TOWN OF TOWNSEND

2020 HAZARD MITIGATION PLAN (HMP) – MUNICIPAL VULNERABILITY PREPAREDNESS (MVP) PLAN

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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 Townsend 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 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) 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) Engaged the public through a Community Resilience Building Workshop and online public engagement techniques.
4) Established a list of critical facilities and assets.
5) Conducted a vulnerability and risk assessment of historic hazards and the potential impact of climate change.
6) Documented the Town's capacity to mitigate and respond to hazards.
7) Detailed progress on the Town's previously identified action items.
8) Developed an action and implementation strategy.
9) Sought public feedback on the final document.

Hazard Mitigation and Climate Adaptation Goals

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

- Coordination: Increase coordination between Townsend and Federal, State, regional, and local partners.
- Protection: Develop programs and strategies to protect the following Town features from natural hazards and climate change impacts:
    - Vulnerable residents, including the elderly, young, homeless, low-income, and those with limited English proficiency
    - Homes and businesses
    - Cultural and historic resources
    - Critical infrastructure, including transportation networks
    - Public utilities, including electric power, water, and wastewater
    - Public facilities and services
    - Future development
    - Open space, conserved land, and other environmental features
- Planning: Incorporate climate change and natural hazard considerations into Town reports, planning efforts, departments, committees, and boards.
- Public Outreach: Increase awareness and support for climate change and natural hazard mitigation among local organizations, businesses, and residents through outreach and education.

- **Capacity:** Increase the Town's capacity for responding to climate change impacts and natural hazard events through adequate staff, training, supplies, equipment, and guidance.
- **Funding:** Identify and pursue funding to support the development and implementation of climate adaptation and hazard mitigation measures.

Vulnerability and Risk

Among the communities of Middlesex County, hazard mitigation and climate adaptation planning tend to focus on flooding because it is one of the most likely natural hazards to impact these communities. However, the Townsend HMP-MVP Plan assesses the potential impacts from a variety of natural disasters including:

Flooding

Extreme Temperatures

Drought and Brushfire

Severe Weather (Snowstorms, Thunderstorms, and Tornadoes)

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

Hazard Mitigation and Climate Adaptation Strategy

Through the planning process, forty-two high priority hazard mitigation and climate adaptation measures were identified covering the following topics:

- Dam safety
- Electricity and Communications Infrastructure
- Public Water Supply
- Culverts and Stormwater Drainage
- Roads, Bridges, and Public Transit
- Residents at Risk of Isolation
- Residents with Limited English-Speaking Ability
- Municipal Buildings and Services
- Local Businesses
- State Forest
- Food Security
- Waterbodies and Wetlands
- Future Development, Regulatory Tools, and Planning

Next Steps

The Town of Townsend 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 mitigate 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 Townsend prepared a joint Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan (HMP-MVP Plan) to create an action roadmap to reduce the impacts of natural hazards and climate change within the community and the region. The Townsend HMP-MVP Plan was adopted by the Board of Selectmen on February 16, 2021 to update and replace the Montachusett Region Natural Hazard Mitigation Plan 2015 Update.

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 impacts through community planning, policy changes, education programs, infrastructure projects, and other activities (FEMA, 2020a). Hazard mitigation planning uses a stepped process with the 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 plan and implementation 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.

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

By completing an HMP, municipalities also become eligible for specific federal funding and allow the use of potential funding sources to reflect 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 A*ct, as amended by the *Disaster Mitigation Act of 2000.*

Table 1-1. 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, 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 a Municipal Vulnerability Preparedness Plan?

In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) 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.

1. The first grant phase is the Planning Grant, which funds a planning process to identify priority 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 (CRB) Workshop, and engaging the public. Communities that complete the Planning Grant program and prepare an MVP Plan become eligible for the second phase of MVP grant funding and receive increased standing in other State grant programs.
2. The second phase is the Action Grant, which funds the implementation of priority climate adaptation actions described in the MVP Plan. Since these Action Grants are only distributed to Massachusetts municipalities, they are much less competitive than similar grants awarded at the national level.

Community Resilience Building Workshop Guidebook

The Community Resilience Building Workshop Guidebook was developed by the Nature Conservancy and provides a process for developing resilience action plans. The process has been successfully implemented in over four hundred communities. The process 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 strengths and vulnerabilities
- Develop prioritized actions for the Community
- Identify immediate opportunities to collaboratively advance actions to increase resilience

1.3 Combining Hazard Mitigation and Municipal Vulnerability Preparedness Planning in Townsend

The Town of Townsend received an MVP Planning Grant to simultaneously prepare an MVP plan and an HMP. Many of the required steps of the MVP process also satisfy requirements for updating an HMP. FEMA requirements for an HMP are content specific, while EEA requirements for an MVP plan are content and process specific. An HMP requires analyzing natural hazards, while an MVP requires analyzing climate change impacts. An MVP also requires convening a Core Team and hosting a CRB Workshop and Public Listening Session. These steps are not required by FEMA but are still an important part of the hazard mitigation planning process. By completing a joint HMP-MVP plan, Townsend was able to fulfill the requirements of both processes.

As a result, the town prepared this joint HMP-MVP Plan in accordance with FEMA guidelines for hazard mitigation planning (*Title 44 Code of Regulations (CFR) 201.6*) and with the Massachusetts Executive Office of Energy & Environmental Affairs' (EOEEA) requirements to follow the Community Resilience Building (CRB) Workshop Guidance developed by the Nature Conservancy. This enabled Townsend to consider the impacts of climate change in addition to historic hazard events as part of its planning process. This approach followed the lead established by the Commonwealth when it adopted the first-ever Massachusetts State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPSS, 2018).

Facilitating discussion among stakeholders about creating a safer, more resilient community is an important aspect of the natural hazard and climate change impact mitigation planning process. The involvement of a variety of stakeholders in the development of a plan leads to results that better reflect the Town's values and priorities. Additionally, the plan is more likely to have greater community support and success in implementing mitigation strategies that reduce risk. The planning and outreach strategy used to develop this HMP-MVP Plan collected input from three categories of stakeholders:

1. The Core Team, which includes representation from municipal leadership
2. Local, regional, and State stakeholders who could be vulnerable to, or provide strength against, natural hazards and climate change
3. The public, who live and work in the Town

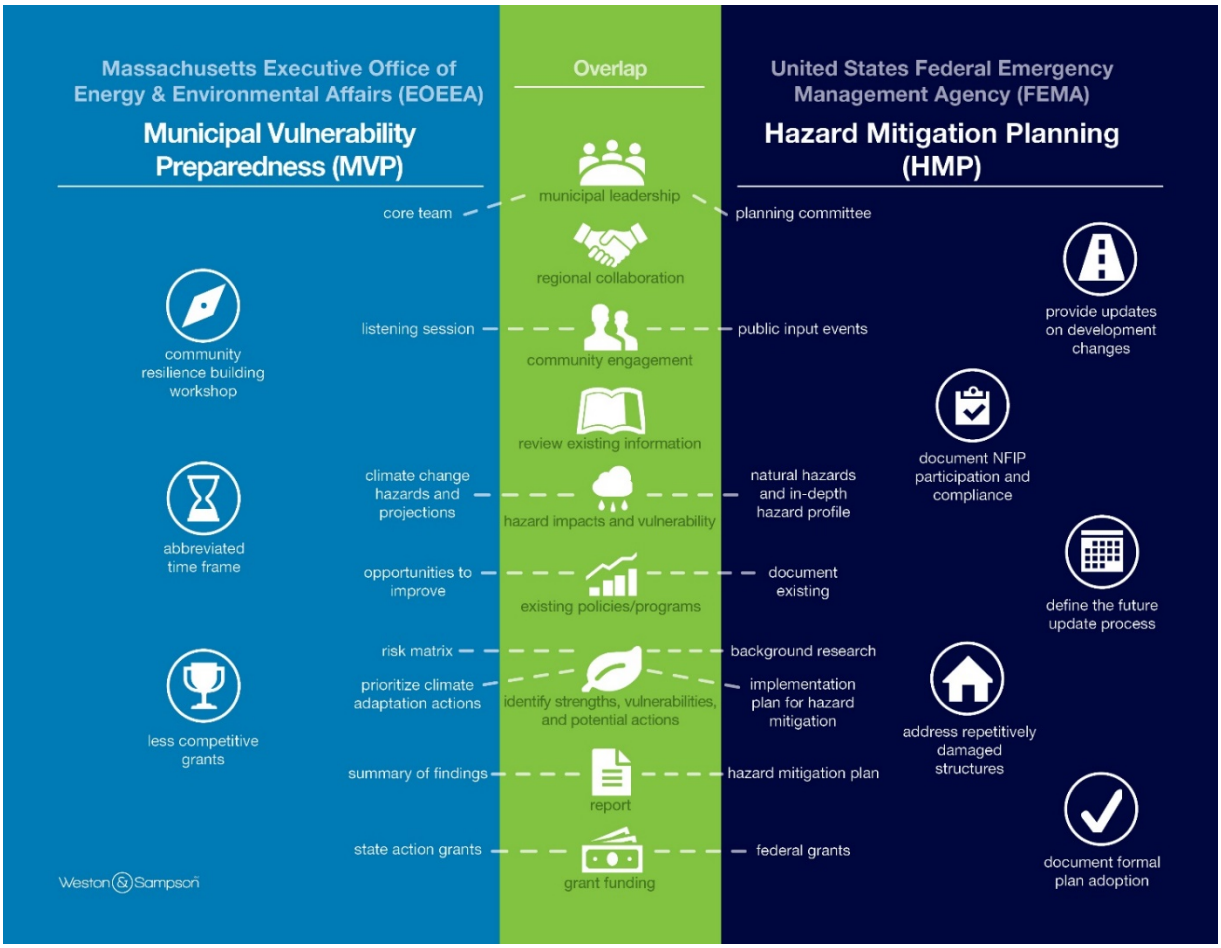


Figure 1-2. Comparison of the MVP and HMP Process

1.4 Planning Process Summary

1.4.1 Core Team

The Town of Townsend convened the Core Team to act as a steering committee for the development of the HMP-MVP Plan. The Core Team met on March 24, 2020 to set goals for the planning process, provide input on historic hazard events, and plan for the CRB Workshop. More information on this meeting is included in Appendix A. The Core Team also provided regular input through email and interviews. The Core Team played an important role in identifying critical infrastructure, involving key stakeholders, and capturing the Town's capacity to mitigate hazard alongside ongoing operations. Members of the Core Team are listed in Table 1-2.

Table 1-2. Townsend's Core Team

Name	Title
James M. Kreidler, Jr.	Town Administrator
Wayne Miller	Chairman, Board of Selectmen
Don Klein	Vice-Chairman, Board of Selectmen
Janet Leavitt	Administrator, Building Department
Laura Shifrin	Vice Chair, Housing Authority

Name	Title
Charles Sexton-Diranian	Planning Board Member
Jerrilyn Bozicas	Planning Board Member
Shirley Coit	Director of TEMA
Mark Boynton	Fire Chief
Jay Sartell	Interim Chief of Police
Dave Henkels	Conservation Administrator
Lance McNally	Planning Board Chair
Susan McNally	Library Trustee
Veronica Kell	Planning Board Clerk
Becky McEnroe	Interim Water Superintendent
Brad Morgan	Superintendent, North Middlesex Regional School District
Carla Walter	Health Administrator
Beth Faxon	Administrator of the Planning Board and Zoning Board of Appeals
Tom Whittier	Deputy Director of TEMA
James Smith	Superintendent of Highway Department

The Core Team also suggested or made available reports, maps, and other pertinent information related to natural hazards and climate change impacts in Townsend. These included:

- Open Space and Recreation Plan (Town of Townsend, 2013)
- Townsend Master Plan Update (Town of Townsend, 2001)
- Townsend Energy Reduction Plan (Town of Townsend 2012)
- Climate Change Data Update for the Montachusett Region (MRPC, 2019)
- Montachusett Region Hazard Mitigation Plan (MRPC, 2015)
- 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 Planning Handbook, May 2017 (FEMA, 2017a)
- Flood Insurance Rate Maps for Townsend, MA (FEMA, 2010)
- Storm Event Database, National Center for Environmental Information (NOAA, 2019)
- National Water Information System (USGS)
- Decennial Census (US Census Bureau, 2010)
- American Community Survey, 5-year estimates (US Census Bureau, 2014-2018)

1.4.2 Stakeholder Involvement: Community Resilience Building (CRB) Workshop

Due to the public health crisis surrounding COVID-19, the Community Resilience Building (CRB) Workshop could not be conducted in person. Instead, the Town hosted a series of three online webinars on April 14, 2020 organized around topic areas that included infrastructure, environment, and society. 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 attend. During these webinars, Weston & Sampson provided information about natural hazards and climate change, including the top four hazards impacting Townsend. Participants were invited to comment on and edit pre-selected infrastructural, societal, and environmental features in town that are vulnerable to, or provide strength against, these challenges.

