hazards chosen:
    - Extreme temperatures and drought
    - Nor'easters, ice storms, severe snow storms
    - Flooding
    - Severe thunderstorms, wind, tornado, hurricanes

Post-Lunch Report-Out about Priority Features:

- Table 3: utilities, elderly residents, and regulations
- Table 1: roadways and stormwater, the river, utilities, lakes/ponds/associations
- Table 2: insects/invasives, public safety infrastructure, utilities, stormwater infrastructure

Closing Thoughts from Participants:

- It was surprising to learn that the senior center doesn't have a generator, and that there's no plan to deliver water to people with private wells during droughts
- This process was helpful to organize thoughts and priorities

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Nor'easter, Snowstorm, Icestorm	Extreme temperatures and drought	Flooding	Wind, Hurricane, Tornado	Priority H - M - L	Time S Short L Long O Ongoing
Infrastructural									
Roadways/ Stormwater	townwide	state/town	S	Increase personell, equipment for snow equipment, Update & adhereing procedures snow removal in extreme events	infastructure assessment for cracks	sizing culverts, infastructure assessment & prioritize Dunstable Rd mitigation oppurtunity stormwater utility	culvert cleaning after wind storm- staff & maintenance, hazrd tree removal, already done could do more	H	O
Water- Utility	N. Chelmsford 1/3 Tyngsborough 1/3 Dracut 1/3	private	B	Have generators at all pump stations	already have regulations for water use during drought well for water use during during drought well for water dept use would generate more water, would have to purchase less			L	O
Sewer - Regional and local	40% town	town	S	already do emergency maintenance	all pump stations have backup generators	continued maintenance of sewer system almost done w/ II (survey of system), no issues w/flooding (100 yr flood 2006)		L	O
Muncipal buildings	town center	town	S	backup generators, more hazard snow removal	update cooling town hall, more maintenance of cooling & heating systems			M	S
Bridges (3 Locations)	town center	state	B	secondary evacuation route, second bridge?		Kendall Rd bridge susceptable to flooding, finish dam reconstruction		L	L
Utilities	throughout	natgrid	V	Continue to increase communication b/w utilities & town , backup generators for critical facilities (senior centers, schools have, pump stations have)	redundant energy (renewable) sytems for brwon ous, power outages		hazard tree removal	H	O
Societal									
Municipal Serivces (Library, Veterans, Town Hall)	specific	town	S	increase staff in emergency shelters				M	O
Schools/Daycare	town wide	town, regoinal, private	B	backup generators, school emergency center	heating & cooling assessment needed			H	O
Senior Center/Council on Aging	specific	town, regoinal, private	B	backup generator, formalize wellness check	senior center cooling already	Westford Rd culvert needs to be repaired for critical access for senior center		H	S
Commercial Disrict - Middle Road	specific	private	S			elevated RR tracks exist , work w/ state for stromwater assessment (State Rd), retrofits for stormwater	hazard tree removal	L	O
Places of Worship	townwide	private	S			retrofits for stormwater		L	O
Historic Buildings	town center	town	B			upkeep & maintenance of buildings, unkeep & maintenance of dams		M	O
Environmental									
Recreation sites	townwide	town	S/B			retrofit recreational spaces near river to store water		M	L
Open space	townwide	state/town	S/B	Forest management plan, stewardship, maintenance	Forest management plan, stewardship, maintenance	Riverfront park -> use of green infastructure for flood storage, flood mitigation plans for high risk areas, retrofit recreational spaces near river to store water	retrofit recreational spaces near river to store water	M	S/L
River	townwide	state	B		Dam ccontrols river level	water quality & health, dam control of flooding, inspect/ clean culverts, CB street sweeping		H	O
Lakes, ponds, associations	townwide	state?	B		look into treatments for bacteria/algae/invasives	bylaw for controlling where sump pumps go around water bodies		H	O
Animals & plants, trees, invasive	townwide	-	B	true inventory	invasive management plan			M	O
Private wells	townwide	private	V		longterm expnad town water, water resource for dry well residents			M	S

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Nor'easters/ Ice storms/ Severe Snow Storms	Flooding (including rivers & stormwater)	Extreme Temperatures/ Drought	Severe Thunder Storms/ Wind/ Tornados/ Hurricanes	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Waste Management	Middlesex & Kendall	Private/State	Both	ID Yard Waste location & process	Waste reduction plan (composting)	-	ID yard waste location of process	L	M-L
Tyngsboro Bridge	Throughout	MassDOT	Both	-	maintenance	-	maintain.	H	O
Power Supply Lines	Throughout	NGRID	Both	Educate people/ Institutions on haz. Trees near powerlines. Maintenance Plans- create, maintain	-	Update regs to require increased resilience in redevelopment	Educate people/ Institutions on haz. Trees near powerlines. Maintenance Plans- create, maintain	H	S-L
Roadways	Throughout	Private/Town/State	Both	Explore problem areas for ice (safety) & poor drainage	Beaver mgmt plans, consider road raising @ Westford Rd (culvert assess)	Update regs to require increased resilience in redevelopment, Power demand, micro grids, solar?		H	S-M
Stormwater Infrastructure **3**	Throughout	Private/Town/State	Both	Explore problem areas for ice (safety) & poor drainage	LID (rain gardens) Assess all culverts & prioritize assess flood risk @ critical infastructure and roadways	-	LID (rain gardens) Assess all culverts & prioritize assess flood risk @ critical infastructure and roadways	H	S-M
Public Water Availability	Throughout	Private/ Town	Both	Plan for private water resilience & water quality testing		ID high risk fire areas (access to water for fighting), free public water filling station	Plan for private water resilience & water quality testing	H	O
Dams	Throughout	Private/ State	Both		Maintain and Inspect			L	O
Communications/Public Safety Infastructure				Implement recommendation of study on public safety infastructure w/ public outreach & education, consider resident power at public safety complex				H	-
Community Spirit	Throughout	N/A	S	Assess using wonderful volunteers in emergency management auxiliary →				M	S
Schools/ Daycare Centers	Several	Private/Town/State	S/V	Educate in emegency response/ preparedness →				H	O
Limited Shopping Sources/ Urgent care	N/A	Private	V	Support economic development; make planning process easier, ID & eliminate barriers (regulatory) →				M	L
Elderly Population, Group Housing	Throughout	-	S/V	Educate in emegency response/ preparedness →				H	O
Farming	Throughout	-	V	Assess agricultural assistance - Disaster planning/ response, Support food production & availability →				M	L
Bordering City	East	Lowell	S	Mutual and public- private partenership →				L-M	O
Merrimac River	N/A	Public	S/V		Consider converting town properties into flood storage along river		Support CSO notification legislation (cross border)	M	L
Open Space	Throughout	Private/Public	S/V	Assess if town open spaces can also manage stormwater (rain garden) and compensatory floodplain storage →				H	S
Streams/ Wetlands/ Ponds	Throughout	Private/Public	S/V	Assess undersized culverts & prioritize upgrades, strengthen wetland protection bylaws →				H	S
Insects/ Invasive Plants/ Disease Vectors **1**	Throughout	N/A	V	Assess all town properties for invasive plants & insects & create plan to address.	Assess all town properties for invasive plants & insects & create plan to address	ID mosquito control issues and solutions, incentivise bat houses, public education	Assess all town properties for invasive plants & insects & create plan to address	H	S
HAZMATS/ Pollutants	RT3/Rail	?	V	Increase local capacity to respond to HAZMAT events & coord. Rail lines →				H	S
Landfill (superfund site)	Charles George	Fed.	V					-	-
Wild Life	Throughout	N/A	S/V		Beaver mgmt plans? WRT culverts & roadways	Education on living w/ wildlife, balance wildlife for vector control	Assess priority habitat to protect for wildlife	M	L

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V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Extreme Temperatures and Drought	Nor'Easters, Ice Storms, Severe Snow Storms	Flooding	Severe, Wind, Thunder Storms, Tornados, Hurricanes	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Red Gate Road & Dunstable Road Middlesex Road	Town-wide	Town & State	V/S		Thinning Trees Before Ice Storms	Beaver Management More Staff Culvert Widening- Inventory, MS4		M	O
Utilities & Stormwater	Town-wide	Varies	V/S	Wells: Water Restrictions for Watering Lawns	Clear Catch Basins- Outreach	Buy Land Upgrade Infastructure	Generators for Pump Stations Backflow Preventors	Varies	O
Buildings	Town-wide	Varies	V/S	Inc. Insulation, Cool Roofs, Improve Insulation and Energy Efficiency	Improve Insulation and Energy Efficiency	Inventory At-Risk Buildings		H	O
Council on Aging and Elementary School Shelters	Schools, Fire dept, council on aging	Town	V/S	Genrator at Council on aging		Diversify Locations (Outside Floodplain)	Assess Properties for Vulnerabilities	H	L
Bridge	Town Center	State	V/S				A New Bridge near Sullivan's Ice Cream or Widen Existing	L	L
Emergency Services	Town-wide	Town	S	Build updated public safety facilty satelite police station on east side of the river (and ambulance service)				M	O
Societal									
Elderly	Town-wide	N/A	V/S	Zoning to Encourage Living in Place			Expand Outreach Test Reverse 911 System, Expand Tranportation Service- Pilot Program	H	O
Non Profit Groups	Town-wide	N/A	S	Education About Risks and Programs Invite to Public Meetings		Inventory At-Risk Buildings		M	O
Youth and Youth Organizations	Town-wide	N/A	V/S	Get Girls Scout/Boy Scout/ Other Programs Involved in Adaption Actions High School & Middle School May Need Generators				H	O
Disabled & Veterans	Town-wide	N/A	V/S	Provide Transportation (with Sign-up in advance) Inventory ADA Accessible Buildings Options for Signage & Awareness				M	O
Environmental									
Open Space Frost Road Park	Town-wide	Private, Town, State	V/S	Preservation of Open Space Through CPC Funds & Preventing Development Buy Open Space	Preservation of Open Space Through CPC Funds & Preventing Development Buy Open Space	Preservation of Open Space Through CPC Funds & Preventing Development Buy Open Space	Preservation of Open Space Through CPC Funds & Preventing Development Buy Open Space	H	O
Trees	Town-wide	Varies	V/S	Tree Inventory Tree Farm to Replace Felled Trees Program to Plant and Maintain Trees	Tree Inventory Tree Farm to Replace Felled Trees Program to Plant and Maintain Trees		Assess Tree Removal Costs Arbor Day Events with Kids	M	O
Water Bodies	Town-wide	Varies	V/S			Assessment of Dams Regional Collaboration to Assess Design Strategies		M	O
Regulations Floodplain/Wetlands Bylaw	N/A	N/A	S	Water Usage Ban Bylaw Study Best Practices	Regulations-Review Bylaws For Snow Ice-Include Snow Removal			H	O
Water Supply	Varies	Varies	V/S	Water Ban, Enforcement Public Education-Signage				M	O
Community Programs (Including Youth Organizations)	N/A	N/A	S	Get Residents Involved in Adaptation Educate Residents- Videos	Adopt a Catch Basin			M	O

FIGURE 1

TOWN OF TYNGSBOROUGH, MASSACHU

MUNICIPAL VULNERABIL
PREPAREDNESS HAZAR
AND FEATURE MAP

OCTOBER 2019 SCALE: NO

Weston & Sampso

FIGURE 1

TOWN OF TYNGSBOROUGH, MASSACHUSETTS

MUNICIPAL VULNERABILITY PREPAREDNESS HAZARD AND FEATURE MAP

OCTOBER 2019

SCALE: NOTED

Weston & Sampson

FIGURE 1

TOWN OF TYNGSBOROUGH, MASSACHUSETTS

MUNICIPAL VULNERABILITY PREPAREDNESS HAZARD AND FEATURE MAP

OCTOBER 2019 SCALE: NOTED

Weston & Sampson


Legend
Bus Station
Daycares
Emergency Shelter
Fire Stations
Food/Grocery/Supply Stores
Gas Stations
Highway Department
Hospitals/Clinics
Hotels/Motels
Housing Authority Properties
National Grid Electric Switching Station
Nursing Home
Privately Owned Pump Station
Police Department
Public Library
Schools
Town Hall
Tyngsborough Water District Water Supply and Public Safety Communications Infrastructure
Underground Storage Tanks
Verizon Control Center
Water Tank
Powerline
Bridge
Conservation/Protected Land
Open Space
Landfill
Median Age 65+
Dams
Significant Hazard
N/A
FEMA National Flood Hazard Layer
1% Annual Chance of Flooding (Zones A, AE, AH, AO)
0.2% Annual Chance of Flooding
Waterways
Hydrologic Connection
Marsh/Bog/Wooded marsh
Open Water
Transportation
Evacuation Route
Roads Prone to Flooding
Railroads
MASSACHUSETTS
NEW HAMPSHIRE
DUNSTABLE
DRACUT
LOWELL
CHELMSFORD
WESTFORD
GROTON
0
0.25
0.5
0.75
1
Miles
FIGURE 1
TOWN OF TYNGSBOROUGH, MASSACHUSETTS
MUNICIPAL VULNERABILITY PREPAREDNESS HAZARD AND FEATURE MAP
OCTOBER 2019
SCALE: NOTED
Weston & Sampson

Additional Priority Actions from the Community Resilience Building Workshop

- Implement a waste reduction plan in Tyngsborough through composting. Update the cooling system in Town Hall and maintain the heating and cooling systems in all municipal buildings. Conduct a heating and cooling assessment in Tyngsborough Schools and Daycares.
- Invest in renewable energy systems to add redundancy to the power grid and prevent brown-outs and storm related power outages.
- Expand Town water resilience by developing own water source. Implement water restrictions for lawn watering and enforce water bans. Provide a water resource for residents on private wells in the event that their well goes dry. Update the public on water supply using signage.
- Continue maintenance of sewer system.
- Determine a secondary evacuation route, which may have to involve a secondary bridge.
- Investigate source of flooding on Kendall Rd and construct a solution.
- Dedicate more staff to culvert cleaning and maintenance after wind storms.
- Increase staff in emergency shelters. Assess using volunteers in emergency management auxiliary.
- Develop a Forest Management plan and continue maintenance and stewardship in the Town's forests. This could include a Tree Farm to replace felled trees. Plan Arbor Day events with schoolchildren.
- Develop a bylaw that regulates sump pump discharges near water bodies.
- Identify high risk fire areas and ensure that there is nearby access to water for firefighting.
- Support economic development and identify and eliminate barriers to food shopping sources and urgent medical care.
- Assess agricultural assistance, including disaster planning and response for local farms. Support local food production and availability.
- Work with neighboring cities and towns to form a mutually beneficial partnership.
- Strengthen wetlands protection bylaws.
- Support cross border combined sewer overflow legislation
- Identify mosquito control issues and solutions as well as increase public education on mosquito management.
- Incentivize bat houses.
- Assess priority habitat to protect wildlife and educate citizens on living with wildlife. Balance wildlife for vector control.
- Increase local capacity to respond to HAZMAT events and coordinate rail lines.
- Inventory at-risk buildings and properties for vulnerabilities, especially Council on Aging buildings and School shelters. Diversity Council on Aging and Emergency Shelter locations to outside of the floodplain.
- Improve building infrastructure including insulation, energy efficiency, and cool roofs.
- Widen existing bridge near Sullivan's Ice Cream or replace the existing one.
- Expand outreach to test Reverse 911 system
- Expand public transportation system in Tyngsborough. Provide transportation to disabled and veteran populations.
- Involve community programs, residents, and youth programs in climate adaptation. Educate these groups about climate risks and programs using videos and through public meetings. Start an "Adopt a Catch Basin" program.