Figure 1-3. Examples of infrastructural, environmental, and societal features in Townsend.
These include the Townsend Water Department Pump Station (left), Townsend State Forest (center) and Townsend Public Library and Meeting Room (right). Photos by the Town of Townsend

Participants also identified and prioritized key actions that would improve the Town's resilience to natural and climate-related hazards. A full list of community representatives who were invited and those who participated in the process are presented in Appendix C, along with the materials from each webinar. The broad representation of local and regional entities that participated in these webinars ensures that the HMP-MVP Plan aligns with the operational policies and hazard mitigation strategies at different levels of government and implementation. A summary of key participants at each webinar is included below.

1. Infrastructure Webinar: 18 participants, including:
    - Municipal staff members from the Water Department, Police Department, Highway Department, and Conservation Department
    - Members of boards and committees, including the Planning Board, Masterplan Committee, and Zoning Board of Appeals
    - Representatives from local groups, including the Library Trustees, Townsend-Ashby Youth Soccer Association, and Townsend-Ashby Youth Baseball and Softball Association
    - Representatives from State agencies, including the Massachusetts Department of Environmental Protection and the MVP Regional Coordinator

2. Environment Webinar: 16 participants, including:
    - Municipal staff members from the Police Department, Highway Department, and Conservation Department
    - Members of boards, including the Planning Board and Zoning Board of Appeals
    - Representatives from local groups, including the Townsend Cultural Council, Townsend-Ashby Youth Baseball and Softball Association, and Library Trustees
    - Representatives from State agencies and regional organizations, including the Nashua River Watershed Association, Society for the Protection of New Hampshire Forests, Massachusetts Department of Environmental Protection, and the MVP Regional Coordinator

3. Society Webinar: 14 participants, including:
    - Municipal staff members from the Police Department and the Townsend Emergency Management Agency
    - Members of boards and committees, including the Planning Board and Masterplan Committee
    - Representatives from local groups, including the Townsend-Ashby Youth Baseball and Softball Association and the Library Trustees
    - Regional representatives, including the MVP Regional Coordinator

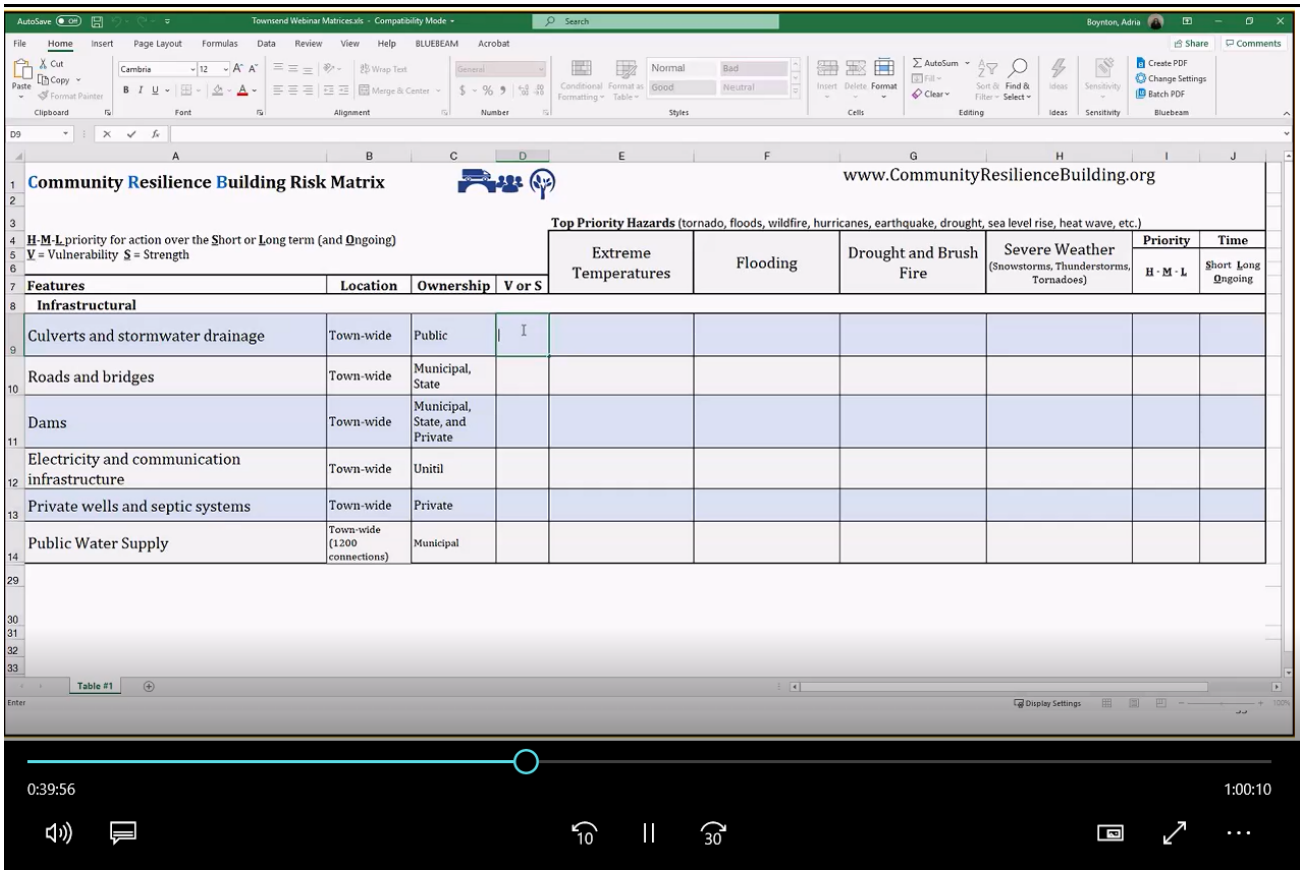


Figure 1-4. A screenshot from Townsend's Community Resilience Building Webinar Recording

For each of these webinars, leadership from neighboring communities of Pepperell, Groton, Shirley, Luneburg, Ashby, Mason, New Hampshire and Brookline, New Hampshire were invited to participate in the Workshop but were unable to attend.

1.4.3 Public Listening Session

Due to the public health crisis surrounding COVID-19, the two required public listening sessions could not be conducted in person. As a solution, and to gather information from the public and educate the public on hazard mitigation and climate change, the Town pursued the below approach:

1. Virtual webinar: this first step involved hosting and recording a Virtual Public Listening Session Webinar. More information on this webinar is included below.

2. Getting the Word Out: this second step involved posting the recorded webinar online, along with an online survey to capture additional input. These online materials allowed residents to engage with the project on their own time, and as their scheduled allowed. The online materials were posted on the Townsend Planning Board and Townsend Master Plan Committee webpage and advertised through the local newspaper, the local cable channel, a press release, email blasts, and a social media post on the Police Department and Public Library Facebook pages. The online survey received thirty-three responses.

The project team planned the webinar to maximize participation and engagement. Step-by-step instructions for joining the webinar were shared with attendees in advance, and moderators were on-hand to assist participants with troubleshooting. The Public Library parking lot was advertised as a location with free Wi-Fi and an alternate call-in number was provided. The webinar started with an icebreaker that allowed attendees to introduce themselves as they joined the call, share their favorite thing about the Town, and test out the webinar's audio and "chat" function. The staffing plan for the meeting included a main facilitator to present information and encourage discussion and a second facilitator to help field questions and moderate the chat. The team also created a presentation that prioritized dynamic, accessible visuals over text-heavy slides.

The webinar presented information related to the MVP program, climate change in Townsend, local strengths and vulnerabilities, existing mitigation measures, and priority action items for future climate adaptation. The webinar also invited attendees to continue participating in the project by taking the online survey. More information about the virtual Public Listening Session, including a summary of survey responses, is available in Appendix D.

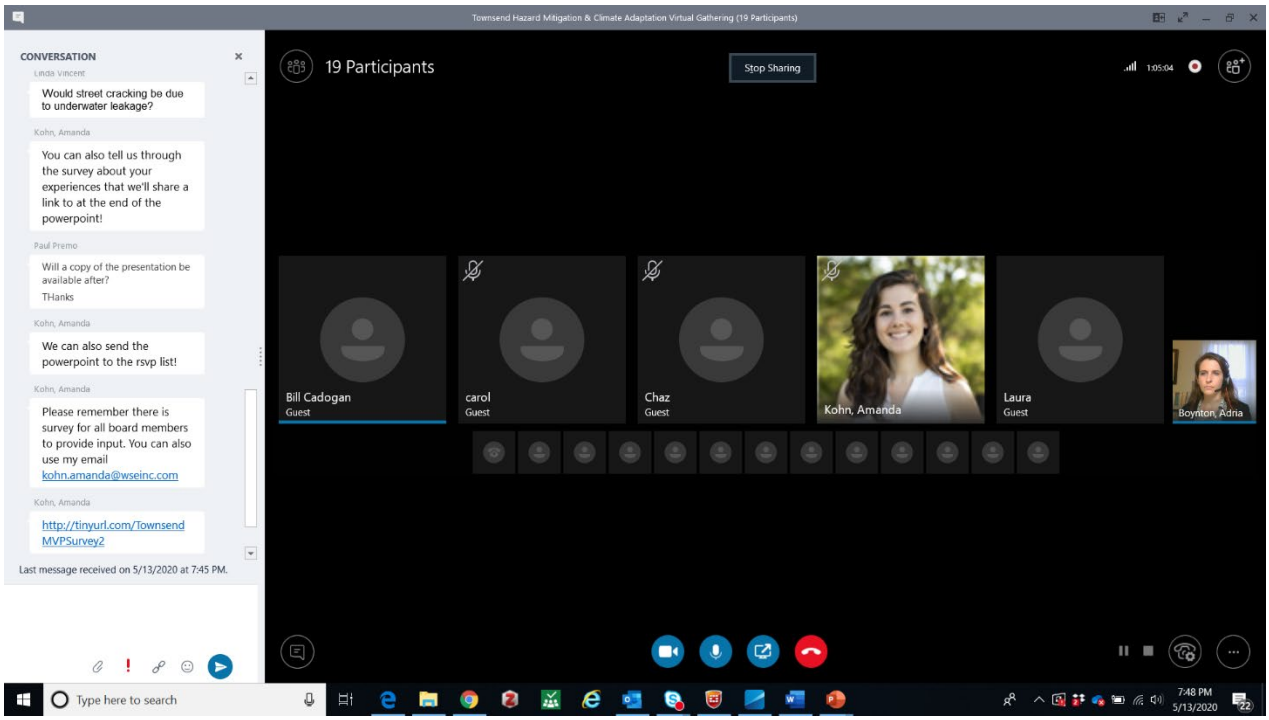


Figure 1-5. A screenshot from Townsend's Public Listening Session Webinar

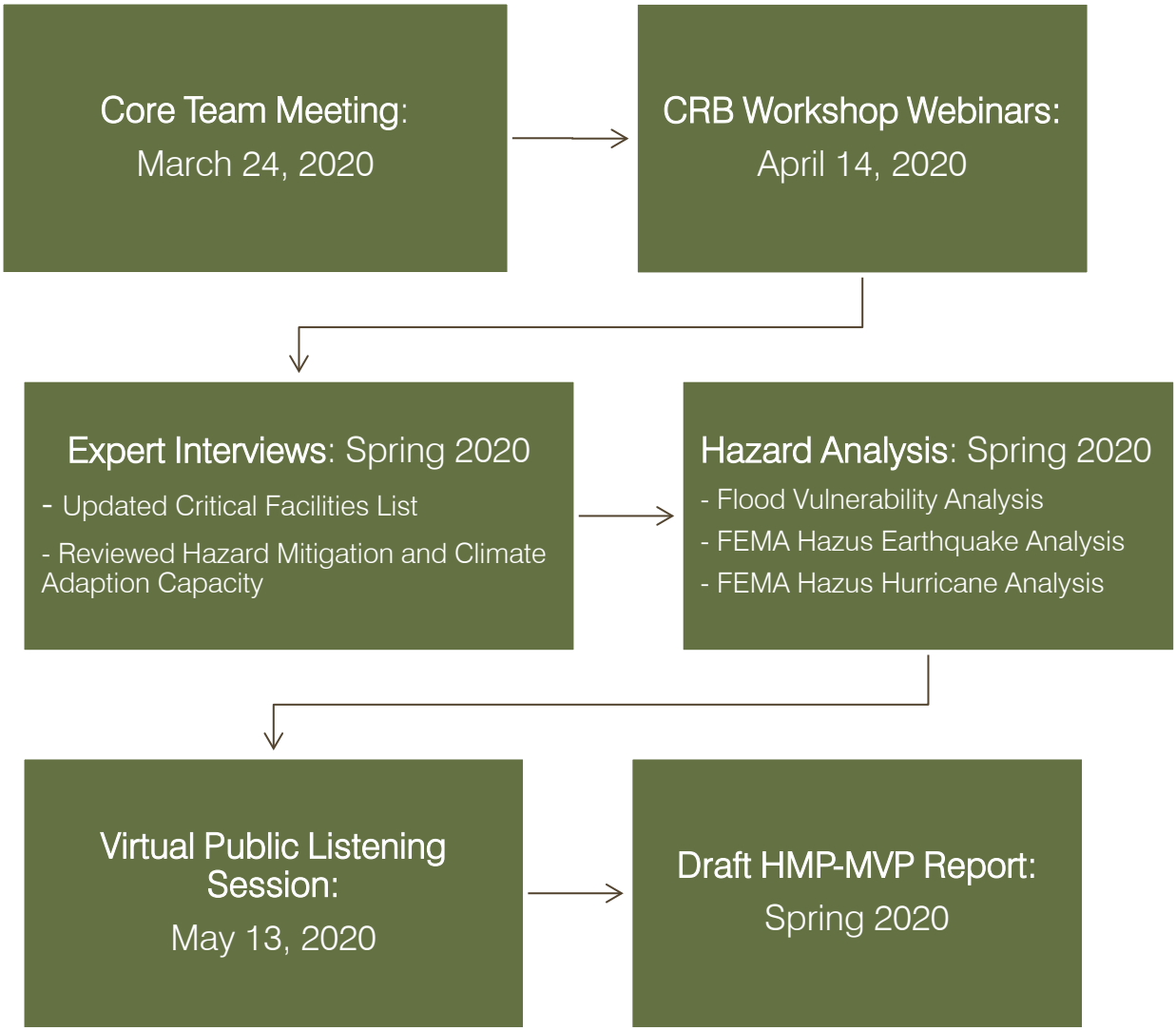
1.4.4 HMP-MVP Report Layout

The report presents the results of the planning process, which was informed by input received from the Core Team and during the CRB Workshop and Public Listening Sessions. This report is organized as follows:

1. Chapter 1: Project introduction and overview
2. Chapter 2: Hazard mitigation and climate adaptation goals
3. Chapter 3: Community profile; societal, economic, infrastructural, and environmental features; land use and development, critical facilities, and vulnerable populations
4. Chapter 4: Detailed assessment of the Town's vulnerability and strengths by hazard type. The hazard types include flooding, wind-related risks (such as hurricanes, tropical storms, tornadoes, nor'easters, and severe thunderstorms), winter storms, geological hazards (such as earthquakes and landslides), brush fires, extreme temperatures, and drought. Each profile also describes the hazards historic occurrences and impact, frequency, level of risk, and climate change projections.
5. Chapter 5: Summary of the existing mitigation measures the Town is currently undertaking
6. Chapter 6: An update of the progress made since the last HMP
7. Chapter 7: An action plan for next steps
8. Chapter 8: Plan adoption, maintenance, and implementation

1.5 Planning Timeline

The HMP-MVP planning process proceeded according to the timeline below.



2.0 HAZARD MITIGATION AND CLIMATE ADAPTATION GOALS

The Townsend Core Team convened to review and discuss the hazard mitigation goals for the HMP-MVP Plan. The following goals were developed and endorsed by the Core Team.

1. Coordination: Increase coordination between Townsend and Federal, State, regional, and local partners.
2. Protection: Develop programs and strategies to protect the following Town features from natural hazards and climate change impacts:
    a. Vulnerable residents, including the elderly, young, homeless, low-income, disabilities, and those with limited English proficiency
    b. Homes and businesses
    c. Cultural and historic resources
    d. Critical infrastructure, including transportation networks
    e. Public utilities, including electric power, water, and wastewater
    f. Public facilities and services
    g. Future development
    h. Open space, conserved land, and other environmental features
3. Planning: Incorporate climate change and natural hazard considerations into Town reports, planning efforts, departments, committees, and boards.
4. Public Outreach: Increase awareness and support for climate change and natural hazard mitigation among local organizations, businesses, and residents through outreach and education.
5. Capacity: Increase the Town's capacity for responding to climate change impacts and natural hazard events through adequate staff, training, supplies, equipment, and guidance.
6. Funding: Identify and pursue funding to support the development and implementation of climate adaptation and hazard mitigation measures.

3.0 COMMUNITY PROFILE, LAND USE, AND DEVELOPMENT TRENDS

Figure 3-1. Townsend Harbor Pond Dam and Cooperage (Town of Townsend, 2020)

3.1. Community Profile

The Town of Townsend is a community rich with history spanning more than three centuries. Originally part of an area called Wistequassuck by the Native Americans, the land was granted to Judge William Hawthorn of Salem as a political gift. Settled in 1676, Townsend was officially incorporated in 1732 and developed as a farming settlement. Over the next two centuries, Townsend saw population growth fueled by agricultural and industrial advancement and perpetuated by the advent of increased coach and rail service from Townsend to surrounding cities. The industrial heart of the town centered around Townsend Harbor Pond, though many manufacturing and agricultural businesses began to slow in the mid-20th century. By the end of the last century and still today, the largest industry and employer in Townsend is Sterlite. With the decrease in industry and agriculture, Townsend has become a residential community with many requisite service providers while retaining much of its rural character. In 2018, the population was 9,547 people (U.S. Census Bureau, 2018), which is approximately a 7% increase from 2010 (U.S. Census Bureau).

Townsend is part the Montachusett-North County Region, which refers to the area economically tied with the cities of Gardner, Fitchburg, and Leominster, and is approximately 51 miles West-Northwest of Boston. Townsend is located in the northwest section of Middlesex County, bordered by

Pepperell, Groton, and Shirley to the East, Lunenburg to the South, Ashby to the West, and Mason, NH and Brookline, NH to the North. Governance of Townsend is overseen by three elected Board of Selectmen who hire a Town Administrator to manage the day to day operations of the town. The Town maintains a website at https://www.townsend.ma.us/.

Table 3-1. Population Demographics

2018	Townsend	Massachusetts
Population	9,547	6,902,149
Under the Age 18	23.3%	20%
Over Age 65	14.8%	16.5%
Bachelor's degree or higher	34.8%	42.9%
Median household income	$85,462	$77,378
Poverty Rate	4.5	11%
With a Disability	7.3%	8%
Limited English-Speaking Skills	3.9	23%
Housing Units	3,570	2,864,989
Renter-Occupancy Rate	15.8%	38%

(US Census Bureau, 2018)

Figure 3-2. Townsend Meeting Hall and Public Library
(Town of Townsend 2020)

3.2. Societal Features

Townsend offers numerous social services including an active senior center, meeting hall, 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 include residents whose everyday stressors make it harder to adapt and recover when shocks or hazards occur. In Townsend, seniors, youth, people who are disabled, non-English speakers, and low-income individuals are considered vulnerable. Youth are the largest vulnerable group in Townsend and represent 23.3% of the total population, 3% more than Massachusetts as a whole (Table 3.1). Townsend is home to North Middlesex Regional School District supporting Early Childhood through High School education as well private early education and day care services.

According to the Townsend Housing Production Plan (2015), the number of senior residents rose from 463 in 1980 to 856 in 2010, an increase of 29.8%, compared to an increase of 9.1% for the general population. The aging of the Baby Boomers will cause the senior population to increase by 1,400 people, or 170 percent, through 2030. As the population continues to increase and grow older emergency service capacity will need to grow at the same rate.

3.2.1. *CRB Workshop Discussion of Societal Features*

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

Table 3-2: Societal Features Identified in the CRB Workshop

Vulnerabilities	Both Vulnerability and Strength
• Residents at risk of isolation, including seniors and children in the presence of increasingly frequent extreme temperatures • Support and resources for residents with limited English fluency • Residents with challenges to prepare for extreme events, including low-income residents and those in low-income housing along the river • Shelters needing additional support/supplies and cooling centers	• Local Businesses (including local farms) • Municipal buildings and services (Police, Fire, Highway Department) • Food Security (supply, delivery, and local farmers)

Figure 3-3: Societal features in Townsend.

Police Department (left) and Spaulding Memorial School (right; Town of Townsend 2020)

3.3. Economic Features

As a smaller, residential community, Townsend's primary industries have shifted since its founding from agriculture to manufacturing. Several businesses and commercial/industrial developments operate in Townsend, including Sterlite Corporation which remains the community's largest employer. The unemployment rate of 4.4% in Townsend is lower the state average (Table 3.3). Communication between businesses and the Town about hazard mitigation planning efforts and developing emergency protocols will be key to increasing resilience. Many of Townsend's residents commute out of Town to go to work. On average, Townsend residents travel thirty-six minutes to work, which is seven minutes longer than the State's average.

Table 3-3: Economic Statistics

	Townsend	Massachusetts
Labor Force	5,310	3,755,481
Unemployment Rate	4.4%	6.0%
Employed in Top Employment Industry - Manufacturing	15.2%	8.9%
Mean Travel Time to Work (minutes)	36.8	29.7

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

3.4. Infrastructure Features

Townsend is located in the northwestern edge of Middlesex County along the New Hampshire border. It is largely bisected by Route 13, Route 119, and Lunenburg Road. Townsend independently supplies drinking water provided by wells within protected and conservation land surrounding the Squannacook River and local tributaries. The Town operates four potable water treatment plants and two large capacity storage tanks located throughout Townsend. Water supply redundancy and the impact of drought is a concern. Additionally, only 2 out of 5 wells have backup generators. Dams within the town are high on the list of vulnerabilities, with three of the seven dams identified as "Significant Hazards" (Montachusett Region Hazard Mitigation Plan, 2015). The majority of the town is supported by on-site septic systems which can be vulnerable to rising groundwater. Backup power of all critical facilities providing water and sewer is essential. Electricity and Communication infrastructures are vulnerable to forest fires spurred by droughts and power outages due to wind, ice and tree damage. Emergency services are generally well equipped, however, services to the West Townsend could be decreased if critical roadways and bridges are flooded. The 2019 MRPC report, "Climate Change Data Update for the Montachusett Region," identified two structurally deficient bridges in 100-year flood zones, including:

1. West Meadow Road over Water Locke Brook, owned by the Town
2. Main Street over Water Pearl Hill Brook, owned by the State

See Section 3.8 for more information on critical facilities in Townsend.

Figure 3-4: Infrastructural features in Townsend.

A dam near Main Street (left) and a road entering Townsend (right; Town of Townsend 2020)

3.4.1. *CRB Workshop Discussion of Existing Infrastructure*

Workshop participants identified key infrastructure features in Townsend 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 3-4: Infrastructural Features Identified in the CRB Workshop

Vulnerability	Both Vulnerability and Strength
• Dams need replacement or removal • Electricity and communication infrastructure need to be diversified to increase resilience during extreme storm and high wind events • Remote areas in Townsend that lack access to reliable internet	• Address culverts and stormwater drainage through water quality improvements and strategies that prepare the system for future stormwater volumes • Roads and bridges should incorporate surface stormwater management strategies and consider future flood levels • Private wells and septic systems • Public water supply needs continued protection

3.5. Environmental Features

Townsend has a total land area of just over 33 square miles. The Squannacook River is formed near West Townsend at the confluence of Walker Brook and Mason Brook. The Squannacook River bisects most of Townsend and is joined by Locke Brook, Willard Brook, Pearl Brook, Bayberry Hill Brook, Bixby Brook, Witch Brook, Trout Brook and several other smaller unnamed streams. Along with these water sources, Wolf Brook, Stewart Brook, Vinton Pond, Harbor Pond and various unnamed ponds are sources of localized flooding. Additionally, there are 56 Natural Heritage and Endangered Species Program (NHESP) certified Vernal Pools, 10 of which qualify with criteria including facultative species or fairy shrimp, and areas with estimated habitats of rare wildlife. Nonpoint source pollution is a concern within many of the waterbodies (including 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. Aquifers are located under the Squannacook Brook State Forest, downstream of the town center between the Harbor Pond, and north and south of Route 119 in West Townsend. The wealth of water resources in Townsend explains the state designation of the majority of Townsend's open water as Area of Critical Environmental Concern (Squannassit ACEC, 2002), Outstanding Resource Waters (ORW), and classification as cold-water fisheries that support brown, brook, and rainbow trout.

In 2013, Townsend completed its Open Space and Recreation Plan intending to balance the competing demands associated with growth and economic development with those for preservation of the natural and historic environment. Unlike many New England municipalities, Townsend does not have many, if any, hazardous material sites. Future potential development represents both a strength and vulnerability and proper oversight and considerations of ACEC's and groundwater resources need to be considered in siting and design. In addition to their abundance of water resources, Townsend has several local and state forests totaling 15,763 acres. Although considered a strength, forests fires occasionally burn, most recently 20 acres in April 2019 (O'Connor 2019). Future drought conditions and lack of forest management could perpetuate uncontrolled burns and shift this resource toward a vulnerability.