- Develop zoning to encourage living in place for elderly populations.
- Develop beaver management plans
- Conduct a flora and fauna inventory and develop an invasive species management plan

Appendix C – Listening Session

ARE WE PREPARED?

LISTENING SESSION

WEDNESDAY

JAN 08

6:30-7:30PM

Help us plan for a future with a changing climate

town of tyngsborough massachusetts

Weston & Sampson
transform your environment

Library

Back Room

25 Bryant Lane

Tyngsborough, MA 01879

Municipal Vulnerability Preparedness Planning Grant and
Hazard Mitigation Planning Grant Update

Listening Session
Back Room of the Tyngsborough Public Library
Wednesday, January 8, 2020
6:30 pm – 7:30 pm

Introductions	3 minutes
Municipal Vulnerability Preparedness (MVP) Program Overview	7 minutes
Climate Change in Tyngsborough	7 minutes
Vulnerabilities in Tyngsborough	5 minutes
Strengths in Tyngsborough	5 minutes
Priorities in Tyngsborough	20 minutes
Resilient Master Plan Chapter Update	10 minutes
Wrap-up	3 minutes

TOWN OF TYNGSBOROUGH

Municipal Vulnerability Preparedness (MVP) Listening Session

Wednesday, January 8th, 2020

Photo: Lake Mascuppic. Photo by the Town of Tyngsborough, Twitter, 2017.

1

1

AGENDA

1. Municipal Vulnerability Preparedness (MVP) Program Overview
2. Climate change in Tyngsborough
3. Summary of Workshop
4. Resilient Master Plan Chapter Update
5. Next Steps

Photo: Old Town Hall. Photo by John Phelan, 2010.

4

WELCOME & INTRODUCTIONS

Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018.

2

2

MVP PROCESS

COMMUNITY RESILIENCE BUILDING WORKSHOP(S)

- Define and characterize hazards using latest science and data
- Identify existing and future community vulnerabilities and strengths
- Develop and prioritize community adaptation actions
- Determine overall priority actions
- Receive MVP designation

MVP Planning Grant

MVP Action Grant

Implement priority adaptation actions identified through planning process

5

5

WELCOME CORE TEAM

Eric Salerno	Patrick Sands
Danielle Mucciarone	Richard Howe
Justin Sultzbach	Kathy Cayer
Matt Hanson	Kerri Oun
Wes Russell	Jim Hustins

Photo: Town Meeting in the Town Hall Community Room. Photo by the Town of Tyngsborough, Twitter, 2018.

3

3

MVP ACTION GRANT PROJECT TYPES

- Detailed Vulnerability and Risk Assessment
- Community Outreach and Education
- Local Regulation and Bylaws Updates
- Redesigns and Retrofits
- Nature-Based Solutions
  - Flood Protection
  - Drought Mitigation
  - Water Quality and Water Infiltration Techniques
  - Reduce Vulnerability to Extreme Heat and Poor Air Quality
- Ecological Restoration and Habitat Management to Increase Resiliency
- Energy Resilience
- Chemical Safety
- Land Acquisition for Resilience
- Subsidized Low-Income Housing Resilience Strategies
- Mosquito Control Districts

6

6

MVP PLANNING GRANT COMPONENTS

HAZARD MITIGATION PLAN UPDATE

- Aligns with MVP Process
- Extended hazard profiles and vulnerability assessment
- Update to previous mitigation measures table

RESILIENCE MASTER PLAN CHAPTER

- Builds on HMP-MVP work
- Incorporates stormwater
- Develop alongside current master planning process

7

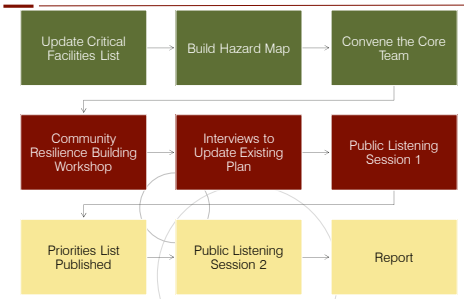
7

CLIMATE CHANGE IN TYNGSBOROUGH

Photo: Snowstorm. Photo by the Town of Tyngsborough, Twitter, 2017.

10

HMP-MVP PROCESS



8

8

What hazard most concerns you?

A. Nor'easters, Snowstorms, Ice
B. Extreme temperatures and Drought
C. Flooding
D. Wind, Hurricane, Tornado
E. Other

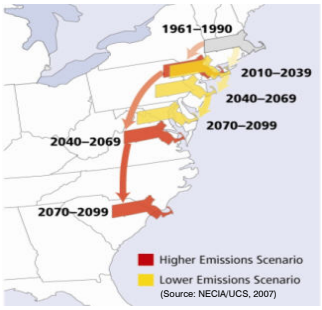
11

11

MASTER CHAPTER PROCESS

9

9



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12

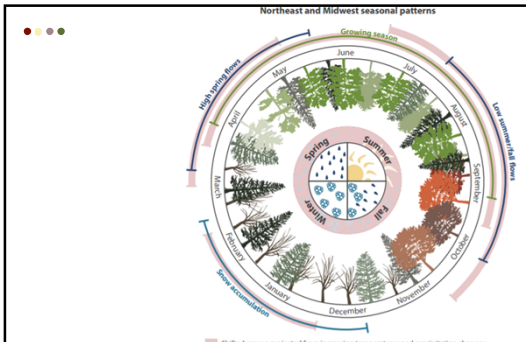
EXTREME TEMPERATURES

WARMER ANNUAL AIR TEMPERATURES
UP 0.5°F PER DECADE SINCE 1970, ON AVERAGE

WARMER WINTERS
UP 1.3°F PER DECADE SINCE 1970, ON AVERAGE

13

13



16

16

EXTREME TEMPERATURES IN MASSACHUSETTS

2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
6	24	35

DAYS WITH TEMPERATURES ABOVE 90°F

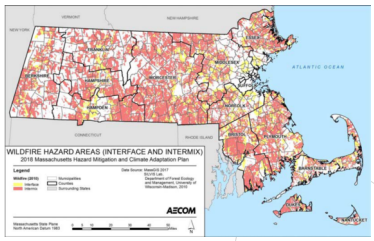
2005 OBSERVED ANNUAL AVERAGE	MID-CENTURY PROJECTED ANNUAL AVERAGE	END-OF-CENTURY PROJECTED ANNUAL AVERAGE
145	114	101

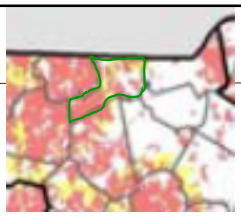
DAYS WITH TEMPERATURES BELOW 32°F

14

14

WILDFIRE





206
brush fires were reported in the Town of Tyngsborough over a 3-year period .

17

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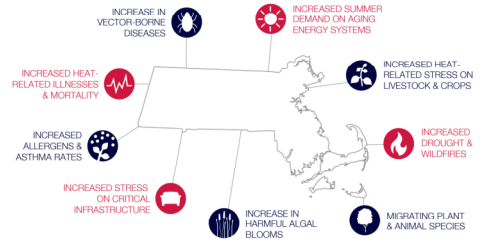
IMPACTS OF RISING TEMPERATURES

WARMER ANNUAL AIR TEMPERATURES
UP 0.5°F PER DECADE SINCE 1970, ON AVERAGE

WARMER WINTERS
UP 1.3°F PER DECADE SINCE 1970, ON AVERAGE



15

15

CHANGES IN PRECIPITATION

MORE **INTENSE & FREQUENT** EXTREME RAIN EVENTS

PRECIPITATION DURING **HEAVY EVENTS** IN THE NORTHEAST

INCREASED BY MORE THAN

70%

BETWEEN 1958-2010

Massachusetts Executive Office of Energy & Environmental Affairs. 2019. "Changes in Precipitation." Massachusetts Climate Change Clearinghouse. Resilientma.org/changes/changes-in-precipitation

18

EXTREME PRECIPITATION

8%

Increase in extreme precipitation events by midcentury

13%

Increase in extreme precipitation events by 2100

19

19

WINTER STORMS

The blizzard of 2013 left nearly **400,000 Massachusetts residents without power**

"Heavy blizzards are among the **most costly and disruptive** weather events for Massachusetts communities."

22

Flood Prone Areas

Access road to the Tyngsborough Elementary School

Route 113 near Vesper Country Club

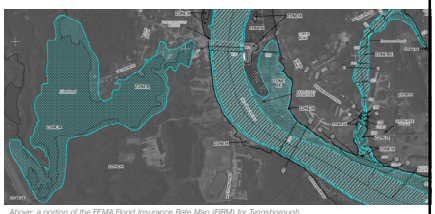
Vicinity of Bridgeview Circle

Riverbend Road

River Road

Red Gate Road

Larson Avenue



Above: a portion of the FEMA Flood Insurance Rate Map (FIRM) for Tyngsborough

REPETITIVE FLOOD LOSS STRUCTURES

- Defined as an NFIP-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978.
- Tyngsborough has **8** repetitive loss structures. All are residential structures.
- As of May 2013, the NFIP paid out **$2,129,486** for **16 claims.**

20

20

HURRICANES AND SEVERE STORMS

HURRICANE SANDY was the most recently identified hurricane

Upward trend in North Atlantic hurricane activity since 1970

Nor'easters along the Atlantic coast are expected to increase in frequency and intensity

23

23

STORMWATER FLOODING

Areas with:

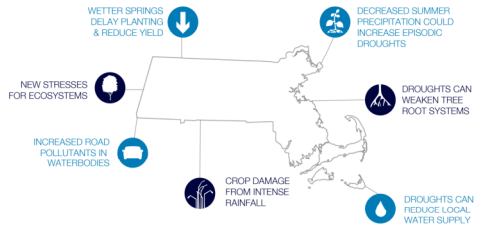
- Poor drainage
- High amounts of impervious surface
- Undersized culverts

21

21

IMPACTS OF CHANGING PRECIPITATION

HIGHER AVERAGE ANNUAL PRECIPITATION
INCREASED BY ABOUT 10% IN THE NORTHEAST INTHE LAST 50 YEARS



24

24

How prepared do you feel the Town is for future extreme events?

A. I feel the Town is completely prepared
B. I feel the Town is somewhat prepared
C. I do not feel the Town is prepared

25

25

What category are most vulnerable to climate hazards?

A. Infrastructure; including roads, bridges, culverts, and dams
B. Natural systems; including parks, trails, rivers, and ponds
C. Societal groups; including elderly residents, young children, and emergency management personnel
D. All of the Above
E. Other

28

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COMMUNITY RESILIENCE BUILDING WORKSHOP

Focus on 4 Hazards

Identify:
- Vulnerabilities
- Strengths
- Priority Action Items

Across 3 Categories
- Infrastructure
- Societal
- Environmental

26

26

What category are our greatest strength regarding climate hazards?

A. Infrastructure; including roads, bridges, culverts, and dams
B. Natural systems; including parks, trails, rivers, and ponds
C. Societal groups; including elderly residents, young children, and emergency management personnel
D. All of the Above
E. Other

29

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4 HAZARDS

Nor'easters, Snow Storm, Ice Storm

Extreme Temperatures & Drought

Flooding

Wind, Hurricane, Tornado

Weston & Sampson

Source: Community Resilience Building Workshop, 2019

27

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INFRASTRUCTURE FEATURES

Both Vulnerability and Strength	Strengths
• Bridges, especially Tyngsborough Bridge • Buildings • Communication and Public Safety Infrastructure • Council on Aging and Elementary School Shelters • Dams • Power or Energy Supply • Public Water Availability and Water Utility • Roadways, especially Red Gate Rd, Dunstable Rd, Middlesex Rd • Stormwater Infrastructure • Waste Management • Water Utility and Public Water Availability	• Emergency Services • Municipal Buildings • Sewer-Regional and Local

Photo by the Tyngsborough Fire Department

30

30

SOCIETAL FEATURES

Both Vulnerability and Strength	Strengths	Vulnerabilities
• Disabled and Veterans • Historic Buildings • Schools and Daycares • Senior Center, Council on Aging, Elderly Population, and Group Housing • Youth and Youth Organizations	• Bordering City • Commercial District-Middle Rd • Community Spirit • Municipal Services (Library, Veterans, Town Hall) • Non-Profit Groups • Places of Worship	• Limited Shopping Sources/Urgent Care • Farming

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ENVIRONMENTAL FEATURES

Both Vulnerability and Strength	Strengths	Vulnerabilities
• Animals, Plants, Trees, and Invasive Species • Frost Road Park • Lakes, Ponds, Lakes and Ponds Associations • Merrimac River • Open Space • Recreation Areas • Streams, Wetlands, and Ponds • Water Bodies • Water Supply • Wildlife	• Community Programs (Including Youth Organizations) • Regulations-Floodplain/Wetland Bylaw	• Insects, Invasive Plants, Vector Borne Diseases • HAZMATS/Pollutants • Landfill (Superfund Site) • Private Wells

32

What are some of Tyngsborough's greatest vulnerabilities?

A. Utilities and municipal services
B. People: emergency services team, volunteers, community groups
C. Wetland Regulations
D. Open spaces
E. Other

33

What group or asset are you most worried about being impacted by climate hazards?

A. Infrastructure; including roads, bridges, culverts, and dams
B. Natural systems; including parks, trails, rivers, and ponds
C. Societal groups; including elderly residents, young children, and emergency management personnel
D. d. Other

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PRIORITY ACTION ITEMS

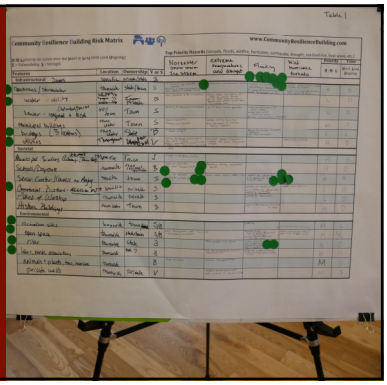


Photo: Tree down on Willowdale and Westland Road. Photo by the Town of Tyngsborough, 2017, Twitter.

35

What services, initiatives, or mitigation measures are you aware the town is taking?

A. RaveMobile
B. Emergency Shelter/Heating and Cooling Station at Elementary School
C. Tree maintenance and coordination with National Grid
D. Stormwater Program—public education, green infrastructure projects, etc.
E. All of the Above

36

How can the Town improve its public education and outreach to better share this information?

A. Share information through public events
B. Share information through printed media; including reports, fact sheets, or brochures
C. Share information digitally, including through the Town of Tyngsborough website and the Town of Tyngsborough Twitter
D. Share information using Tyngsborough TV
E. Strategic outreach to vulnerable populations, such as elderly residents or other groups

37

37

40

What steps have you already taken?

A. I have a kit in case of emergencies (which may include food, water, flashlights, batteries, and other supplies)
B. I receive news, updates, and information about emergency preparedness in Tyngsborough
C. I know where the nearest local shelter is
D. All of the above
E. Other

38

38

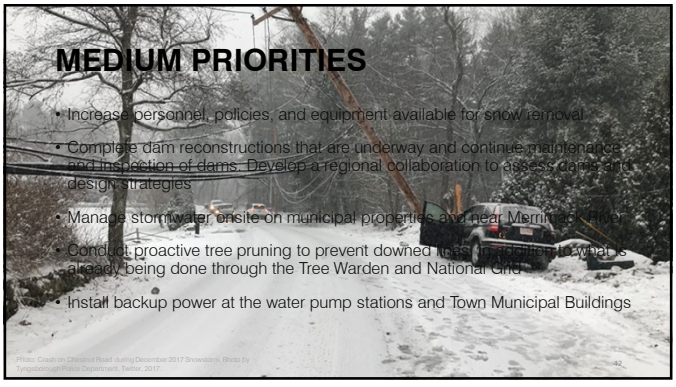
41

What resources do you need to feel more prepared?

A. More information on areas and infrastructure in town vulnerable to climate impacts
B. More information on evacuation routes and shelters
C. More information on preparing an emergency kit and receiving news updates during an extreme event
D. Other

39

39



42

43

Which of the following priority action items would you rank as a top priority?

A. Reduce the impact of riverine and stormwater flooding
B. Develop an invasive species management plan
C. Increase public engagement about climate resilience and preparedness
D. Preserve the Town's open space
E. Other

44

44

How should Tyngsborough prioritize climate adaptation measures?

A. Based on funding
B. Time frame
C. Asset type (i.e., infrastructure, buildings, or natural systems)
D. Impact on public safety
E. Other

45

45

NEXT STEPS FOR HMP-MVP PLAN

1. Post Draft Plan
2. Finalize Plan
3. Comment Period
4. Send to the State for approval
5. Apply for grants

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RESILIENT MASTER PLAN CHAPTER UPDATE

Photo: Crash on Chestnut Road during December 2017 Snowstorm. Photo by Tyngsborough Police Department, Twitter, 2017.

47

RESILIENT MASTER PLAN PROGRESS

- Outline developed and reviewed with Town
- Completed initial literature review for drafting of the climate resiliency chapter
- Initiated review and integration of HMP/MVP data
- Initiated drafting of the Climate Resiliency Chapter for the Master Plan

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NEXT STEPS FOR MASTER PLAN CHAPTER

- Integrate data from HMP/MVP
- Expand upon priorities from HMP/MVP regarding land use stormwater and/or applicable actions
- Complete draft resiliency chapter
- Integrate as part of the master plan update

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THANK YOU

Weston & Sampson

50

placeholder for sign in sheet

Municipal Vulnerability Preparedness Planning Grant and
Hazard Mitigation Planning Grant Update

Listening Session
Back Room of the Tyngsborough Public Library
Wednesday, January 8, 2020
6:30 pm – 7:30 pm

Introductions 3 minutes

- 11 people in attendance
- **Bold text indicates answer with the highest vote.**

Municipal Vulnerability Preparedness (MVP) Program Overview 7 minutes

- Purpose, intent, and objectives
- Introduction to additional components (Hazard Mitigation Plan and Master Plan Chapter)

Climate Change in Tyngsborough 7 minutes

- Brief Overview
- Interactive Polling
    1. What hazard most concerns you?
        a. **Nor'easters, snowstorms, ice**
        b. Extreme temperatures and drought
        c. Flooding
        d. Wind, hurricane, tornado
        e. Other

    Discussion: Why do these hazards concern you the most?

    ***Nor'easters**: Power outages are common in Tyngsborough and in the winter many people rely on electricity for heat. The maximum outage in recent memory was five days. West Tyngsborough experiences more outages. Many people wish copper phone lines were still the norm.*

    ***Floods**:*
    -There was a major flood in the 1980s that impacted a few parcels near the river with mobile homes. The Town bought the parcels.
    -Pawtucket Boulevard and Golf Club have previously flooded.
    -Sherburne Ave and Coburn Rd near Lowell—new developments of single family homes has lead to stormwater flooding
    -Red Gate Rd floods
    -Some homes on the east side have water standing in driveway
    - Swan Pond intersection—had two cars floating in the garage

    Discussion: What memories of climate hazards do you have?

- Prompt with:
    - Winter Storm Grayson in January 2018
    - Four Nor'easters in March 2018 (Winter Storms Riley, Quinn, Skylar, and Toby)
    - Heatwave during July 2018

2. How prepared do you feel the Town is for future extreme events?
    a. I feel the Town is completely prepared
    b. I feel the Town is somewhat prepared
    c. I do not feel the Town is prepared

    Discussion: why do you feel this way?

    The Highway Department does a great job, but they have limited capacity. Intermunicipal coordination between departments is a real strength. The communication system lacks redundancy. Station 2 is not manned.

Vulnerabilities in Tyngsborough 5 minutes

- Interactive Polling
    1. What group or asset are you most worried about being impacted by climate hazards?
        a. Infrastructure; including roads, bridges, culverts, and dams
        b. Natural systems; including parks, trails, rivers, and ponds
        c. Societal groups; including elderly residents, young children, and emergency management personnel
        d. Other

        Discussion: why do these groups or assets concern you the most?

    2. What are some of Tyngsborough's greatest vulnerabilities?
        a. Power lines
        b. Support during hazard events for vulnerable populations (for example, youth and seniors)
        c. Exposure to ticks and vector-borne illnesses
        d. Flood-prone areas, such as Route 113 or other low-lying roads
        e. Other

        Discussion: what are some of the Town's other climate-related weaknesses?
- Summary of Outcomes from Workshop

Strengths in Tyngsborough 5 minutes

- Interactive Polling
    1. What group or asset are provide the most strength from climate hazards?
        a. Infrastructure; including roads, bridges, culverts, and dams
        b. Natural systems; including parks, trails, rivers, and ponds

c. **Societal groups; including elderly residents, young children, and emergency** management personnel
d. Other

Discussion: why do these groups or assets concern you the most?

1. What are some of Tyngsborough's greatest strengths considering climate resilience?
    e. Utilities and municipal services
    f. People: emergency services team, volunteers, community groups
    g. Wetland Regulations
    h. Open spaces
    i. Other

    Discussion: how can the Town's greatest strengths help prepare it for climate change impacts?

- Summary of Outcomes from Workshop

Priorities in Tyngsborough 20 minutes

- Interactive Polling Part 1
    1. What services, initiatives, or mitigation measures are you aware the town is taking?
        a. RaveMobile
        b. Emergency Shelter/Heating and Cooling Station at Elementary School
        c. Tree maintenance and coordination with National Grid
        d. Stormwater Program—public education, green infrastructure projects, etc.
        e. All of the Above

        Discussion: what other services, initiatives, or measures have you heard of?

    2. How can the Town improve its public education and outreach to better share this information?
        a. Share information through public events
        b. Share information through printed media; including reports, fact sheets, or brochures
        c. Share information digitally, including through the Town of Tyngsborough website and the Town of Tyngsborough Twitter
        d. Share information using Tyngsborough TV
        e. Strategic outreach to vulnerable populations, such as elderly residents or other groups

        Discussion: tell us more about how the Town could reach more residents by sharing information on climate change impacts and preparedness.

        Need more education on how residents can be prepared (generators, fuel, water reserves).

    3. What steps have you already taken?

a. I have a kit in case of emergencies (which may include food, water, flashlights, batteries, and other supplies)
b. I receive news, updates, and information about emergency preparedness in Tyngsborough
c. I know where the nearest local shelter is
d. All of the above
e. Other

Discussion: tell us more about how you have prepared for climate impacts.

4. What resources do you need to feel more prepared?
    a. More information on areas and infrastructure in town vulnerable to climate impacts
    b. More information on evacuation routes and shelters
    c. More information on preparing an emergency kit and receiving news updates during an extreme event
    d. Other

Discussion: tell us about other resources that you need to feel prepared.

- Summary of Outcomes from Workshop

- Interactive Polling Part **2--Optional (Time Pending)**
    5. How should Tyngsborough prioritize climate adaptation measures?
        a. Based on funding
        b. Time frame
        c. Asset type (i.e., infrastructure, buildings, or natural systems)
        d. Impact on public safety
        e. Other

    Discussion: What other considerations should guide the Town's prioritization of adaptation measures?

    Why should the element you voted for be used during prioritization?

    6. Which of the following priority action items would you rank as a top priority?
        a. Reduce the impact of riverine and stormwater flooding
        b. Develop an invasive species management plan
        c. Increase public engagement about climate resilience and preparedness
        d. Preserve the Town's open space
        e. Other

Resilient Master Plan Chapter Update — 10 minutes

Wrap-up — 3 minutes

- What we've heard
- Next steps

Appendix D – Additional Hazard Data

Legend

- Affordable Housing Units
- Bus Station
- Communications Infrastructure
- Critical Intersection
- Daycares
- Emergency Shelter
- Fire Stations
- Food/Grocery/Supply Stores
- Gas Stations
- Highway Department
- Hospitals/Clinics
- Hotels/Motels
- Housing Authority Properties
- National Grid Electric Switching Station
- Nursing Home
- Police Department
- Privately Owned Pump Station
- Public Library
- Schools
- Town Hall
- Tyngsborough Water District Water Supply and Public Safety Communications Infrastructure
- Underground Storage Tanks
- Verizon Control Center
- Water Tank
- Powerline
- Bridge
- Conservation/Protected Land
- Open Space
- Landfill

Dams

- Significant Hazard
- N/A

Transportation

- Evacuation Route
- Roads Prone to Flooding
- Railroads

FEMA National Flood Hazard Layer

- 1% Annual Chance of Flooding (Zones A, AE, AH,
- 0.2% Annual Chance of

Waterways

- Hydrologic Connection
- Marsh/Bog/Wooded marsh
- Open Water

Census

- > 25% of population is < 18 (Census 2010)
- > 25% of population is 65+ (Census 2010)

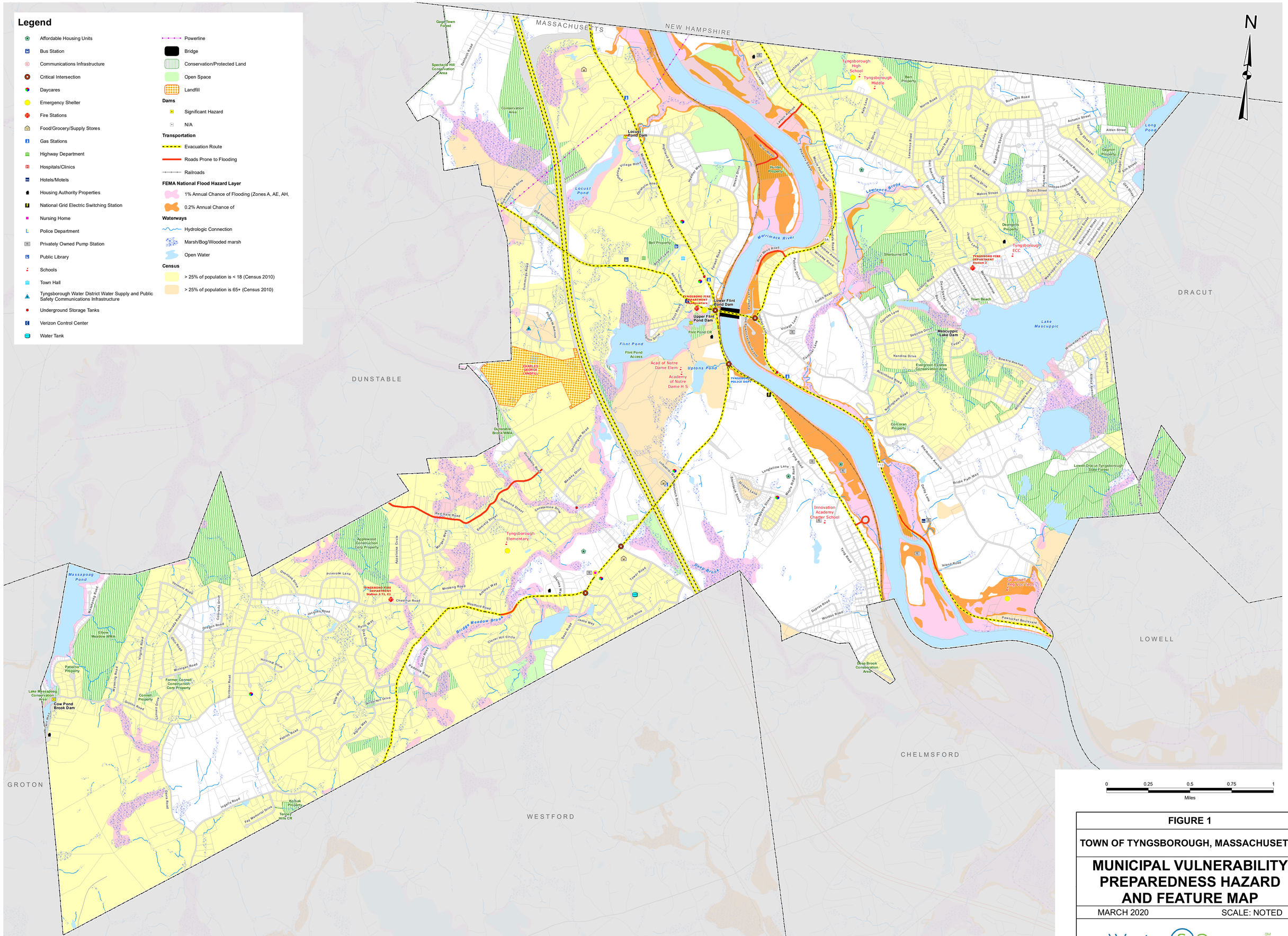


FIGURE 1

TOWN OF TYNGSBOROUGH, MASSACHUSETTS

MUNICIPAL VULNERABILITY PREPAREDNESS HAZARD AND FEATURE MAP

MARCH 2020 SCALE: NOTED

Weston & Sampson℠

Hazus: Earthquake Global Risk Report

Region Name	Tyngsborough_HMP
Earthquake Scenario:	Tyngsborough Magnitude 5.0 Earthquake
Print Date:	February 13, 2020

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

Hazus-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 18.08 square miles and contains 2 census tracts. There are over 3 thousand households in the region which has a total population of 11,292 people (2010 Census Bureau data). The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 4 thousand buildings in the region with a total building replacement value (excluding contents) of 1,762 (millions of dollars). Approximately 90.00 % of the buildings (and 80.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 402 and 12 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 4 thousand buildings in the region which have an aggregate total replacement value of 1,762 (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 86% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 7 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 414.00 (millions of dollars). This inventory includes over 26.72 miles of highways, 10 bridges, 387.74 miles of pipes.