Figure 3-5. Figure 3-4: Environmental features in Townsend.

Wetland off Dudley Road (left), Townsend State Forest (center), and Willard Brook (right; Town of Townsend 2020)

3.5.1. *CRB Workshop Discussion of the Environment*

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

Table 3-5: Environmental Features Identified in the CRB Workshop

Vulnerabilities	Both Vulnerability and Strength	Strengths
• Need invasive species controls or removal strategies • Vector borne diseases need greater awareness and prevention education	• Street trees provide shade but require maintenance • Future development, including residential, commercial, resource, downtown, and land use	• Waterbodies • Wetlands • Forests • Parks • Open Space

3.6. Land Use

Townsend is approximately 21,184 acres and has the largest land area of any town in Middlesex County. Three-quarters of the land (75%) is considered forested, comprised of state-owned and locally owned parcels. Residential housing accounts for 10% of the land area. Wetlands and water represent 7% of the total land area, followed by agriculture at 4%. Parcels labeled "Other" account for 3%, while Commercial & Industrial Use make a total of 1% of Townsend's land use. (Fig. 3-6)

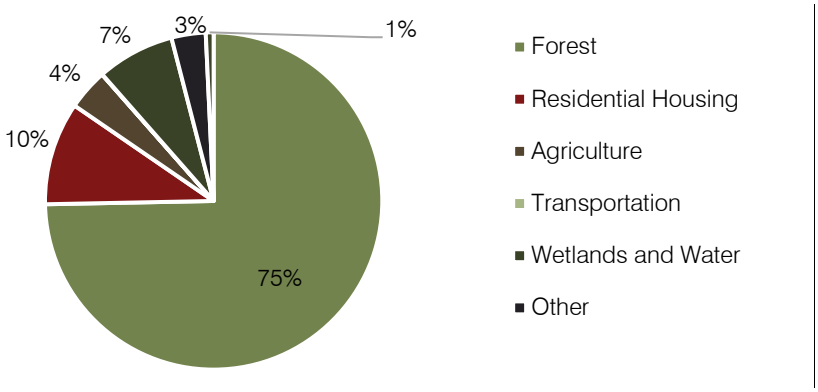


Figure 3-1 Land Use Distribution in Townsend, MA

3.7. Recent and Potential Development

There is currently no major development in Townsend. Since 2000, nine housing developments have been approved with a total of 184 new residential units. However, due to the economic downturn beginning in 2008, only 69 of those were built, 8 of which were affordable units. The downturn and slower economic recovery of Townsend's housing market has made it increasingly difficult for the Town to reach the State's 10% "affordability" goal. From 2005 to 2015, Townsend's subsidized housing inventory (SHI) increased from 80 to 174 units, comprising 5.2% of the total housing stock (Townsend Housing Production Plan, 2015). The new North Middlesex Regional High School building opened in August 2017 with 21st century learning environments and 180,530 square feet of space. The school is designated as an emergency shelter in the Town's emergency action plans.

Strategies for future development are outlined in the town's Housing Production Plan from 2015 and identify, through a needs assessment, a lack of affordable housing that impacts low income renter households, the elderly and others on fixed incomes, lower income homeowners, and young adults and families locked out of homeownership. Impediments to housing and development in Townsend include high productions costs, ecological constraints, water supply constraints, and zoning and regulatory restrictions. The Townsend Planning and Zoning Board of Appeals Administrator provided the list below of recent developments, which were defined as occurring in the last ten years.

Table 3-6: Current and Future Development in Townsend

Name of Development	Address	Type of Development	Number of Housing Units	Sq. Ft.	Date of Completion
Locke Brook Solar Array	22 West Meadow Road	Private property leasing land for the solar array with connection to Unitil	1 MW AC ground mounted solar array covering 5.5 acres		2020 finish date
Campbell Farm OSPD Development	187 & 199 North end Rd	Residential	6 Lots		Permit pending for an amendment
Harbor Trace	Harbor Trace Rd. & Cooperage Way	Residential	17		2018
Lois Lane & Penny Lane	Off Coppersmith way	Residential 40 B phase 3	10 Lois Ln. 7 Penny Ln.		2020
Locke Brook Estates	West Meadow Road	Residential	20 condo units in 5 buildings		Started on 6/2019
Deer Run	Alyssa Dr.	Residential	15 lots		2015
Storage Units	11 Depot Ext.	Commercial	Warehouse-mini	17,220	2013
Storage Units	144 Tyler Rd	Commercial	Warehouse-mini	1,168	2010
Fire Dept.-Station	13 Elm St	Municipal. Included associated parking and utilities. Replaced	Bldg.	12,000	2016

Name of Development	Address	Type of Development	Number of Housing Units	Sq. Ft.	Date of Completion
		an old Fire Station that was demolished.			
Restaurant-Patriot Pizza	24 Main St.	Commercial	Bldg.	3,496	2013
Turnpike Village	72-74 Turnpike Road	Residential	8 Apts.	59,700	2014
Atwood Elder Housing, Inc.	70 Dudley Rd.	Residential	Apartment bldg.	33,758	2010
The Village at Patriot Common	1-6 Trophy Ave.	Residential	7 Lots		2014
BK & BK, LLC Repair garage	366 Main St.	Commercial	Bldg.	3,600	2015
Fire Dept. Engine House West	460 Main	Municipal	Bldg.	640	2018
Pine Ridge Condo Association solar array	52 Fitchburg Road	Ground mounted 750 KW solar array serves the apartment complex			2017
North Middlesex Regional High School	19 Main Street	Built to new design standards for earthquake resilience. Included parking, utilities, and playing fields		180,530	2017
Library & Senior Center Complex	12 Dudley Road	Municipal		23,429	2009

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 include:

1. Resources that can be utilized to respond and recover from natural hazards
2. Facilities where additional assistance might be needed
3. Hazardous sites that could be dangerous if it is compromised during a natural disaster.

Critical facilities in the Town of Townsend have been identified with help from knowledgeable Town staff, MassGIS data, and existing Town and regional plans, including the Montachusett Region Natural Hazard Mitigation Plan (MRPC, 2015). Critical facilities have been broken into four categories: emergency response, nonemergency response, hazardous materials and facilities, and vulnerable populations and community facilities.

Table 3-7: Emergency Response Facilities

Feature Type	Name	Address
Animal Shelter	Town of Ashby/Townsend Animal Control	352 Main Street
	Townsend Veterinary Hospital	354 Main Street
	Best friends veterinary hospital	Main Street
Municipal Buildings	Townsend Town Hall	272 Main Street
	Townsend Highway Department	177 Main Street

Feature Type	Name	Address
Hospitals	Nashoba Valley Regional Hospital	200 Groton Rd, Ayer, MA
	Leominster Hospital	60 Hospital Rd, Leominster
	Emerson Hospital	133 Old Rd to 9 Acre Corner, Concord, MA
	Urgent Care	442 Nashua St, Milford, NH
Communication Infrastructure	Cell Tower	82 Bayberry Hill Road
	Cell Tower	12 Dudley Road
	Cell Tower	Ball Road
	Cell Tower with associated equipment in an on-site building	60 Warren Road
	Repeater Site: standalone tower with only town equipment	139 Lunenburg
	Buried fiber cable IT infrastructure	Between Squannacook and Spaulding schools
Electric Substations	East Power Substation	Main Street
	West Power Substation	West Main Street
Emergency Dispensing Sites	North Middlesex Regional High School	19 Main Street
Emergency Operation Centers	Townsend Memorial Hall	272 Main Street
	Townsend Police Station	70 Brookline Street
	Townsend Police Communication Center	70 Brookline Street
Emergency Shelters	Hawthorne Brook School	64 Brookline Road
	North Middlesex Regional High School (Alternate)	19 Main Street
	Squannacook Early Childhood Center (Alternate)	66 Brookline Road
Fire Department Facilities	Harbor Station	47 Main Street
	Headquarters	13 Elm Street
	West Townsend Station	460 Main Street
	Townsend Center Fire Station	8 Elm Street
	Townsend Center FS- Annex	272 Main Street

Table 3-8: Non-Emergency Response Facilities

Feature Type	Name	Address
Dams	Townsend Harbor Dam	
	Mason Road Dam	
	Bixby Reservoir Dam	
	Adams Dam	
	Graves Pond Dam	
	Pearl Hill Brook Dam	
	VFW Dam	
	Main Street Dam (identified by the Town)	

Feature Type	Name	Address
Energy Resilient Infrastructure	Solar Farm (768KW)	Route13
	Solar Farm (1.2MW)	West Meadow Road
Other Government Buildings	DCR Forest Fire Station	65 Main Street
	Townsend Townhall Clerk	272 Main St
	Garage facility for Water Dept.	14 Ash Street
	Townsend Capital Meeting Room	14 Dudley Street
	Townsend Public Library	12 Dudley Road
	Townsend Senior Center COA	16 Dudley Road
	Townsend Storage Tank	Highland Street
	Townsend Storage Tank	Fitchburg Road
	Townsend Water Department	540 Main Street
	US Post Office	227 Main Street
	Townsend Recreation Building	274 Main Street
	Board of Health	272 Main Street
Supply Store	Hannaford Supermarket	18 Main Street
	McNabb's Pharmacy	233 Main St
	Mr. Mike's Mini Market	Main Street
	Walgreens	18 Main Street
	Apple Meadow Hardware	10 Elm Street
	Old Brick Store	440 Main St
Wastewater Treatment Plant	Wastewater Treatment Plan/Septic System	66 Brookline Road
Public Water Supply	Cross Street Gravel Packed Well 2	Kimplen Court
	DCR Pearl Hill State Park	105 New Fitchburg Rd
	DCR Willard Brook State Forest	599 Main Street
	Harbor Trace Gravel Packed Well	25 Harbor Trace Road
	Main Street Tubular Well Field #1	512 Main Street
	Witches Brook Well 1	14 Ash Street
	Witches Brook Well 2	14 Ash Street
Pumping Stations	Booster Pumping Station	West Meadow Road
Other Critical Facilities	Co-located Food Bank and Clothes Closet	82 Bayberry Hill Road
	Deluxe Corp	12 South Street
	Sterlite Corporation	198 Main Street
	Sterlite Corporation	30 Scales Lane

Table 3-9: Hazardous Materials and Facilities

Feature Type	Name	Address
HazMat Sites	Sterlite Corporation	198 Main Street
	M&M Auto Supply Inc.	5 Center Street
	Apple Meadow True Value Hardware Store	10 Elm Street

Table 3-10: Vulnerable Populations and Community Facilities

Feature Type	Name	Address
Early Education Childcare Facilities	Lecuyer, Jeanne	173 Lunenburg Road
	Village Common Children's Center	3 Brookline St
	Rainbow Preschool & Child Care	27 Main St
	Dussault, Tracy	271 S. Row Road
	Maura Price	16 Regan Rd.
	Michalczyk, Elizabeth	14 Sumac Drive
	Laura Alimayu	6 Pisces Lane
	Kidsborough@ Spaulding	1 Whitcomb St.
	Tammy Sontag	9 Laurel woods Dr.
Sports and Cultural	Townsend-Ashby Squannacook Soccer Complex	42 Mason Road
	Craven Baseball Field	15 New Fitchburg Rd
	Spaulding Baseball (Playing) Fields	1 Whitcomb St
	Townsend Senior Center	16 Dudley Rd
	VFW Post #6583	491 Main St
Religious Centers	Townsend Congregational Church, UCC	3 Brookline St
	St John the Evangelist Catholic Church	1 School St
	New Beginnings United Methodist Church	265 Main St
	First Baptist Church	461 Main St
	Historical Society Harbor Church	80 Main Street
	Greater Grace Community Church	354 Main Street
Elderly Housing	Townsend Woods	70 Dudley Rd
	Atwood Acres	66 Dudley Rd
End of Life Facilities	Hillside Cemetery	Highland St
	Old Burial Ground	Highland Street/Old Meetinghouse Hill Road
	Riverside Cemetery	Dudley Road
	TJ Anderson & Son Funeral Home	250 Main Street
Historic Properties	The Spaulding Cooperage	1 South Street
	The Spaulding Grist Mill	1 South Street

Feature Type	Name	Address
	Reed Homestead	72 Main Street
	Harbor Church	80 Main Street
	Cooperage	1 South Street
	Townsend Historical Society	72 Main Street
Open Space	Howard Park	Howard Road
Schools	North Middlesex Regional High School	19 Main Street
	Hawthorne Brook School	64 Brookline Road
	Squannacook Early Childhood Center	66 Brookline Road
	Spaulding Memorial School	1 Whitcomb Street

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 related climate change projections. The risk and vulnerability assessment examines both the frequency and severity of hazards and their potential impact to the Town of Townsend. Each hazard risk and vulnerability assessment uses previous occurrences and climate projections to identify high risk areas and the likelihood that a hazard will occur. The vulnerability analysis looks at various factors in the community, including 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 also considered as part of 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 conducted by the project team. 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 Townsend on current and future development. FEMA's Hazus software was used to model the potential damage of hurricanes and earthquakes.