Table 1: Transportation System Lifeline Inventory

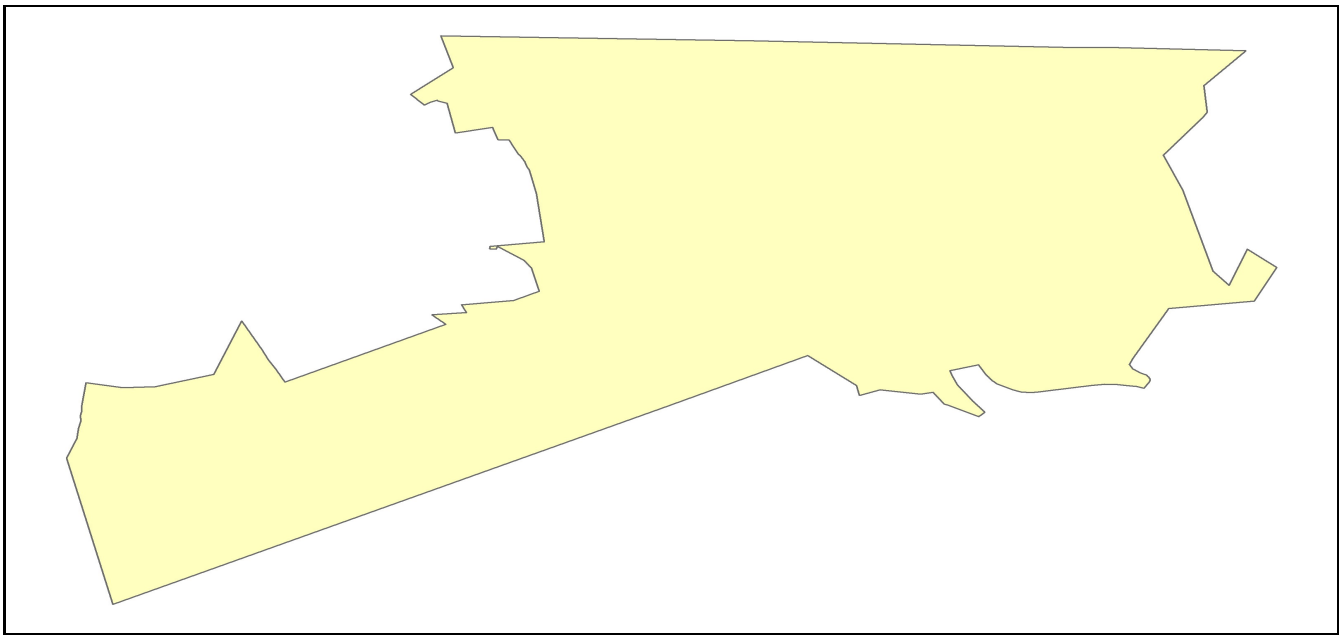
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	10	160.0520
	Segments	14	223.7423
	Tunnels	0	0.0000
		Subtotal	**383.7943**
Railways	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	18	18.5385
	Tunnels	0	0.0000
		Subtotal	**18.5385**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**402.30**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	6.2436
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**6.2436**
Waste Water	Distribution Lines	NA	3.7462
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**3.7462**
Natural Gas	Distribution Lines	NA	2.4975
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**2.4975**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	0	0.0000
		Subtotal	**0.0000**
		Total	**12.50**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	Tyngsborough Magnitude 5.0 Earthquake
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-71.43
Latitude of Epicenter	42.67
Earthquake Magnitude	5.00
Depth (km)	10.00
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	Central & East US (CEUS 2008)

Direct Earthquake Damage

Building Damage

Hazus estimates that about 858 buildings will be at least moderately damaged. This is over 21.00 % of the buildings in the region. There are an estimated 44 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

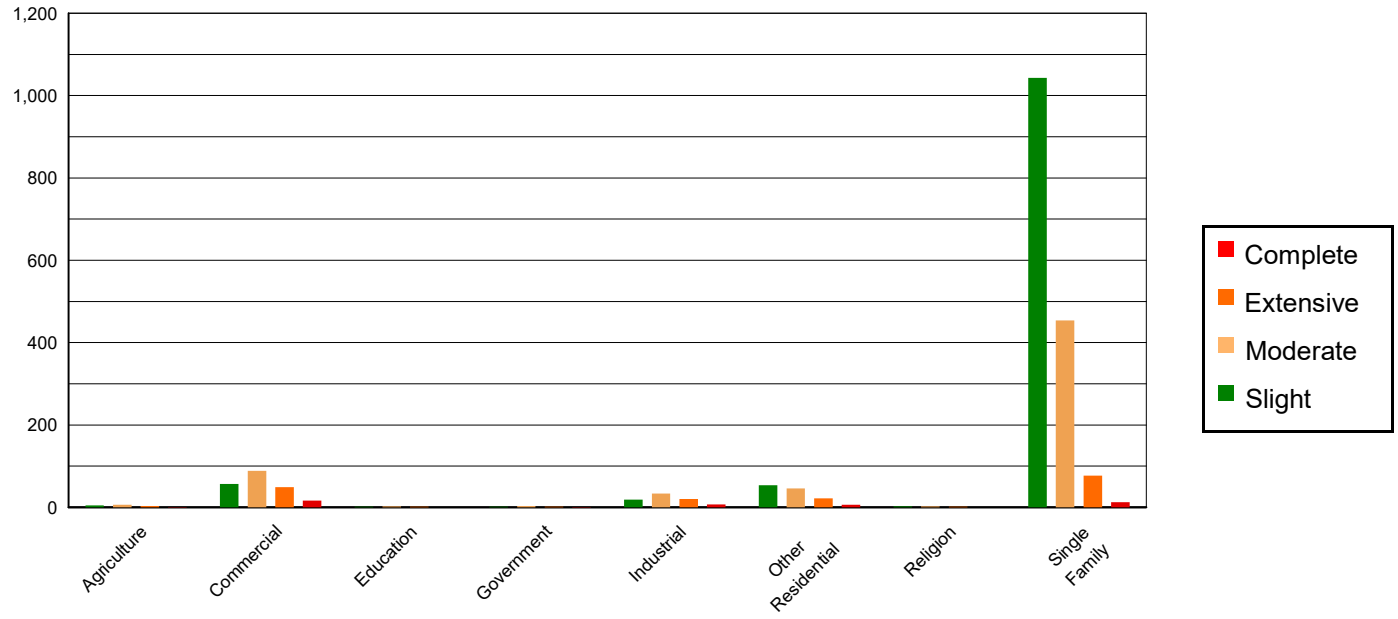


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	4.19	0.21	4.61	0.39	6.31	0.99	2.91	1.64	0.97	2.17
Commercial	60.97	3.03	56.47	4.77	88.63	13.91	49.27	27.87	16.66	37.17
Education	1.89	0.09	1.61	0.14	2.60	0.41	1.43	0.81	0.47	1.05
Government	2.14	0.11	1.86	0.16	3.33	0.52	2.00	1.13	0.67	1.50
Industrial	21.58	1.07	18.99	1.61	33.79	5.30	20.63	11.67	7.00	15.62
Other Residential	83.65	4.16	53.50	4.52	45.76	7.18	21.99	12.44	6.10	13.61
Religion	3.94	0.20	2.60	0.22	2.62	0.41	1.39	0.79	0.45	1.00
Single Family	1833.16	91.13	1043.08	88.19	454.08	71.27	77.18	43.66	12.50	27.88
Total	**2,012**		**1,183**		**637**		**177**		**45**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1878.14	93.37	1070.41	90.50	455.63	71.51	63.00	35.63	4.87	10.87
Steel	38.85	1.93	33.16	2.80	69.48	10.91	44.71	25.29	15.84	35.32
Concrete	5.80	0.29	5.14	0.43	12.11	1.90	7.77	4.39	2.34	5.22
Precast	2.12	0.11	1.54	0.13	3.96	0.62	3.96	2.24	1.20	2.67
RM	13.89	0.69	6.66	0.56	13.92	2.18	11.15	6.31	1.97	4.39
URM	68.99	3.43	60.74	5.14	71.70	11.25	39.12	22.13	16.85	37.57
MH	3.73	0.19	5.08	0.43	10.33	1.62	7.09	4.01	1.78	3.96
Total	**2,012**		**1,183**		**637**		**177**		**45**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	7	7	0	0
EOCs	1	1	0	0
PoliceStations	1	1	0	0
FireStations	1	1	0	0

Transportation Lifeline Damage

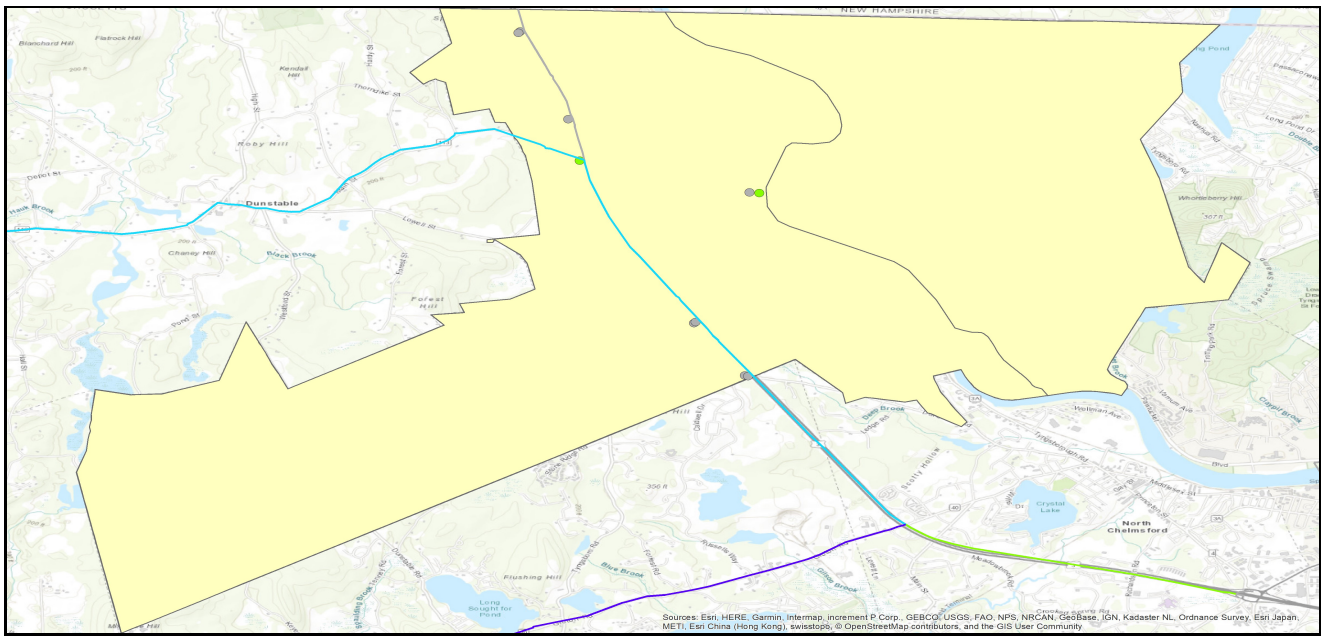


Table 6: Expected Damage to the Transportation Systems

System	Component		Number of Locations			
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	14	0	0	14	14
	Bridges	10	5	0	5	9
	Tunnels	0	0	0	0	0
Railways	Segments	18	0	0	18	18
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	194	51	13
Waste Water	116	25	6
Natural Gas	78	9	2
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	3,999	0	0	0	0	0
Electric Power		3,349	2,209	914	162	4

Induced Earthquake Damage

Fire Following Earthquake

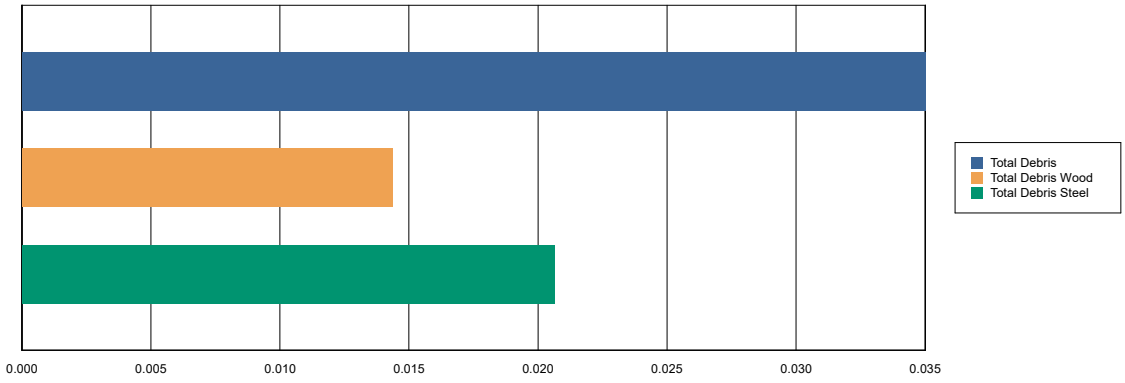
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 35,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 41.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 1,400 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



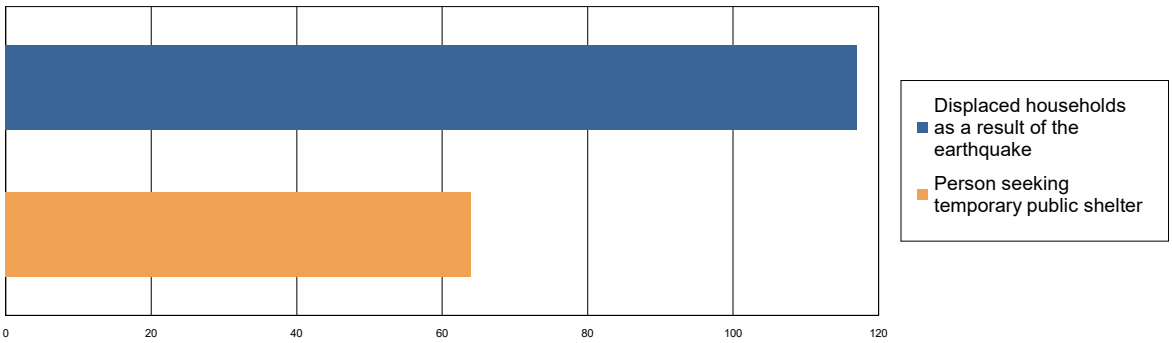
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.01	0.02	0.04	1,400 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 117 households to be displaced due to the earthquake. Of these, 64 people (out of a total population of 11,292) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
117	64