4.1 State-wide 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. The 2013 plan summarized 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 on the Frequency and Severity

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

characterizations. Table 4-1 summarizes the frequency and severity of hazard risk in the Commonwealth. These frequency and severity classifications will assist the Town in prioritizing mitigation actions for each hazard.

Table 4-1. 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% probability of magnitude 5.0 or greater in New England in 10 years)	Minor to Catastrophic
Landslide	Low (once every two 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)	Minor to Serious

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

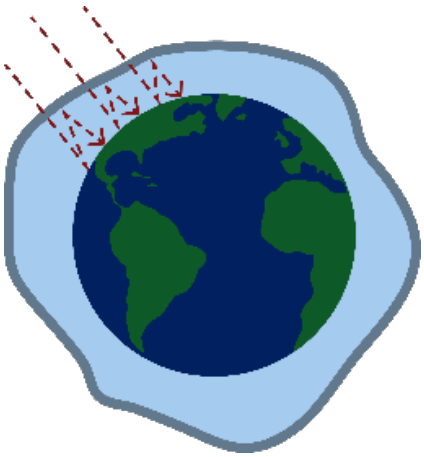
Not all hazards included in the 2018 SHMCAP apply to the Town of Townsend. Given Townsend's inland location, coastal hazards and tsunamis are unlikely to affect the Town. Given the smaller scale of fires that have occurred in Townsend's history and in the northeast region of the country, the Town will focus

on brushfires rather than wildfires due to their smaller size. It is assumed that the entire Town of Townsend and its critical facilities are exposed to earthquakes, high wind events, hurricanes, winter storms, temperature extremes and snow and ice, to a similar extent. Flood risk from riverine flooding is elevated in the vicinity of 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 types of hazards, including flooding, blizzards, and hurricanes. Since 1991, there have been 22 storms in Massachusetts that resulted in federal or state disaster declarations (NOAA, 2019a). 16 disaster declarations occurred in Middlesex County. Federally declared disasters present 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 Townsend 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 (CO2), 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. Due to these changes, the future 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 impact Massachusetts and these trends are likely to continue. Climate change is likely to affect Massachusetts' 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

Community Resilience Building (CRB) Workshop participants were asked to identify the four top climate hazards impacting the Town of Townsend. Those top four hazards included:

The CRB Workshop was designed to bring stakeholders together to brainstorm action items that will facilitate a climate resilient future while also supporting the Town's unique features and characteristics. Concerns related to flooding, power supply, communications, and water supply were frequent topics of discussion. Stakeholders cited flooded roads, remote areas that lack access to reliable internet, and concerns related to the impacts of drought on the water supply.

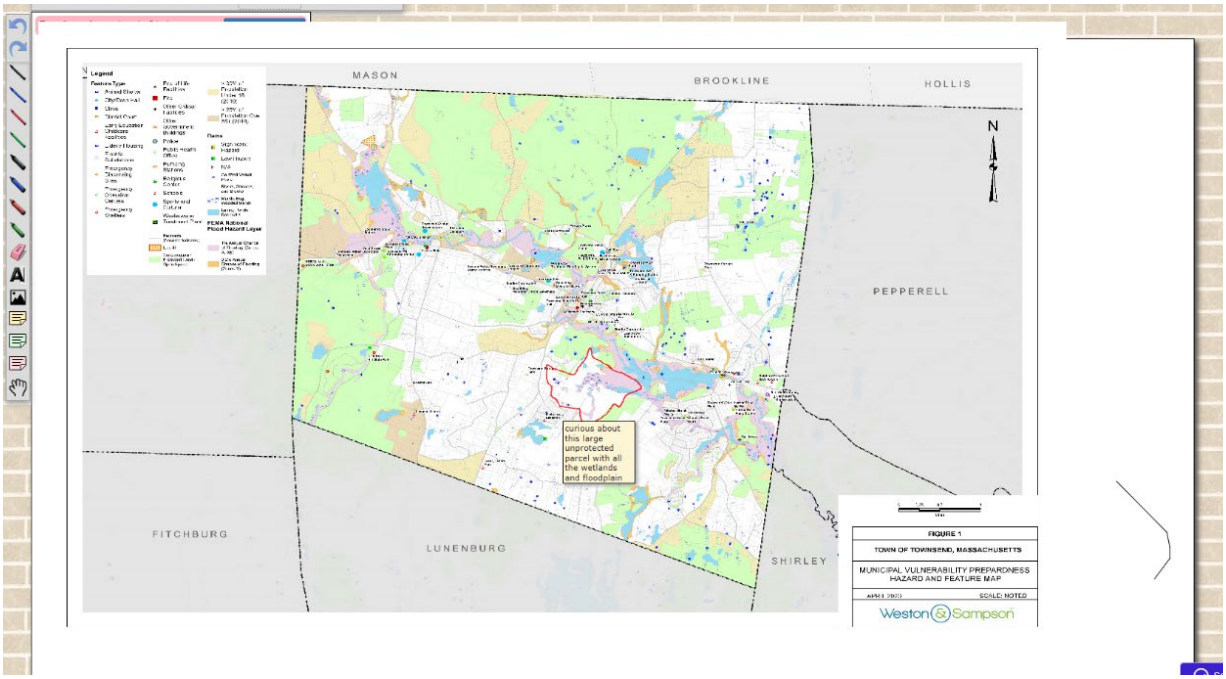


Figure 4-1. A shared, virtual whiteboard of Townsend's hazard map used during the CRB Webinar

4.2 Flood-Related Hazards

Flooding was one of the four main hazards identified by participants during Townsend's CRB Workshop. Flooding can be caused by various weather events including hurricanes, extreme precipitation, thunderstorms, nor'easters, and winter storms. While Townsend currently experiences these events, the impacts of climate change will likely lead to increasingly severe storms and, therefore, increasingly severe flooding. In addition, undersized or outdated stormwater system components and culverts can lead to flooding in Townsend. The winter and spring thaw can also bring challenges to the Town, with clogged catch basins or ice flowing into dams. Beaver dam activity and poor soil drainage can also cause flooding in certain areas.

The effects of flooding include injury or fatalities, property damage, and traffic disruption. Flood hazards are directly linked to erosion, which can compromise receiving water quality, slope stability, and the stability of building foundations. These conditions put current and future structures and populations located near steep embankments at risk. Erosion can also undercut streambeds and scour around stream crossings, creating a serious risk to roadways. Areas within the FEMA Flood Zones, repetitive loss sites, and local areas identified as flood prone are more vulnerable to the impacts of flooding. Flooding events in Townsend can be classified as a high frequency event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard occurs more frequently than once in 5 years or greater than 20% per year.

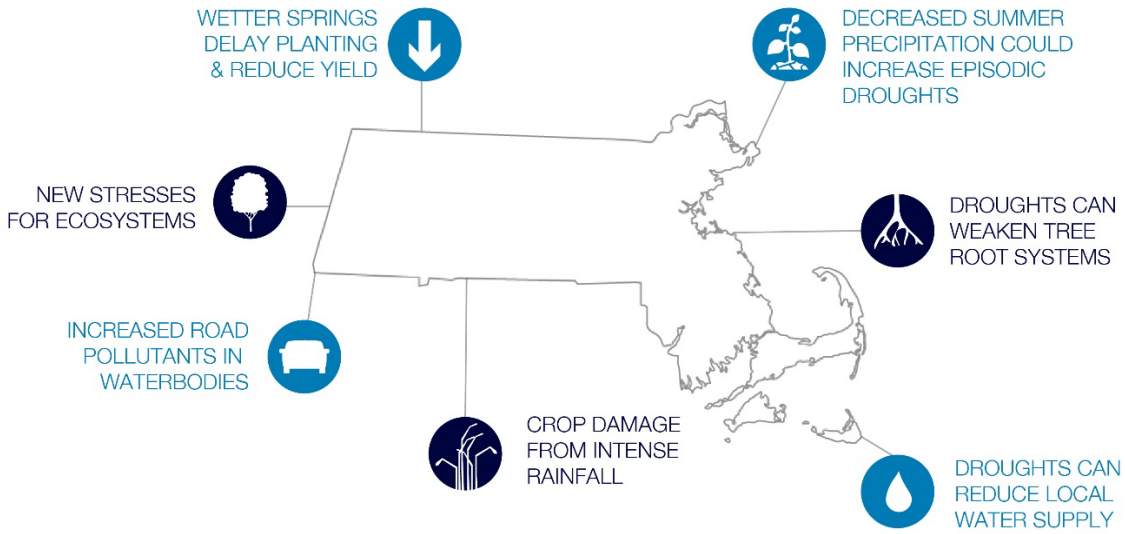


Figure 4-2: An infographic visualizing potential impacts of increasing precipitation (Weston & Sampson based on MA EOEEA, 2018)

The following sub-sections provide more information on historic flooding events, potential flood hazards, a vulnerability assessment, locally identified areas of flooding, and information on the risk of dam failures. This analysis of flood hazard areas was informed by the FEMA Flood Insurance Rate Maps (FIRMs), a GIS vulnerability analysis, information from Townsend municipal staff, and accounts of past flood events provided by public stakeholders.

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 due to blocked or undersized drainage systems.

Riverine Flooding

The entire Town of Townsend is located within the Nashua River Watershed. The town is home to the Squannacook River, which runs through the center of town and flows into Harbor Pond south of Town. Flooding is more common during the spring when snowmelt water from higher elevation flows through the river followed by intense spring showers. More developed areas may have higher amounts of impervious surfaces that can exacerbate flood conditions.

FEMA Flood Zones

FEMA Flood Insurance Rate Maps (FIRM) designate areas likely to experience flooding. The FIRM delineates both the special flood hazard areas and the risk premium zones under the NFIP. This includes high risk areas that have a one percent chance of being flooded in any year (often referred to as the "100-year floodplain"), which under the NFIP, is linked to mandatory purchase requirements for federally backed mortgage loans. It also identifies moderate to low risk areas, defined as the area with a 0.2 percent chance of flooding in any year (often referred to as the "500-year floodplain"). The definitions of these flood zones are provided below. FEMA-designated flood zones for Townsend (FEMA, 2010) are included in Appendix B.

Flood Insurance Rate Map Zone Definitions

Zone A (1% annual chance): 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): 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): 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.

Source: https://www.fema.gov/flood-zones

In addition, Townsend is downstream from other communities and may be impacted by increased development in surrounding municipalities. An analysis of the FEMA FIRM indicates that there is a total of 1575.41 acres of 100-year floodplain within Townsend (7.46% of the Town). Based on additional analysis, 77.87 acres (4.94%) of the floodplain are developed.

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, 2019e). Townsend has three repetitive loss structures, and all are residential buildings (FEMA, 2019d). All of the repetitive loss buildings are located within B, C, or X zones, which are defined by FEMA as areas of moderate or minimal flood hazard (DCR, 2020a). One of the repetitive loss buildings is insured through the National Flood Insurance Program. Table 4-2 illustrates the repetitive loss sites and flood insurance data for Town of Townsend.

Table 4-2. Flood Insurance Data and Repetitive Loss Data

Flood Insurance Data		Repetitive Loss (RL) Data	
Flood Insurance Policies in Force	26	RL Buildings	3
Total Premiums	$23,964	RL Losses	6
Insurance in Force	$6,813,100	RL Payments (total)	$28,087.60
Number of Closed Paid Losses	19	RL Payments (building)	$24,856.00
Dollar Amount of Closed Paid Losses	$54,166	RL Payments (contents)	$3,231.60

(FEMA, 2019d and MA DCR, 2020)

It is important to remember that repetitive loss data only includes buildings that qualify for the repetitive loss designation, which does not represent all losses due to flooding. The numbers of buildings that experience losses due to flooding is likely higher than what is reported above.

Stormwater Flooding

Stormwater flooding occurs during a precipitation event where the rate of rainfall is greater than the capacity of the stormwater management system. 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 4-3 shows how anticipated rainfall during design storms 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 demand on the existing stormwater system by increasing infiltration on-site. Rain gardens and pervious pavement are two examples of possible strategies. Upsizing culverts with new rainfall data is also recommended.