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.73	0.18	0.02	0.05
	Commuting	0.00	0.01	0.01	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	1.35	0.34	0.05	0.09
	Other-Residential	7.21	1.73	0.24	0.47
	Single Family	11.37	1.94	0.20	0.39
	Total	**21**	**4**	**1**	**1**
2 PM	Commercial	39.89	9.82	1.36	2.64
	Commuting	0.04	0.05	0.09	0.02
	Educational	19.49	4.99	0.75	1.45
	Hotels	0.00	0.00	0.00	0.00
	Industrial	9.99	2.50	0.35	0.68
	Other-Residential	1.09	0.27	0.04	0.07
	Single Family	1.67	0.30	0.03	0.06
	Total	**72**	**18**	**3**	**5**
5 PM	Commercial	29.55	7.31	1.02	1.96
	Commuting	0.78	0.95	1.72	0.33
	Educational	1.85	0.47	0.07	0.14
	Hotels	0.00	0.00	0.00	0.00
	Industrial	6.24	1.56	0.22	0.43
	Other-Residential	2.85	0.69	0.10	0.19
	Single Family	4.46	0.79	0.09	0.16
	Total	**46**	**12**	**3**	**3**

Economic Loss

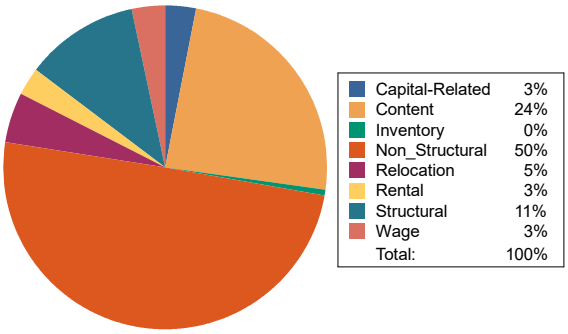
The total economic loss estimated for the earthquake is 239.98 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 223.58 (millions of dollars); 14 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 57 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

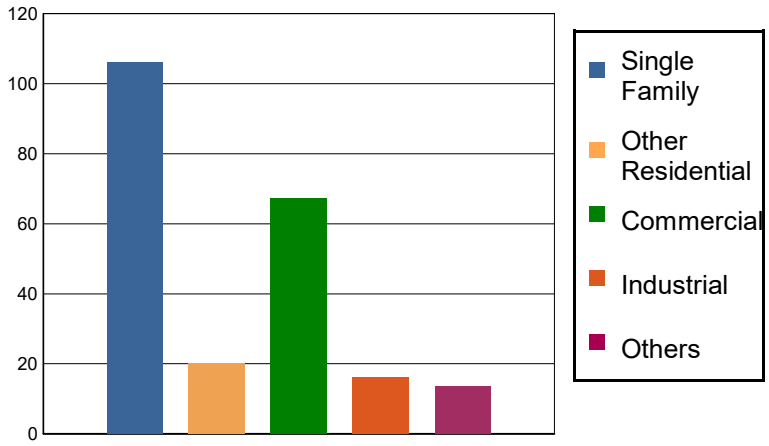


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.4568	6.3590	0.3130	0.3845	7.5133
	Capital-Related	0.0000	0.1950	6.4873	0.1801	0.1026	6.9650
	Rental	1.1334	1.2656	3.2409	0.1031	0.1669	5.9099
	Relocation	4.0596	0.7412	4.6319	0.5936	1.4824	11.5087
	Subtotal	**5.1930**	**2.6586**	**20.7191**	**1.1898**	**2.1364**	**31.8969**
Capital Stock Losses							
	Structural	10.1597	1.9315	8.9295	2.2088	2.1913	25.4208
	Non_Structural	61.2913	11.9409	24.4611	7.5019	5.9315	111.1267
	Content	29.4884	3.7069	12.8288	4.7162	3.3428	54.0831
	Inventory	0.0000	0.0000	0.3146	0.6917	0.0474	1.0537
	Subtotal	**100.9394**	**17.5793**	**46.5340**	**15.1186**	**11.5130**	**191.6843**
	Total	**106.13**	**20.24**	**67.25**	**16.31**	**13.65**	**223.58**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	223.7423	0.0000	0.00
	Bridges	160.0520	16.0167	10.01
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**383.7943**	**16.0167**	
Railways	Segments	18.5385	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**18.5385**	**0.0000**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**402.33**	**16.02**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	6.2436	0.2274	3.64
	Subtotal	**6.2436**	**0.2274**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	3.7462	0.1142	3.05
	Subtotal	**3.7462**	**0.1142**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	2.4975	0.0391	1.57
	Subtotal	**2.4975**	**0.0391**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**12.49**	**0.38**	

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	11,292	1,405	357	1,762
Total Region		**11,292**	**1,405**	**357**	**1,762**

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In terms of building construction types found in the region, wood frame construction makes up 86% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 7 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 414.00 (millions of dollars). This inventory includes over 26.72 miles of highways, 10 bridges, 387.74 miles of pipes.

Table 1: Transportation System Lifeline Inventory

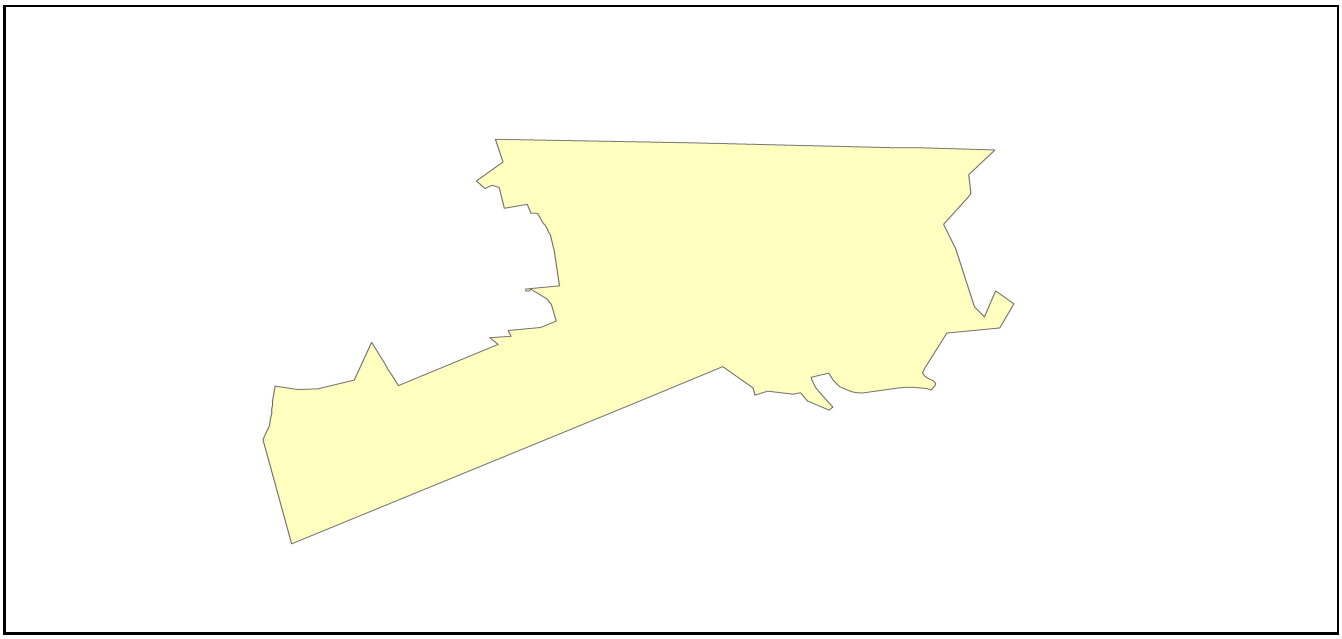
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	10	160.0520
	Segments	14	223.7423
	Tunnels	0	0.0000
		Subtotal	**383.7943**
Railways	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	18	18.5385
	Tunnels	0	0.0000
		Subtotal	**18.5385**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**402.30**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	6.2436
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**6.2436**
Waste Water	Distribution Lines	NA	3.7462
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**3.7462**
Natural Gas	Distribution Lines	NA	2.4975
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**2.4975**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	0	0.0000
		Subtotal	**0.0000**
		Total	**12.50**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	Tyngsborough Magnitude 7.0 Earthquake
Type of Earthquake	Arbitrary
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-71.43
Latitude of Epicenter	42.68
Earthquake Magnitude	7.00
Depth (km)	12.00
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	Central & East US (CEUS 2008)

Direct Earthquake Damage

Building Damage

Hazus estimates that about 3,914 buildings will be at least moderately damaged. This is over 97.00 % of the buildings in the region. There are an estimated 1,885 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

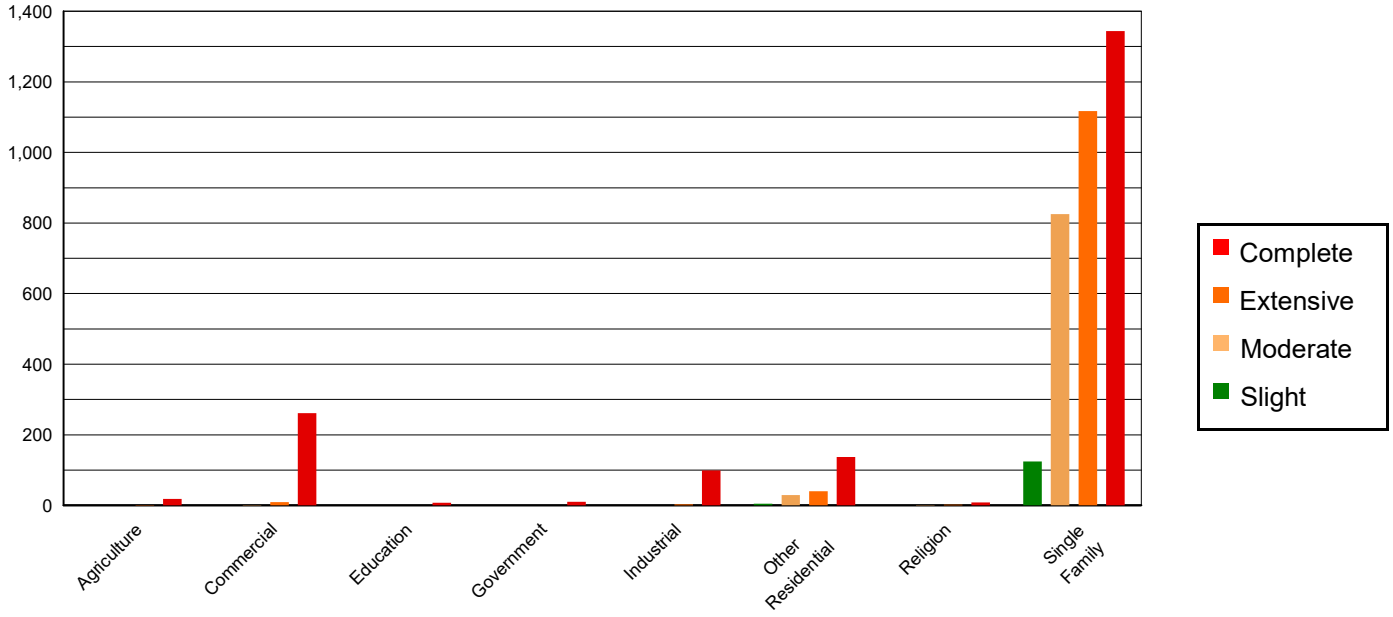


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0.00	0.01	0.01	0.00	0.10	0.01	1.02	0.09	17.88	0.95
Commercial	0.01	0.13	0.07	0.05	1.02	0.12	9.35	0.80	261.55	13.87
Education	0.00	0.00	0.00	0.00	0.03	0.00	0.24	0.02	7.73	0.41
Government	0.00	0.01	0.00	0.00	0.02	0.00	0.24	0.02	9.73	0.52
Industrial	0.00	0.05	0.02	0.01	0.27	0.03	2.61	0.22	99.10	5.25
Other Residential	0.32	3.46	4.40	3.40	28.79	3.36	40.34	3.44	137.15	7.27
Religion	0.01	0.12	0.15	0.12	1.02	0.12	1.51	0.13	8.31	0.44
Single Family	8.85	96.22	124.67	96.41	825.09	96.35	1117.02	95.28	1344.37	71.29
Total	**9**		**129**		**856**		**1,172**		**1,886**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	9.17	99.75	129.12	99.86	854.17	99.75	1158.72	98.84	1320.87	70.04
Steel	0.01	0.11	0.01	0.01	0.19	0.02	3.42	0.29	198.41	10.52
Concrete	0.00	0.00	0.00	0.00	0.04	0.00	0.43	0.04	32.69	1.73
Precast	0.00	0.00	0.00	0.00	0.02	0.00	0.09	0.01	12.66	0.67
RM	0.01	0.13	0.01	0.01	0.21	0.02	0.64	0.05	46.72	2.48
URM	0.00	0.00	0.15	0.12	1.64	0.19	8.32	0.71	247.27	13.11
MH	0.00	0.00	0.01	0.01	0.07	0.01	0.72	0.06	27.20	1.44
Total	**9**		**129**		**856**		**1,172**		**1,886**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	7	7	7	0
EOCs	1	1	1	0
PoliceStations	1	1	1	0
FireStations	1	1	1	0

Transportation Lifeline Damage

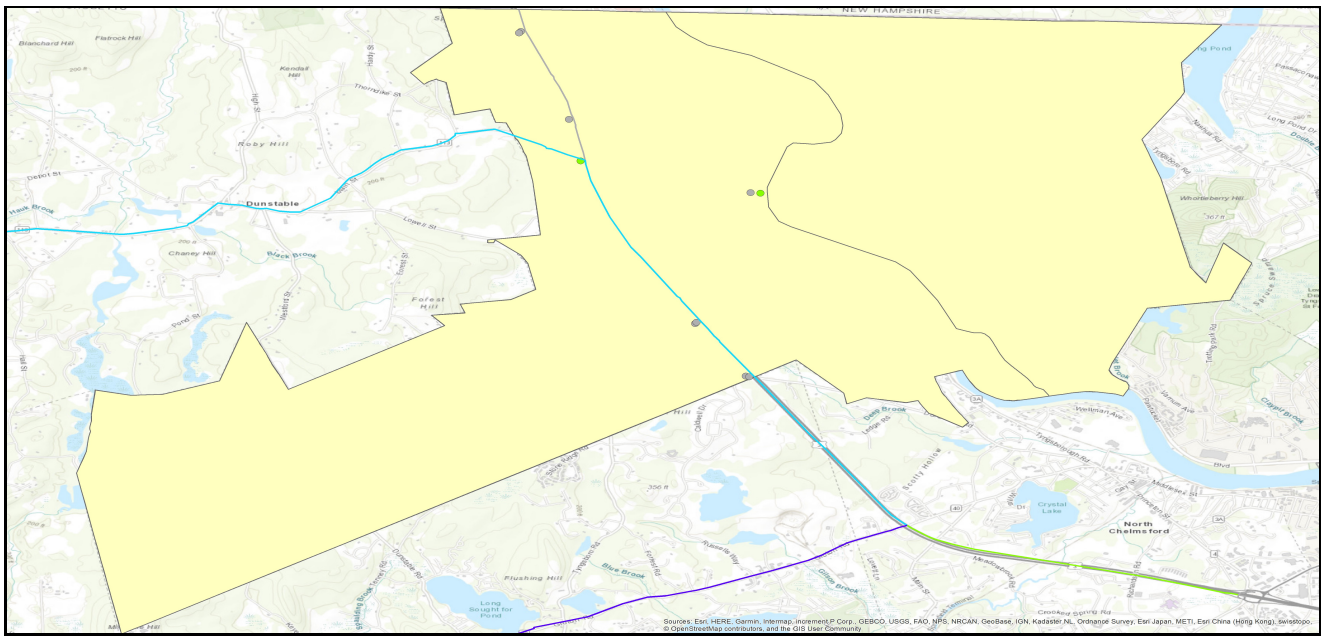


Table 6: Expected Damage to the Transportation Systems

System	Component		Number of Locations			
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	14	0	0	14	14
	Bridges	10	10	8	0	0
	Tunnels	0	0	0	0	0
Railways	Segments	18	0	0	18	18
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	194	1623	406
Waste Water	116	815	204
Natural Gas	78	279	70
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	3,999	3,992	3,988	3,961	0	0
Electric Power		3,855	3,633	2,999	1,268	4

Induced Earthquake Damage

Fire Following Earthquake

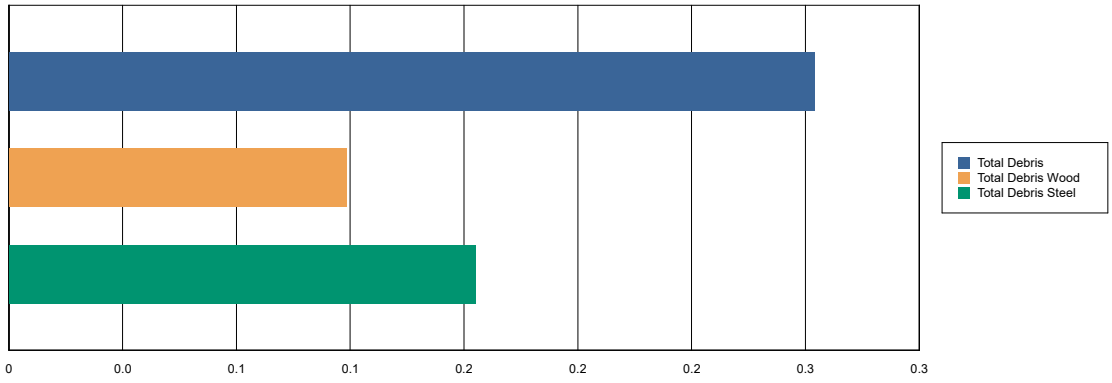
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 283,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 42.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 11,320 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



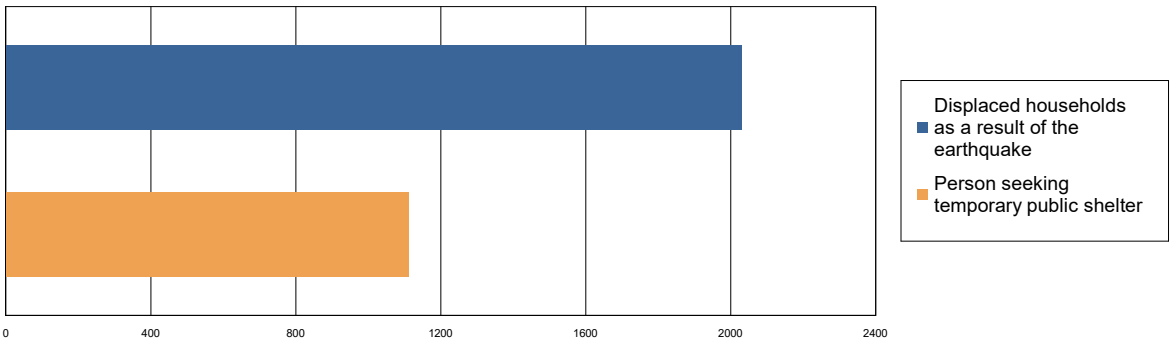
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.12	0.16	0.28	11,320 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 2,030 households to be displaced due to the earthquake. Of these, 1,111 people (out of a total population of 11,292) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
2,030	1,111

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	7.48	2.38	0.38	0.74
	Commuting	0.03	0.05	0.07	0.01
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	12.82	4.16	0.68	1.33
	Other-Residential	92.89	28.52	4.19	8.15
	Single Family	286.50	72.02	6.04	10.68
	Total	**400**	**107**	**11**	**21**
2 PM	Commercial	411.70	131.27	20.85	40.85
	Commuting	0.27	0.42	0.63	0.13
	Educational	200.57	65.99	11.12	21.69
	Hotels	0.00	0.00	0.00	0.00
	Industrial	95.15	30.86	5.04	9.83
	Other-Residential	14.22	4.40	0.67	1.24
	Single Family	43.14	10.90	1.06	1.62
	Total	**765**	**244**	**39**	**75**
5 PM	Commercial	306.80	97.92	15.75	30.20
	Commuting	5.30	8.32	12.53	2.50
	Educational	18.97	6.24	1.05	2.06
	Hotels	0.00	0.00	0.00	0.00
	Industrial	59.47	19.29	3.15	6.15
	Other-Residential	37.06	11.46	1.75	3.22
	Single Family	115.57	29.20	2.85	4.35
	Total	**543**	**172**	**37**	**48**

Economic Loss

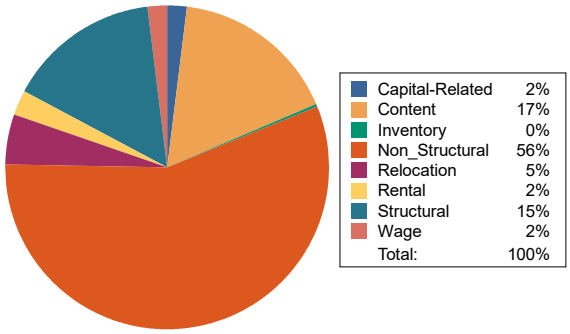
The total economic loss estimated for the earthquake is 1,772.60 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 1,673.60 (millions of dollars); 11 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 67 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

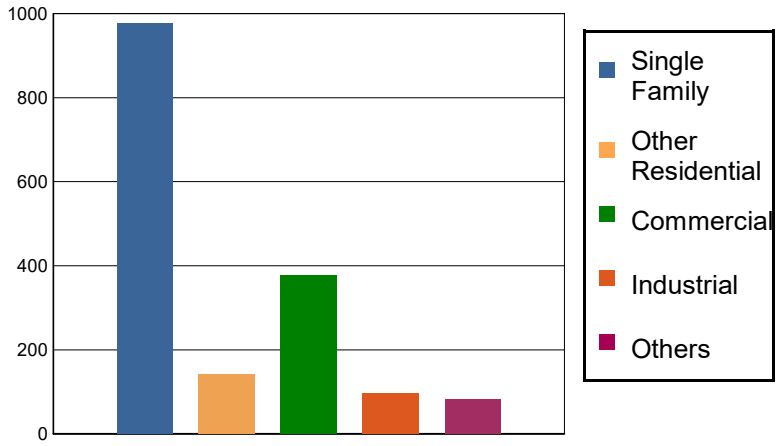


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	2.5717	27.5454	1.4895	1.6514	33.2580
	Capital-Related	0.0000	1.0982	29.0557	0.8490	0.5239	31.5268
	Rental	17.2695	8.9280	12.0513	0.3696	0.7153	39.3337
	Relocation	56.8827	4.7022	16.2043	1.7002	6.3034	85.7928
	Subtotal	**74.1522**	**17.3001**	**84.8567**	**4.4083**	**9.1940**	**189.9113**
Capital Stock Losses							
	Structural	171.1602	15.1284	46.2475	10.4601	12.1933	255.1895
	Non_Structural	596.6599	90.0463	165.6587	49.8033	41.0089	943.1771
	Content	134.3604	19.0593	77.5416	28.0445	19.9977	279.0035
	Inventory	0.0000	0.0000	1.8920	4.1240	0.2984	6.3144
	Subtotal	**902.1805**	**124.2340**	**291.3398**	**92.4319**	**73.4983**	**1483.6845**
	Total	**976.33**	**141.53**	**376.20**	**96.84**	**82.69**	**1673.60**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	223.7423	0.0000	0.00
	Bridges	160.0520	86.7695	54.21
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**383.7943**	**86.7695**	
Railways	Segments	18.5385	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**18.5385**	**0.0000**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**402.33**	**86.77**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	6.2436	7.3036	116.98
	Subtotal	**6.2436**	**7.3036**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	3.7462	3.6688	97.93
	Subtotal	**3.7462**	**3.6688**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Line	2.4975	1.2569	50.33
	Subtotal	**2.4975**	**1.2569**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**12.49**	**12.23**	

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	11,292	1,405	357	1,762
Total Region		**11,292**	**1,405**	**357**	**1,762**

Hazus: Hurricane Global Risk Report

Region Name: Tyngsborough_HMP

Hurricane Scenario: Probabilistic 100-year Return Period

Print Date: Friday, February 14, 2020

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 18.09 square miles and contains 2 census tracts. There are over 4 thousand households in the region and a total population of 11,292 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 4 thousand buildings in the region with a total building replacement value (excluding contents) of 1,763 million dollars (2014 dollars). Approximately 90% of the buildings (and 80% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 4,053 buildings in the region which have an aggregate total replacement value of 1,763 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

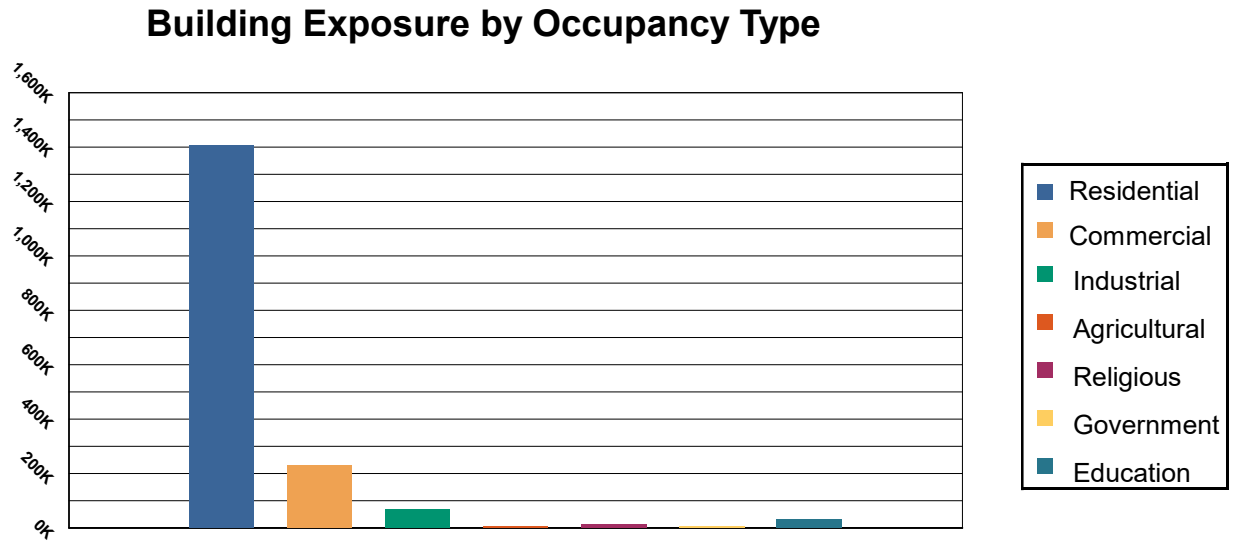


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	1,405,159	79.72 %
Commercial	230,905	13.10%
Industrial	67,643	3.84%
Agricultural	7,355	0.42%
Religious	12,945	0.73%
Government	6,676	0.38%
Education	32,044	1.82%
Total	**1,762,727**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 7 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 2 buildings will be at least moderately damaged. This is over 0% of the total number of buildings in the region. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