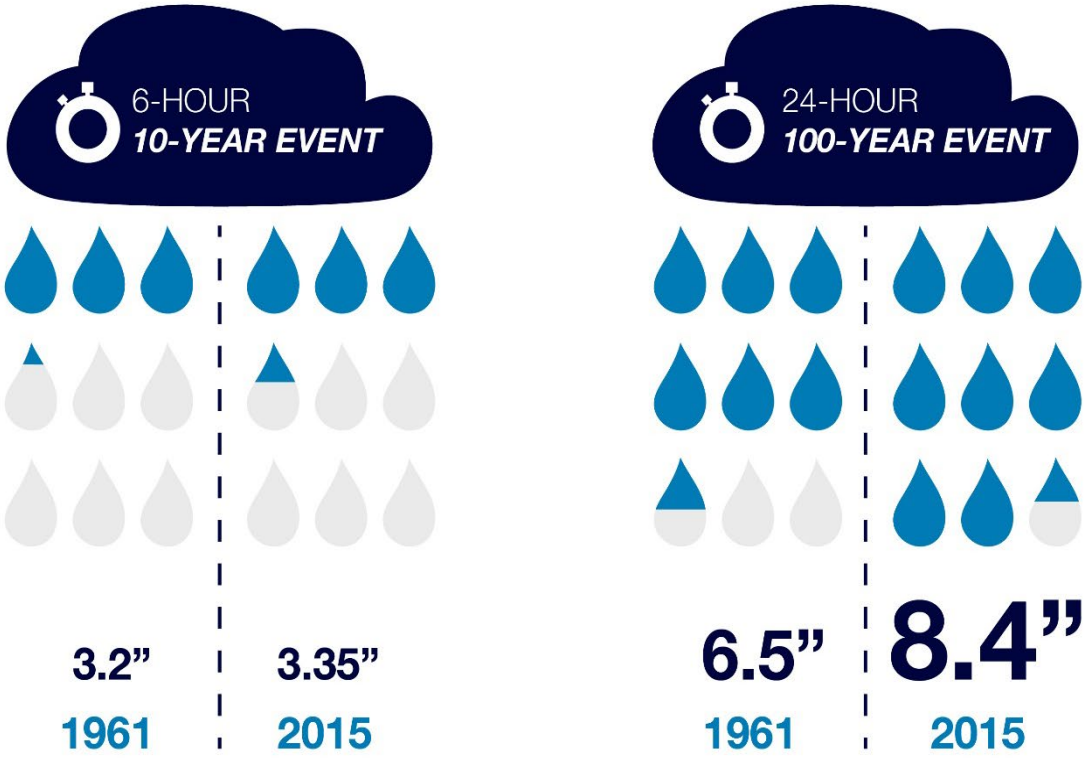


Figure 4-3. Stormwater Design Standards (NOAA TP 40 (1961) and NOAA Atlas 14 Volume 10 (2015))

Locally Identified Areas of Flooding

Town staff and stakeholders helped identify local areas of flooding, summarized in Table 4-3 below. These areas may or may not directly overlap with the FEMA-designated flood zones previously

discussed. However, these areas have been noted to flood during a significant rain event. Identifying these areas is an important part of hazard mitigation planning. An awareness of vulnerable areas, particularly critical emergency routes, can help in prioritizing and implementing climate adaptation projects.

Table 4-3. Locally Identified Areas of Flooding

Name	Description
Route 13	Area will pond during and after heavy rain events and cause flood-related hazards.
North End Road, west of Ball Road	Heavy rain in this area caused the road to flood in 2006. Residents noted that flood-related hazards in this location still exist.
Pearl Hill Brook, south of Old Town Road	Beaver activity exists in the area immediate south of Old Town Road. Culverts that cross the road get blocked up annually and need to be cleared of debris. This causes the area of Pearl Hill Brook (to the south) to become swampy and the road to flood occasionally. Residents noted this area is a continual maintenance issue and there are rain related hazards. They also note that beavers may have moved from this area.
Intersection of South Row, South Harbor and Old Meeting House Road	Beaver activity in this area causes occasional flooding of the intersection and the area to the northeast.
Highland Street by Adams Road	Beaver activity in this location has been a hazardous issue along with heavy rain events.
24 Meadow Road	Beaver activity and damming causes swamping and flooding in the area.
17 Meadow Road	Beaver activity and damming cause flooding. Heavy rain and seasonal runoff hazards are common in the area.

Townsend and Middlesex Flooding Events

NOAA's National Centers for Environmental Information Storm Events Database (NOAA, 2019a) provides information on previous flood and flash flood events for Middlesex County. Flash flood events are considered by the NOAA's 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)" (US Department of Commerce et al., 2018, p.A-15). 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" (US Department of Commerce et al., 2018, p.A-20).

Between 2000 and 2019, Middlesex County has had 129 flood events and 30 flash flood events. 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). Property damages ranged from $1,000 to $26 million. Two events listed in the database were documented as county-wide impacts in May of 2006 with $5 million in damages. Although not all the flooding documented in the database directly affected Townsend, 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 Townsend, due to regionally dependent utilities, supply of goods, transportation networks, and economic impacts, among other considerations.

Federal 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 local capabilities. Ten disaster declarations were made in Middlesex County due to flooding between 2000 and 2019, as can be seen in Table 4-4 below.

Table 4-4. Previous Federal Disaster Declarations - Flooding

Disaster Name and Date of Event	Disaster Number	Type of FEMA Assistance	Counties Under Declaration
Severe Storms and Flooding March 5-April 16, 2001	DR-1364	None	Counties of Bristol, Middlesex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Flooding April 1-30, 2004	DR-1512	Individual & Households Program	Middlesex, Middlesex, Norfolk, Suffolk, Worcester
Severe Storms and Flooding October 7-16, 2005	DR-1614	Public Assistance; Individual & Households Program	All 14 Massachusetts Counties
Severe Storms and Flooding May 12-23, 2006	DR-1642	Public Assistance; Individual & Households Program	Middlesex, Middlesex, Suffolk
Severe Storm and Flooding April 15 - 25, 2007	DR-1701	Public Assistance	Middlesex, Plymouth, Barnstable, Dukes, Hampshire, Hampden, Franklin, Berkshire
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	Public Assistance	All 14 Massachusetts Counties
Severe Storm and Flooding March 12-April 26, 2010	DR-1895	Public Assistance; Individual & Households Program	Bristol, Middlesex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	Public Assistance	Barnstable, Bristol, Dukes, Middlesex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Flooding March 02- 03, 2018	DR-4372	Public Assistance	Middlesex, Norfolk, Bristol, Plymouth, Barnstable, Nantucket

(FEMA, 2020c)

4.2.2 GIS Flooding Exposure Analysis

Hazard location and extent of riverine flooding was determined using the current effective FEMA Flood Insurance Rate Map (FIRM) data for Townsend, which is dated 2010. For purposes of this exposure analysis, the following special flood hazard areas identified in the Town of Townsend's current FIRMs 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 using MassGIS data, FEMA flood maps, and information gathered from the municipality. Table 4-5 below displays critical infrastructure in Townsend that are located within either the 100-year or 500-year FEMA flood zone.

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. To calculate the exposure of parcels and buildings to the flood hazards, parcels with buildings, that are located completely or partially within recognized hazard zones were identified using the ArcGIS overlay analysis (i.e. select by location using the intersect function). The number of parcels and buildings for each land use category was then totaled, along with the value of buildings and real property associated with those parcels.

Table 4-5. Critical Facilities Located within the FEMA Flood Zone

Facility	Address	100-Year Flood Zone	500-Year Flood Zone
Townsend Harbor Dam	N/A	X	
Mason Road Dam	N/A	X	
Adams Dam	N/A	X	
Pearl Hill Brook Dam	N/A	X	
Bixby Reservoir Dam	N/A		X
Graves Pond Dam	N/A		X
VFW Dam	N/A		X
Historic Properties	1 South Street	X	
Historic Properties	72 Main Street	X	
Other Government Buildings (Garage facility for Water Dept.)	14 Ash Street	X	
Historic Building/Nonprofit (Townsend Historical Society)	72 Main Street	X	
Other Government Buildings (DCR Forest Fire Station)	65 Main Street		X
Pumping Station	West Meadow Road	X	
Religious Center	80 Main Street	X	

As demonstrated by Table 4-5, dams, government buildings, historic properties, a pumping station, and a religious center are located in the flood zone. If dams fail, they can cause significant damage to properties and populations downstream.

During the CRB Workshop, stakeholders discussed concern for residents who may experience social isolation, including elderly residents and children. 40 of the 48 census blocks in Townsend are located partially within a FEMA flood zone and have a higher concentration of youth or seniors. More data related to this analysis is included in Appendix B.

Table 4-6. Vulnerable Populations Located within the FEMA Flood Zone

Census Block Number	Vulnerable Populations	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
250173011011005	Minor	1491.0906	0.96	0.06	23.6	1.6
250173011011010	Minor	176.3552	0	0	3.1	1.8
250173011011011	Minor	67.1132	0	0	3.8	5.6
250173011011012	Minor	505.7474	31	6	31.0	6.1
250173011011022	Minor	728.8759	0.42	0.06	52.8	7.2
250173011012000	Minor	1125.3594	0	0	18.1	1.6
250173011012004	Minor	43.1667	8.2	18.9	1.6	3.6
250173011012005	Minor	367.4948	12.5	3.4	10.2	2.8
250173011012006	Elderly	10.0429	3.9	38.8	0.82	8.2
250173011012007	Minor	23.6339	1.9	7.8	0.02	0.07
250173011012010	Minor	545.7393	126	23	12	2.2
250173011012015	Elderly	16.167	2.5	15.2	0.0	0
250173011012019	Minor	101.4088	0	0	32.7	32.2
250173011012020	Minor	210.9848	84.9	40.3	16.2	7.7
250173011012022	Elderly	14.1351	6.5	45.8	1.5	10.6
250173011012023	Elderly	205.1416	31.8	15.5	0.07	0.04
250173011012025	Minor	95.6827	12.4	12.9	0.21	0.22
250173011012034	Elderly	12.3	0.78	6.31	1.0	8.5
250173011012041	Elderly	18.115	4.8	26.5	1.7	9.5
250173011012049	Minor	10.6493	3.6	33.4	2.3	21.7
250173011013000	Minor	325.4231	72.1	22.2	21.9	6.7
250173011013003	Minor	10.8704	0.004	0.038	0.46	4.2
250173011013004	Minor	29.899	0.82	2.75	8.9	29.9
250173011013028	Elderly	1.7962	0.12	6.44	0.20	11.0
250173011013030	Minor	4.2497	0.16	3.77	0.17	3.9
250173011021010	Minor	663.6115	162	24	16.8	2.5
250173011021016	Minor	315.14	30.1	9.5	-	-
250173011021017	Minor	597.0571	2.9	0.5	26.5	4.4
250173011021020	Minor	350.6974	0	0	2.7	0.77

Census Block Number	Vulnerable Populations	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
250173011022005	Minor	257.5679	106	41	14.4	5.6
250173011022007	Elderly	6.6435	0.65	9.72	1.4	20.8
250173011022010	Minor	12.1946	0.71	5.79	0	0
250173011022011	Minor	876.3723	33.2	3.8	64.2	7.3
250173011022016	Minor	18.9973	1.6	8.7	0	0
250173011022018	Minor	72.9391	18.1	24.8	0.60	0.83
250173011022019	Minor	9.7092	0.56	5.76	0	0
250173011022022	Minor	16.3296	2.5	15.5	0	0
250173011022029	Minor	56.6059	0	0	0.39	0.68
250173011022033	Minor	166.8361	34.7	20.8	6.4	3.8
250173011023003	Minor	21.2067	3.9	18.3	2.7	12.9
250173011023011	Minor	7.5579	0.27	3.64	0.82	10.9
250173011023016	Minor	23.4303	0.36	1.54	0.19	0.81
250173011023018	Minor	865.5507	13.8	1.6	1.6	0.19
250173011023026	Minor	141.6363	0	0	6.9	4.9
250173011023031	Minor	367.2286	1.8	0.5	0	0
250173011023034	Elderly	535.8169	0	0	26.4	4.9
250173011023041	Minor	39.9604	4.7	11.8	0	0
250173011011005	Minor	1491	0.96	0.06	23.6	1.6
250173011011010	Minor	176	0	0	3.1	1.8
250173011011011	Minor	67	0	0	3.8	5.6
250173011011012	Minor	506	31	6	31.0	6.1
250173011011022	Minor	729	0.42	0.06	52.8	7.2
250173011012000	Minor	1125	0	0	18.1	1.6
250173011012004	Minor	43	8.2	18.9	1.6	3.6
250173011012005	Minor	367	12.5	3.4	10.2	2.8
250173011012006	Elderly	10	3.9	38.8	0.82	8.2
250173011012007	Minor	24	1.9	7.8	0.02	0.07
250173011012010	Minor	546	126	23	12	2.2
250173011012015	Elderly	16	2.5	15.2	0.0	0
250173011012019	Minor	101	0	0	32.7	32.2
250173011012020	Minor	211	84.9	40.3	16.2	7.7
250173011012022	Elderly	14	6.5	45.8	1.5	10.6
250173011012023	Elderly	205	31.8	15.5	0.07	0.04
250173011012025	Minor	96	12.4	12.9	0.21	0.22
250173011012034	Elderly	12	0.78	6.31	1.0	8.5
250173011012041	Elderly	18	4.8	26.5	1.7	9.5
250173011012049	Minor	11	3.6	33.4	2.3	21.7
250173011013000	Minor	325	72.1	22.2	21.9	6.7