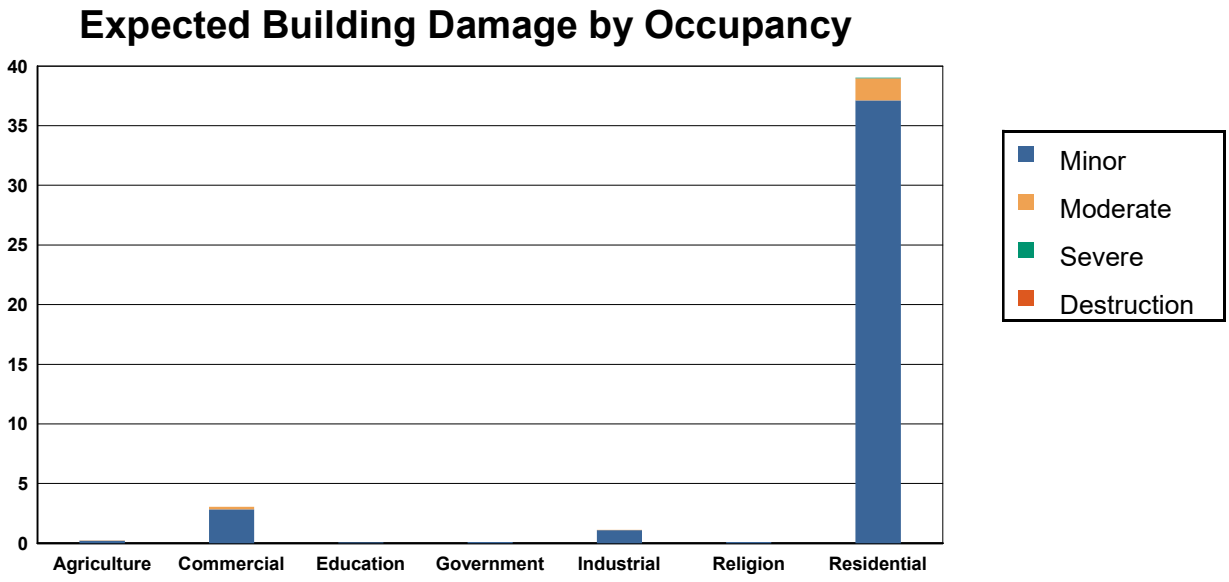


Table 2: Expected Building Damage by Occupancy : 100 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	18.78	98.83	0.20	1.07	0.02	0.08	0.00	0.02	0.00	0.00
Commercial	268.96	98.88	2.83	1.04	0.20	0.08	0.00	0.00	0.00	0.00
Education	7.92	98.96	0.08	1.03	0.00	0.01	0.00	0.00	0.00	0.00
Government	9.89	98.95	0.10	1.04	0.00	0.01	0.00	0.00	0.00	0.00
Industrial	100.89	98.91	1.08	1.06	0.02	0.02	0.00	0.00	0.00	0.00
Religion	10.90	99.10	0.10	0.88	0.00	0.02	0.00	0.00	0.00	0.00
Residential	3,591.97	98.93	37.13	1.02	1.85	0.05	0.05	0.00	0.00	0.00
Total	**4,009.32**		**41.53**		**2.09**		**0.06**		**0.00**	

Table 3: Expected Building Damage by Building Type : 100 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	21	98.77	0	1.23	0	0.00	0	0.00	0	0.00
Masonry	213	97.99	4	1.74	1	0.27	0	0.01	0	0.00
MH	12	99.95	0	0.04	0	0.01	0	0.00	0	0.00
Steel	184	98.86	2	1.08	0	0.06	0	0.00	0	0.00
Wood	3,411	99.07	31	0.90	1	0.02	0	0.00	0	0.00

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

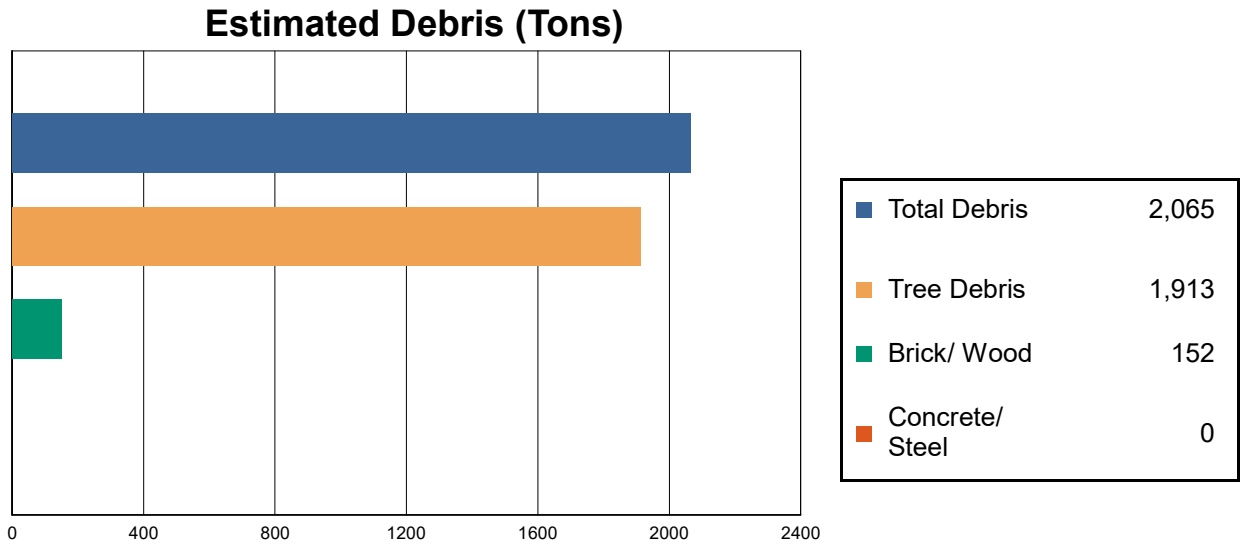
Thematic Map of Essential Facilities with greater than 50% moderate

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	1	0	0	1
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	7	0	0	7

Induced Hurricane Damage

Debris Generation

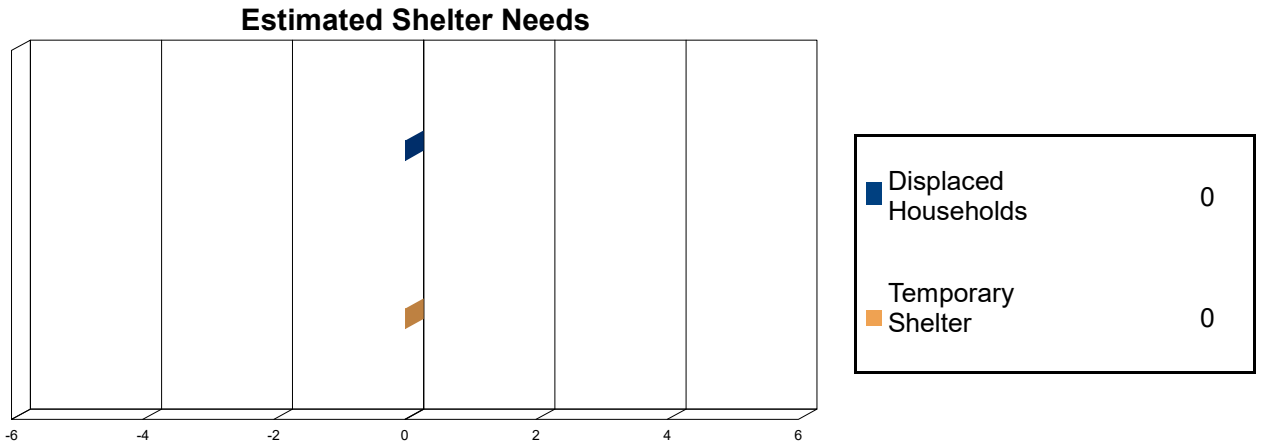


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 2,065 tons of debris will be generated. Of the total amount, 1,385 tons (67%) is Other Tree Debris. Of the remaining 680 tons, Brick/Wood comprises 22% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 6 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 528 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 0 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 11,292) will seek temporary shelter in public shelters.

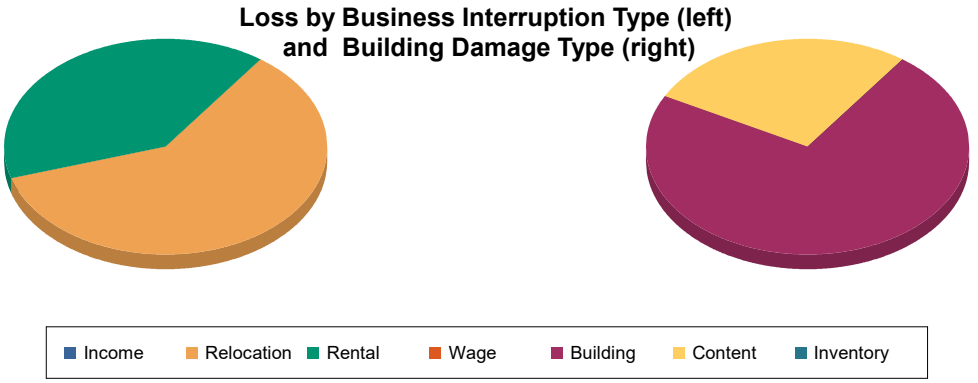
Economic Loss

The total economic loss estimated for the hurricane is 5.5 million dollars, which represents 0.31 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 6 million dollars. 1% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 98% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.



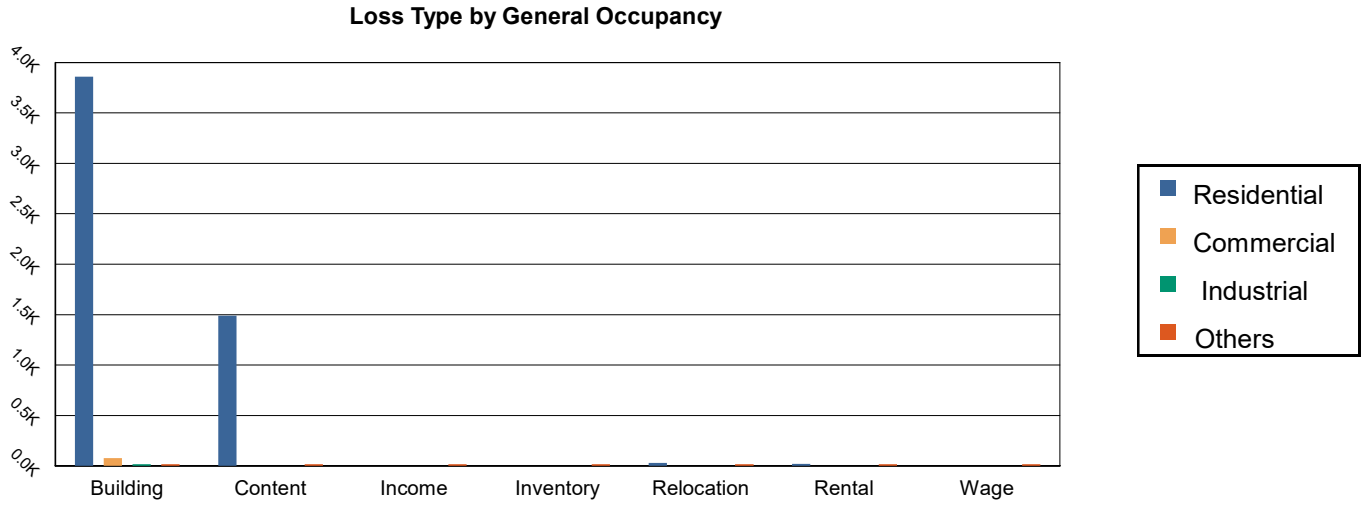


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	3,859.27	77.25	16.00	16.42	3,968.95
	Content	1,489.13	1.83	0.30	0.17	1,491.43
	Inventory	0.00	0.02	0.05	0.02	0.08
	Subtotal	**5,348.40**	**79.10**	**16.36**	**16.61**	**5,460.46**
Business Interruption Loss						
	Income	0.00	0.00	0.00	0.00	0.00
	Relocation	30.55	1.21	0.06	0.08	31.90
	Rental	21.05	0.00	0.00	0.00	21.05
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**51.60**	**1.21**	**0.06**	**0.08**	**52.96**

Total

Total	**5,400.01**	**80.31**	**16.42**	**16.68**	**5,513.42**

Appendix A: County Listing for the Region

Massachusetts
- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	11,292	1,405,159	357,568	1,762,727
Total	**11,292**	**1,405,159**	**357,568**	**1,762,727**
Study Region Total	**11,292**	**1,405,159**	**357,568**	**1,762,727**

Hazus: Hurricane Global Risk Report

Region Name: Tyngsborough_HMP

Hurricane Scenario: Probabilistic 500-year Return Period

Print Date: Friday, February 14, 2020

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 18.09 square miles and contains 2 census tracts. There are over 4 thousand households in the region and a total population of 11,292 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 4 thousand buildings in the region with a total building replacement value (excluding contents) of 1,763 million dollars (2014 dollars). Approximately 90% of the buildings (and 80% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 4,053 buildings in the region which have an aggregate total replacement value of 1,763 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

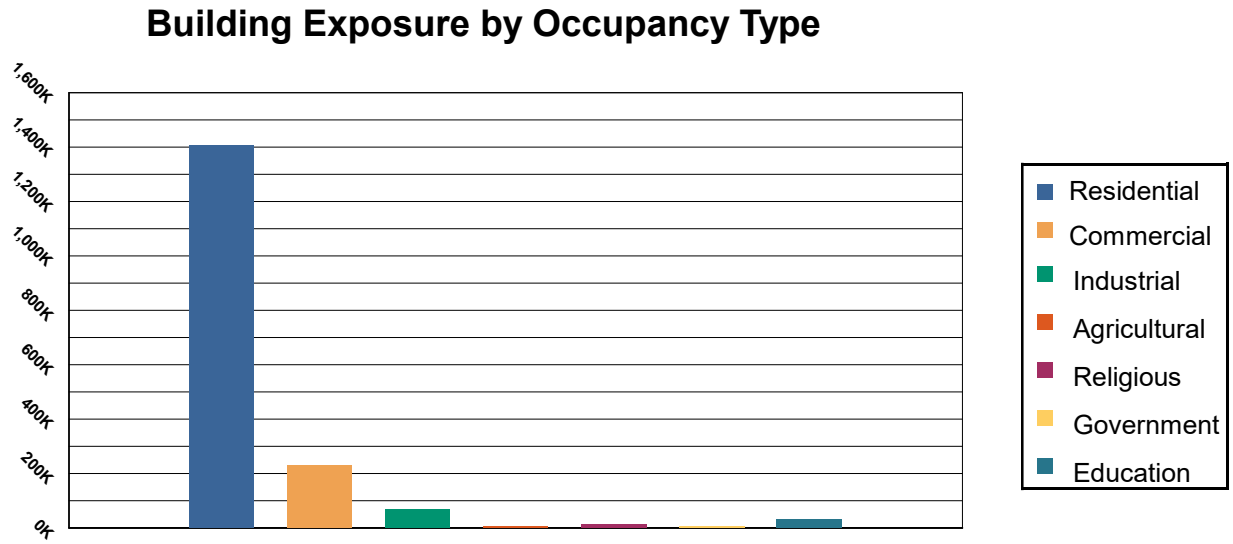


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	1,405,159	79.72 %
Commercial	230,905	13.10%
Industrial	67,643	3.84%
Agricultural	7,355	0.42%
Religious	12,945	0.73%
Government	6,676	0.38%
Education	32,044	1.82%
Total	**1,762,727**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 7 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 49 buildings will be at least moderately damaged. This is over 1% of the total number of buildings in the region. There are an estimated 1 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