Census Block Number	Vulnerable Populations	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
250173011013003	Minor	11	0.004	0.038	0.46	4.2
250173011013004	Minor	30	0.82	2.75	8.9	29.9
250173011013028	Elderly	2	0.12	6.44	0.20	11.0
250173011013030	Minor	4	0.16	3.77	0.17	3.9
250173011021010	Minor	664	162	24	16.8	2.5
250173011021016	Minor	315	30.1	9.5	-	-
250173011021017	Minor	597	2.9	0.5	26.5	4.4
250173011021020	Minor	351	0	0	2.7	0.77
250173011022005	Minor	258	106	41	14.4	5.6
250173011022007	Elderly	7	0.65	9.72	1.4	20.8
250173011022010	Minor	12	0.71	5.79	0	0
250173011022011	Minor	876	33.2	3.8	64.2	7.3
250173011022016	Minor	19	1.6	8.7	0	0
250173011022018	Minor	73	18.1	24.8	0.60	0.83
250173011022019	Minor	10	0.56	5.76	0	0
250173011022022	Minor	16	2.5	15.5	0	0
250173011022029	Minor	57	0	0	0.39	0.68
250173011022033	Minor	167	34.7	20.8	6.4	3.8
250173011023003	Minor	21	3.9	18.3	2.7	12.9
250173011023011	Minor	8	0.27	3.64	0.82	10.9
250173011023016	Minor	23	0.36	1.54	0.19	0.81
250173011023018	Minor	866	13.8	1.6	1.6	0.19
250173011023026	Minor	142	0	0	6.9	4.9
250173011023031	Minor	367	1.8	0.5	0	0
250173011023034	Elderly	536	0	0	26.4	4.9
250173011023041	Minor	40	4.7	11.8	0	0

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 in hazard areas and their respective assessed values. The parcel data set includes size, land use type, and assessed value. The parcel data was also classified into various land use types based on the Massachusetts Department of Revenue's Property Type Classification Code, 2019.

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 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 18% of the developed parcels in Townsend are located within the FEMA 100-year flood zone, while an additional 25% is in the 500-year FEMA flood zone. Residential properties have the greatest area located in both flood zones and some of the highest property value in both flood zones. Institutional development has a slightly higher property value in the 100-year flood zone. Additionally, over 90% of institutional parcels are in the 100-year flood zone. Institutional parcels may include government facilities. Tables 4-7 and 4-8 below show the exposure of developed parcels in the Town of Townsend.

Table 4-7. Developed Parcels in 100-Year FEMA Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone	Property Value in the Flood Zone
Residential	3051	7577	273	914	12	$54,371,800
Commercial	82	595	11	294	49	$3,041,800
Industrial	13	114	3	51	45	$2,104,600
Government	23	294	10	266	91	$56,698,500
Agricultural	1	16	N/A	N/A	N/A	N/A
Open Space	N/A	N/A	N/A	N/A	N/A	N/A
Total	**3170**	**8597**	**297**	**1525**	**18**	**$116,216,700**

Table 4-8. Developed Parcels in 500-Year FEMA Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone	Property Value in the Flood Zone
Residential	3051	7577	419	1560	21	$83,722,000
Commercial	82	595	11	300	50	$2,632,600
Industrial	13	114	5	56	49	$2,286,900
Government	23	294	9	204	69	$27,643,500
Agricultural	1	16	N/A	N/A	N/A	N/A
Open Space	N/A	N/A	N/A	N/A	N/A	N/A
Total	**3170**	**8597**	**444**	**2120**	**25**	**$116,285,000**

The MassBuilds database does not provide development data for the Town of Townsend. Instead, information about recent developments or redevelopments within the past 10 years (2010 – 2020) was provided by the Townsend Planning Board and Zoning Board of Appeals Administrator. 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. There are no recently developed

properties in 100-year flood zone, but there are two properties that are located in the 500-year flood zone.

Table 4-9. Recently Developed Parcels in the 500-Year FEMA Flood Zone

Development Name	Development Address	Land Use Type	Total Area of Parcels (acres)	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone	Property Value in the Flood Zone
Fire Department Station	13 Elm Street	Government	0.72	0.01	0.9	$1,580,400
	10 Lois Lane	Residential	0.45	0.37	83	N/A
Total			**1.17**	**0.38**	**32**	**$3,157,000**

As Townsend's population grows, so does the demand for additional facilities. To further resiliency in the Town, a flood exposure analysis was completed on all vacant, developable parcels. The analysis was conducted utilizing MassGIS data, FEMA flood maps, and information from the Town. The results of this analysis identifies future flooding that could occur on these parcels if they were to be developed.

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 the FEMA Flood Zones. While 793 acres of land in Townsend are vacant and developable, 33% of that land is located within the 100-year flood zone and an additional 30% is 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 4-4. Developable, Vacant Land in the 100-Year FEMA Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Residential	82	710	13	228	32
Commercial	14	48	5	2	4
Industrial	7	36	2	34	94
Government	N/A	N/A	N/A	N/A	N/A
Agricultural	N/A	N/A	N/A	N/A	N/A
Open Space	N/A	N/A	N/A	N/A	N/A
Total	**103**	**794**	**20**	**264**	**33**

Table 4-5. Developable, Vacant Land in the 500-Year FEMA Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Residential	82	710	14	206	29
Commercial	14	48	1	0	1
Industrial	7	36	2	34	94
Government	N/A	N/A	N/A	N/A	N/A
Agricultural	N/A	N/A	N/A	N/A	N/A
Open Space	N/A	N/A	N/A	N/A	N/A
Total	**103**	**794**	**17**	**240**	**30**

The information about recent developments provided by the Townsend Planning Board and Zoning Board of Appeals Administrator was overlaid with the FEMA flood zones 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. 83% of the potential development of Locke Brook Solar array is located in the 100-year flood zone. However, the facility is outside of 500-year flood zone. More information is included in Tables 4-12 and 4-13 below.

Table 4-6. Planned Development in the 100-Year FEMA Flood Zone

Development Name	Development Address	Land Use Type	Total Area of Parcels (acres)	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Locke Brook Solar array	22 West Meadow Road	Residential	35	29	83
Total			**35**	**29**	**83**

Table 4-13. Planned Development in the 500-Year FEMA Flood Zone

Development Name	Development Address	Land Use Type	Total Area of Parcels (acres)	Total Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Locke Brook Solar array	22 West Meadow Road	Residential	35	0.04	0.1
Total			**35**	**0.04**	**0.1**

4.2.3 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 second 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 back 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.

There have been no recorded dam failures in Townsend, and although dam failure is classified as a very low frequency event in the town, a dam failure can still present a high level of risk and could result in a catastrophic event with extreme damage and loss of life. These impacts can be at least partially mitigated through advance warning to communities that would be impacted by a dam failure. In addition, the breach may result in erosion on the rivers and stream banks that are inundated. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, a very low frequency hazard may occur less frequently than once in 100 years (less than a 1% chance per year).

According to the Massachusetts Department of Conservation and Recreation's (DCR) Office of Dam Safety, there are seven dams in Townsend. Information related to these dams is summarized in Table 4-14. 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 4-14. Inventory of Dams in Townsend

Dam Name	Dam Owner	Hazard Potential Classification
Bixby Reservoir Dam	David R. Dyer	Low
Pearl Hill Brook Dam	DCR	Low
Adams Dam	Town of Townsend	N/A
Graves Pond Dam	Unknown	N/A
Townsend Harbor Dam	Hollingsworth & Vose Company	Significant
Mason Road Dam	John M. and Barbara Delaney	Low
VFW Dam	Department of Fish and Game	N/A

(Office of Dam Safety 2019)

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, 2020b). 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 owner 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.

4.2.4 Climate Change Impacts: Flooding

Extreme rain and snow events are becoming increasingly common and severe, particularly in the Northeast region of the country (Figure 4-4). Large rain or snow events that happened once a year in the middle of the 20th century now occur approximately every nine months. Additionally, the largest annual events now generate 10% more rain than in 1948. Regionally, New England has experienced the greatest increase in frequency of extreme rain and snow events. These events now occur 85% more frequently than they did 60 years ago (Madsen and Willcox, 2012). A more recent study demonstrates that 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).

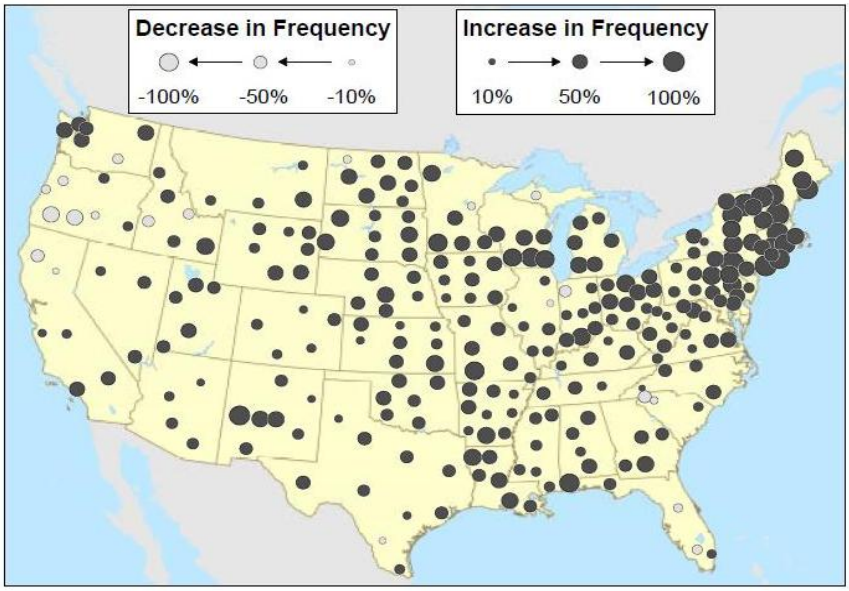


Figure 4-4. Changes in Frequency of Extreme Downpours
(Madsen and Willcox, 2012)

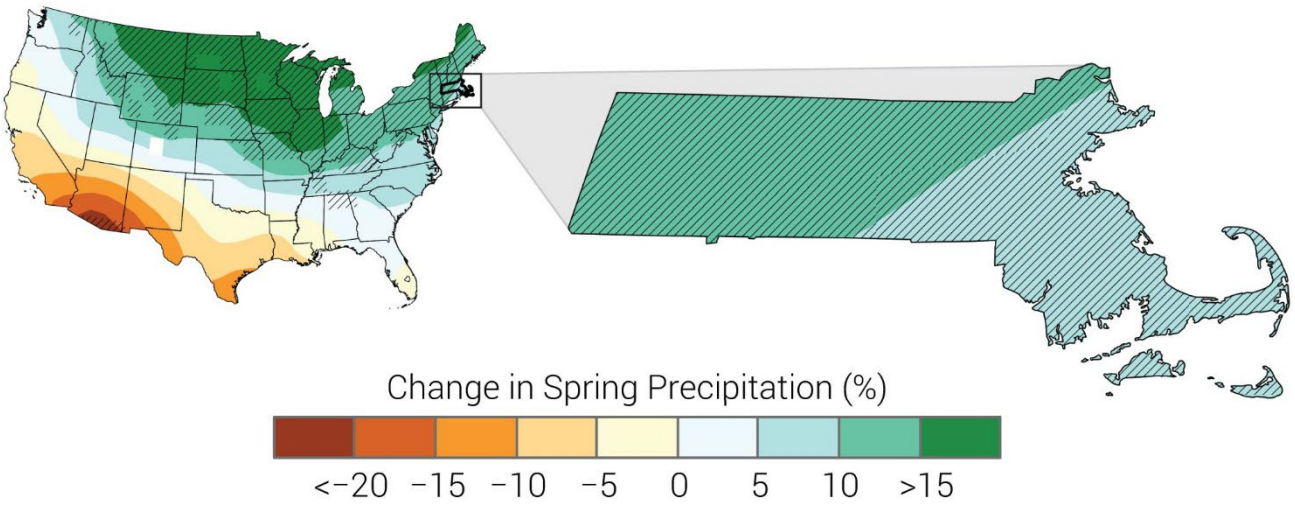


Figure 4-5. Projected Change in Spring Precipitation in Massachusetts (NOOA and Department of Commerce, 2017)

4.3 Wind Related Hazards

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. Wind may down trees and power lines, cause property damage and hazardous driving conditions. While Townsend's current 100-year wind speed is 95 mph (ASCE, 2018), climate change will likely increase events and severity.