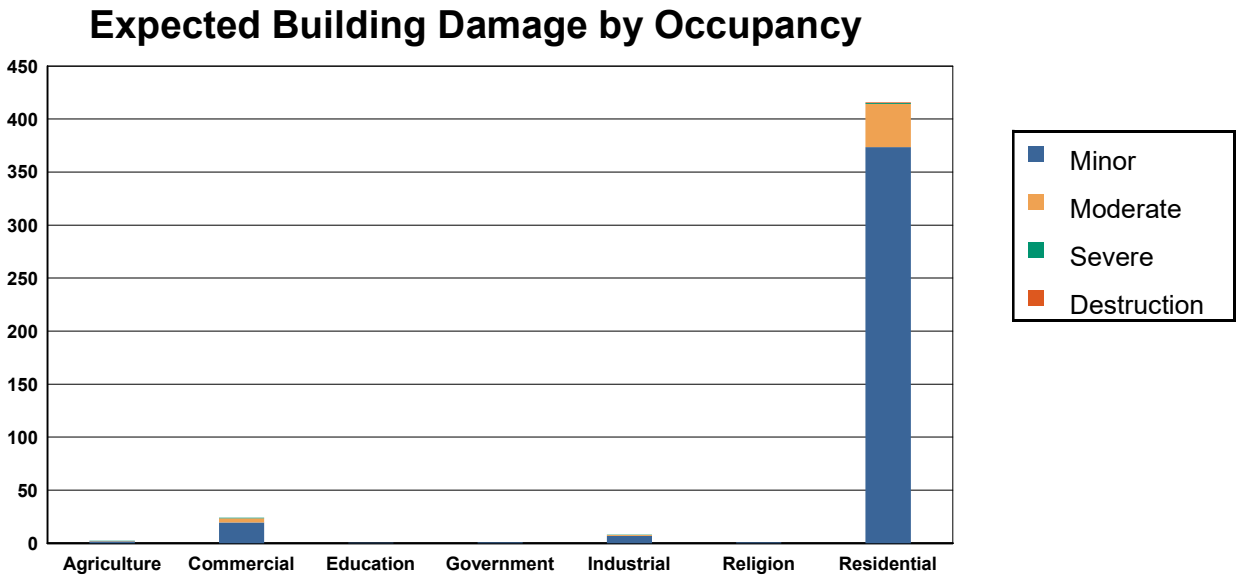


Table 2: Expected Building Damage by Occupancy : 500 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	16.79	88.38	1.67	8.82	0.36	1.89	0.16	0.85	0.01	0.07
Commercial	247.98	91.17	19.62	7.21	3.86	1.42	0.53	0.20	0.00	0.00
Education	7.42	92.75	0.52	6.55	0.05	0.68	0.00	0.02	0.00	0.00
Government	9.22	92.23	0.69	6.95	0.08	0.80	0.00	0.03	0.00	0.00
Industrial	93.97	92.13	6.89	6.75	0.98	0.96	0.16	0.15	0.01	0.01
Religion	10.12	92.02	0.80	7.30	0.07	0.64	0.00	0.03	0.00	0.00
Residential	3,215.10	88.55	373.56	10.29	40.86	1.13	0.88	0.02	0.60	0.02
Total	**3,600.61**		**403.77**		**46.26**		**1.74**		**0.62**	

Table 3: Expected Building Damage by Building Type : 500 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	19	91.24	2	7.61	0	1.11	0	0.03	0	0.00
Masonry	190	87.76	20	9.03	7	3.06	0	0.13	0	0.01
MH	12	96.93	0	2.08	0	0.73	0	0.02	0	0.25
Steel	171	91.90	12	6.47	3	1.39	0	0.24	0	0.00
Wood	3,062	88.95	351	10.20	28	0.82	1	0.02	0	0.01

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

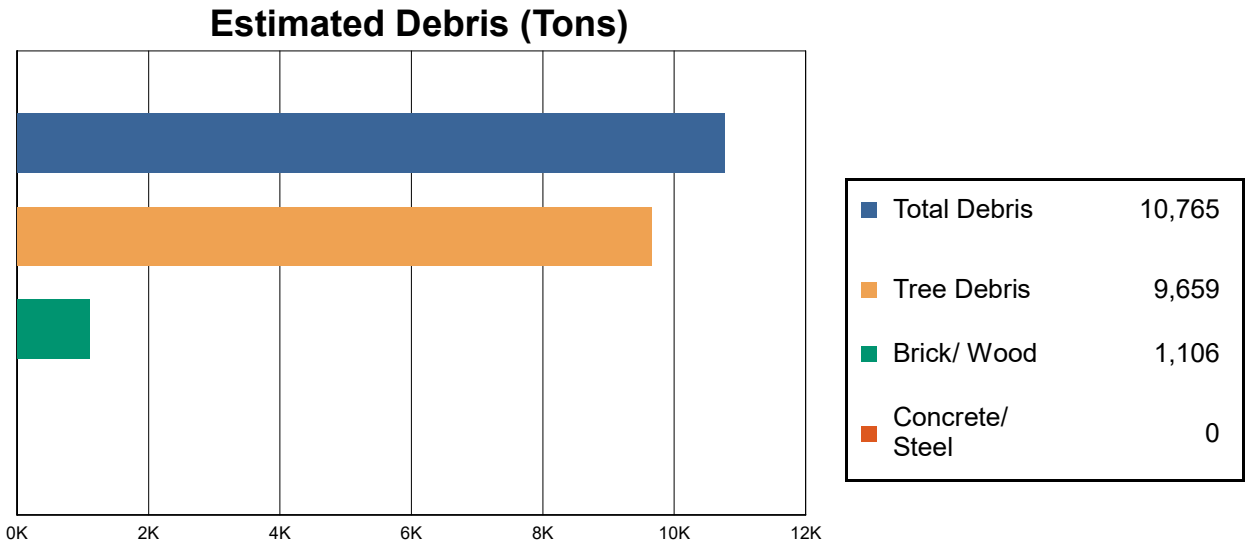
Thematic Map of Essential Facilities with greater than 50% moderate

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	1	0	0	1
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	7	0	0	7

Induced Hurricane Damage

Debris Generation

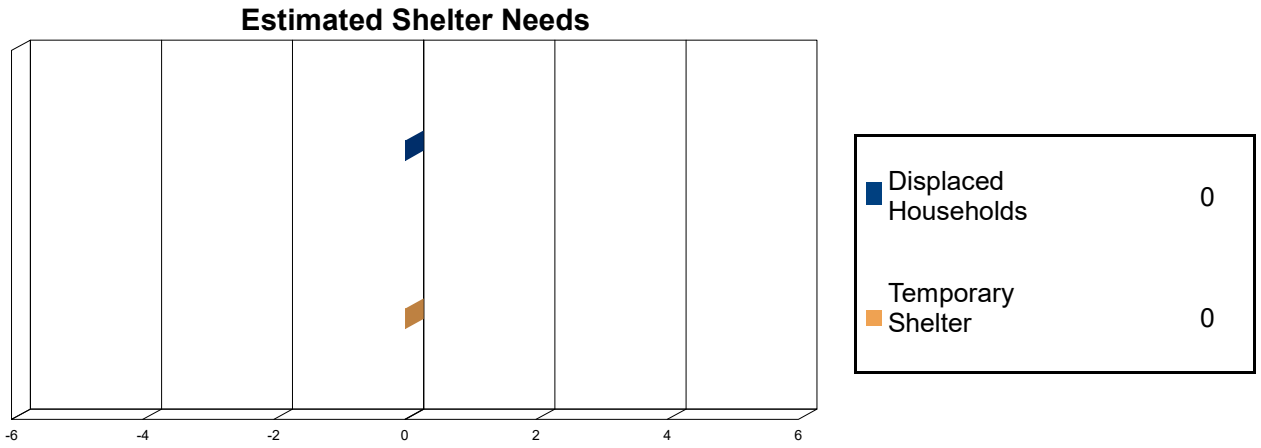


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 10,765 tons of debris will be generated. Of the total amount, 7,009 tons (65%) is Other Tree Debris. Of the remaining 3,756 tons, Brick/Wood comprises 29% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 44 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 2,650 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 0 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 11,292) will seek temporary shelter in public shelters.

Economic Loss

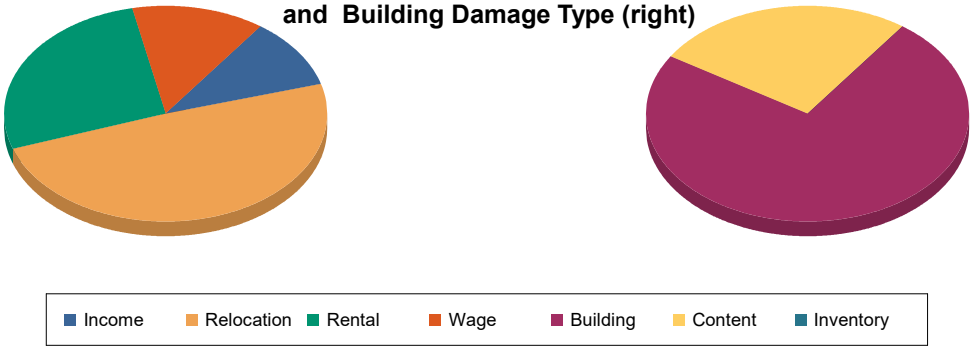
The total economic loss estimated for the hurricane is 23.3 million dollars, which represents 1.32 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 23 million dollars. 4% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 93% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Loss by Business Interruption Type (left) and Building Damage Type (right)



Loss Type by General Occupancy

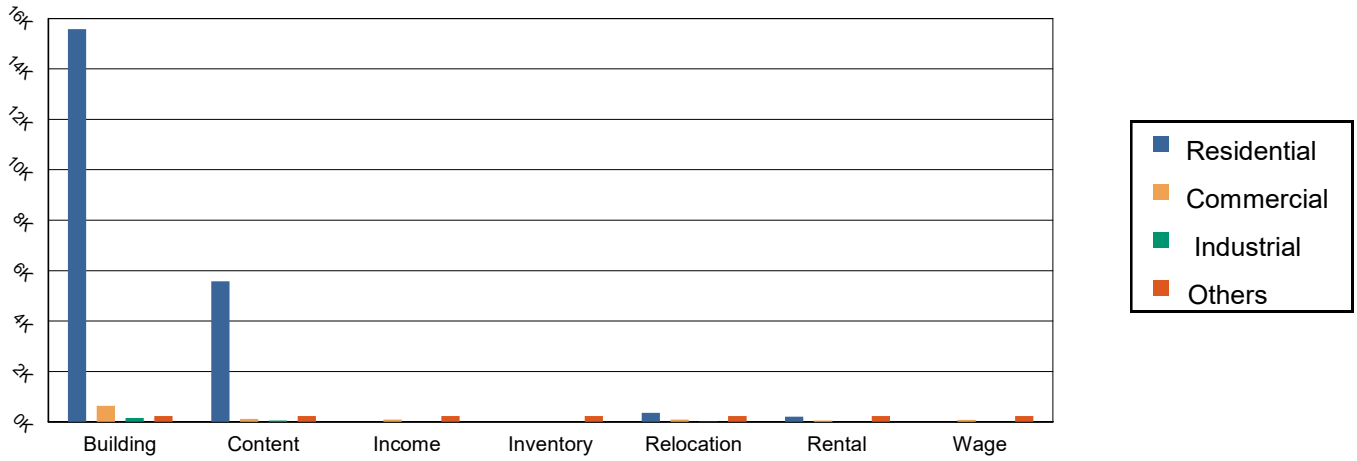


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	15,582.86	634.24	154.22	133.97	16,505.30
	Content	5,578.06	121.03	56.67	25.11	5,780.87
	Inventory	0.00	3.03	7.72	1.25	12.00
	Subtotal	**21,160.92**	**758.30**	**218.61**	**160.34**	**22,298.17**
Business Interruption Loss						
	Income	0.00	89.63	1.95	10.47	102.04
	Relocation	356.80	93.59	8.57	15.44	474.40
	Rental	202.57	55.95	1.41	1.40	261.34
	Wage	0.00	79.77	3.33	45.60	128.70
	Subtotal	**559.38**	**318.94**	**15.26**	**72.91**	**966.48**

Total

Total	**21,720.30**	**1,077.24**	**233.86**	**233.24**	**23,264.65**

Appendix A: County Listing for the Region

Massachusetts
- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	11,292	1,405,159	357,568	1,762,727
Total	**11,292**	**1,405,159**	**357,568**	**1,762,727**
Study Region Total	**11,292**	**1,405,159**	**357,568**	**1,762,727**

Appendix E – Plan Adoption

TOWN OF TYNGSBOROUGH

Town Offices
25 Bryants Lane
Tyngsborough, MA 01879
Tel: (978) 649-2300 x100 | Fax: (978) 649-2320

CERTIFICATE OF ADOPTION
TYNGSBOROUGH BOARD OF SELECTMEN
TOWN OF TYNGSBOROUGH, MASSACHUSETTS

A RESOLUTION ADOPTING THE
TOWN OF TYNGSBOROUGH
2020 HAZARD MITIGATION - MUNICIPAL VULNERABILITY PREPAREDNESS PLAN

WHEREAS, the Town of Tyngsborough established a Core Team to prepare the *Town of Tyngsborough Hazard Mitigation - Municipal Vulnerability Preparedness Plan 2020*; and

WHEREAS, the *Town of Tyngsborough Hazard Mitigation - Municipal Vulnerability Preparedness Plan 2020* contains several potential future projects to mitigate potential impacts from natural hazards as well as climate change in the Town of Tyngsborough, and

WHEREAS, a public meeting was held by the local Planning Department in coordination with the Master Planning Committee on January 8, 2020, and

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

NOW, THEREFORE BE IT RESOLVED that the Town of Tyngsborough Board of Selectmen adopts the *Town of Tyngsborough Hazard Mitigation - Municipal Vulnerability Preparedness Plan 2020*, in accordance with M.G.L. 40 §4 or the charter and bylaws of the Town of Tyngsborough.

ADOPTED AND SIGNED (December 14, 2020).

For the Board of Selectmen

David Robson, Chairman

Appendix F – FEMA Approval

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

FEMA

January 04, 2021

Samantha C. Phillips, Director
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, Massachusetts 01702-5399

Dear Director Phillips:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division has approved the Town of Tyngsborough 2020 Hazard Mitigation-Municipal Vulnerability Preparedness Plan effective **December 23, 2020** through **December 22, 2025** in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

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

The plan must be updated and resubmitted to the FEMA Region I Mitigation Division for approval every five years to remain eligible for FEMA mitigation grant funding.

Thank you for your continued commitment and dedication to risk reduction demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please contact Melissa Surette at (617) 956-7559 or Melissa.Surette@fema.dhs.gov.

Sincerely,

PAUL F FORD
Digitally signed by PAUL F FORD
Date: 2021.01.04 12:20:59 -05'00'

Captain W. Russ Webster, USCG (Ret.), CEM
Regional Administrator
FEMA Region I

WRW:ms

cc: Sarah White, State Hazard Mitigation Officer, MEMA
Jeffrey Zukowski, Hazard Mitigation Planner, MEMA
Beth Dubrawski, Hazard Mitigation Contract Specialist, MEMA