The planning process identified vulnerabilities related to potential storm damage to power and phone wires if overhanging trees have not been trimmed by the electric utilities (Unitil) or the phone or cable companies. The tree maintenance program by Unitil should be upgraded in an effort to reduce the risk associated with tree damage to utility lines. During Townsend's MVP Workshop in May 2020, attendees discussed the impact of past storms on power systems and service disruption. High winds and heavy snow loads caused significant power line damage in Townsend during a nor'easter in 2018. Falling trees and branches can also block traffic and emergency routes. Town officials stated that their communications systems may be at risk during flooding and high wind events. The development of emergency communication plans for vulnerable populations should be developed, that includes an inventory of current resources and an identification of additional needs.

4.3.1 Severe Storms and Thunderstorms

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 Townsend. Thunderstorms can include lightning, winds of up to 60 mph, heavy rain, hail, and sometimes tornadoes. Thunderstorms typically last for about 30 minutes. During periods of drought, lightning from thunderstorm cells can also result in fire ignition. Thunderstorms with little or no rainfall are rare in New England but have occurred (EEA and EOPSS, 2018).

Table 4-7. Federal Disaster Declarations in Middlesex County – Severe Storms (2000-2019)

Disaster Name and Date of Event	Disaster Number	Type of Assistance	Counties Under Declaration
Severe Storms & Flooding March 5-April 16, 2001	DR-1364	None	Counties of Bristol, Middlesex, Essex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storm February 17-18, 2003	EM-3175	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Storms and Flooding October 7-16, 2005	DR-1614	FEMA Public Assistance; FEMA Individual & Households Program	All 14 Massachusetts Counties
Severe Storms and Flooding May 12-23, 2006	DR-1642	FEMA Public Assistance; FEMA Individual & Households Program	Middlesex, Suffolk, Essex
Severe Storm and Flooding April 15, 2007 - April 25, 2007	DR-1701	FEMA Public Assistance	Middlesex, Plymouth, Barnstable, Dukes, Hampshire, Hampden, Franklin, Berkshire
Severe Storm and Flooding March 12-April 26, 2010	DR-1895	FEMA Public Assistance; FEMA Individual & Households Program	Bristol, Middlesex, Essex, Suffolk, Norfolk, Plymouth, Worcester
Severe Storm October 29 -30, 2011	EM-3343	None	Middlesex, Essex, Norfolk, Worcester, Hampshire, Hampden, Franklin, Berkshire

(FEMA, 2020c)

NOAA's National Centers for Environmental Information offers thunderstorm data for Middlesex County, which includes Townsend. Between 2000 and 2019, 371 thunderstorm events (8 originated in Townsend) caused $3,902,550 in property damages. Seven injuries and no deaths were reported.

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. On May 11, 2020, a powerful storm accompanied by microburst knocked down several trees from residential streets in the Nashoba Valley area (Lowellsun, 05/18/2020) and affected Townsend and the neighboring towns of Groton, Pepperell, and Westford.

Thunderstorms are considered high frequency events in Townsend. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur more frequently than once in 5 years or greater than 20% per year.

4.3.2 Tornadoes

A tornado is a narrow, violently rotating column of air that extends from the base of a cloud to the ground. 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 1995 Great Barrington, Massachusetts, tornado occurred in May; and the 1979 Windsor Locks, Connecticut, tornado 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 4-16 provides more detailed information on the EF Scale.

Table 4-8. 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 experiences an average of 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 recent tornadoes in Massachusetts occurred in 2011 in Springfield, 2014 in Revere, and 2016 in Concord. The most recent Tornado watch was on May 15, 2020 and included Middlesex County. There have been 18 recorded tornados in Middlesex County since 1955. One fatality and six injuries were reported. Table 4-17 below provides additional information.

Table 4-9. Tornado Records for Middlesex County 1950-2019

Date	Fujita	Fatalities	Injuries	Property Damage
10/24/1955	1	0	0	$2,500
6/19/1957	1	0	0	$25,000
6/19/1957	1	0	0	$250
7/11/1958	2	0	0	$250,000
8/25/1958	2	0	0	$2,500
7/3/1961	0	0	0	$25,000
7/18/1963	1	0	0	$25,000
8/28/1965	2	0	0	$250,000
7/11/1970	1	0	0	$25,000
10/3/1970	3	1	0	$250,000
7/1/1971	1	0	1	$25,000
11/7/1971	1	0	0	$250
7/21/1972	2	0	4	$2,500,000
9/29/1974	3	0	1	$250,000
7/18/1983	0	0	0	$250
9/27/1985	1	0	0	$250
8/7/1986	1	0	0	$250,000
8/22/2016	1	0	0	$1,000,000

(NOAA, 2019a)

Although tornadoes are a potential town-wide hazard in Townsend, there have been no recorded tornadoes in the town. If a tornado were to occur in Townsend, damages would depend on the track of the tornado and would be most likely due to the prevalence of older construction and the density of development that exist. 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. Tornado events in Townsend are a very low frequency event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur less than once in 100 years (a less-than 1% chance per year). Tornadoes are difficult to simulate well in climate models because of their small size. However, it is predicted that the frequency of tornadoes in eastern Massachusetts will rise in the future due to climate change.

4.3.3 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 could 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 Townsend'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 4-18.

Table 4-10. 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.

(MEMA and DCR, 2013) (table originally created by NOAA)

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. Between 1938 and 2019, Massachusetts experienced over twenty hurricanes or related storm events. The most recent FEMA disaster declaration in Massachusetts due to a hurricane was Hurricane Sandy in 2012 (FEMA, 2019b). Hurricanes that have occurred in the region since 1938 are listed in Table 4-19. Four were Category 3 events.

Table 4-19. 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 Event	Date
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012
Hurricane Jose	September 20, 2017
Hurricane Florence	September 18, 2018
Tropical Storm Dorian	September 7, 2019

*Category 3 (EEA and EOPSS, 2018 and Blake et al., 2007)

Hurricane damage in Townsend 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 Townsend was outlined by the census tracts in the Town and the probabilistic scenario was used. 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 Townsend 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 4-11. Estimated Damages in Townsend from Probabilistic Category 2 Hurricanes

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged[1]	Percent of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	2,991	19	0.6%	$4,818,730
Commercial	177	1	0.6%	$28,530
Industrial	61	1	1.6%	$4,420
Others	40	1	2.5%	$6,420
TOTAL	**3,269**	**22**	**0.8%**	**$4,858,100**

[1]Includes Minor, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

Table 4-12. Estimated Damages in Townsend from Probabilistic Category 4 Hurricanes

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged[1]	Percent of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	2,991	245	8.2%	$ 18,576,910
Commercial	177	10	5.6%	$242,670
Industrial	61	3	4.9%	$47,280
Others	40	2	2.0%	$68,080
TOTAL	**3,269**	**260**	**8.0%**	**$ 18,934,930**

[1]Includes Slight, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

In addition to infrastructural damage, Hazus also calculates the potential societal impact, property damage, and business interruption loss. A full Hazus risk report for each hurricane category can be found in Appendix B. Hurricanes are a town-wide hazard in Townsend and are considered a medium frequency event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard occurs from once in 5 years to once in 50 years, or 2% to 20% per year.

4.3.4 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 winter 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 on at least an annual basis, typically in late fall and early winter. Some years bring up to four nor'easter events. This is currently the most frequently occurring natural hazard in the state. 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). Some of the historic events described in the "Flood-Related Hazards" section of this report was 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 Townsend 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, Townsend is not subject to the coastal hazards often associated with nor'easters. Nor'easters in Townsend are high frequency events. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur more frequently than once in 5 years or greater than 20% per year. Previous nor'easters events are listed in Table 4-22.

Table 4-22. Nor'easter Events for Massachusetts, 1978 to 2020

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, 2019a)

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 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. Additional impacts can include fatalities, injuries, 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 residents 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 Townsend. 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. Examples of winter storms that warranted disaster declarations are summarized in Table 4-23.

Figure 4-6: Snow in Townsend. Photos from Townsend, MA Facebook

Table 4-23. Federal Disaster Declarations in Middlesex County – Winter Weather (2000-2019)

Disaster Name and Date of Event	Disaster Number	Type of Assistance	Counties Under Declaration
Snowstorm March 05, 2001 - March 07, 2001	EM-3165	FEMA Public Assistance	Middlesex, Essex, Norfolk, Worcester, Hampshire, Franklin, Berkshire
Snowstorm December 6-7, 2003	EM-3191	FEMA Public Assistance	Middlesex, Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Worcester, Hampshire, Hampden, Franklin, Berkshire
Snowstorm January 22 - 23, 2005	EM-3201	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm December 11-18, 2008	EM-3296	None	Middlesex, Essex, Suffolk, Bristol, Worcester, Hampshire, Hampden, Franklin, Berkshire
Severe Winter Storm and Snowstorm January 11-12, 2011	DR-1959	FEMA Public Assistance	Berkshire, Middlesex, Hampden, Hampshire, Essex, Norfolk, Suffolk
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	FEMA Public Assistance	Barnstable, Bristol, Dukes, Middlesex, Essex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Flooding March 02- 03, 2018	DR-4372	FEMA Public Assistance	Middlesex, Norfolk, Bristol, Plymouth, Barnstable, Nantucket
Severe Winter Storm and Snowstorm March 13-14, 2018	DR-4379	FEMA Public Assistance	Middlesex, Essex, Norfolk, Suffolk, Worcester

(FEMA, 2020c)

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) and National Weather Service, 2019). Winter storms can be combined with the nor'easters discussed previously in the section 4.3.4.

The current winter snowfall record in Eastern Massachusetts is 108.6 inches during the 2014-2015 season. NOAA's National Centers for Environmental Information Storm Events Database provides 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. Blizzards are classified as high frequency events in Townsend. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard can occur more than once in five years or greater than 20% per year).

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 criteria 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 Townsend. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard can occur from once in five years to once in 50 years, or 2% to 20% per year).

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 (MEMA and DCR, 2013). There were no data entries for sleet in Middlesex County in NOAA's National Centers for Environmental Information Storm Events Database (NOAA, 2019a).

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, 3 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.

4.5 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 4-24 summarizes Richter scale magnitudes and corresponding earthquake effects (MEMA and DCR, 2013).

Table 4-13. 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 occasionally in New England as compared to other parts of the country but are oftentimes so small that they are not felt. 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. Historically, moderately damaging earthquakes strike somewhere in the region every few decades, and smaller earthquakes are felt approximately twice per year (MEMA and DCR, 2013). A summary of historic earthquakes in Massachusetts is included in Table 4-25 below.

Table 4-14. Historical Earthquakes in Massachusetts and Surrounding Area, 1727-2020

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

Location	Date	Magnitude
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
MA - Nantucket	4/12/2012	4.5
MA – Newburyport	2/20/2013	2.3
MA – Freetown	1/9/2014	2.0
MA – Bliss Corner	2/11/2014	2.2
MA – off Northshore	8/18/2014	2.0
MA – Rockport Coast	6/1/2016	2.2
MA – Nantucket	8/18/2018	2.4
MA – Templeton	12/21/2018	2.1
MA – Gardner	12/23/2018	2.2
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 man-made 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 4-7 provides additional information.

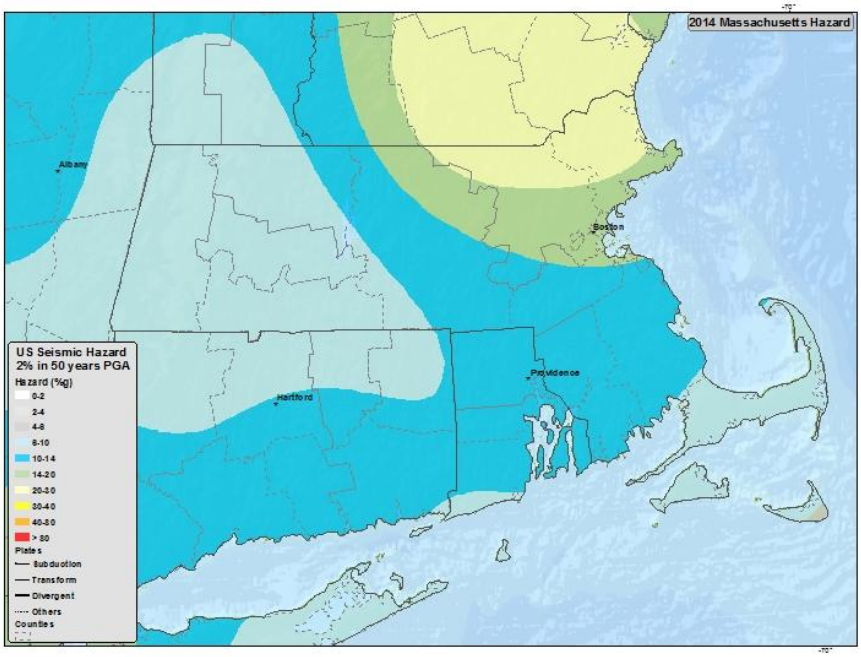


Figure 4-7. 2014 Seismic Hazard Map- Massachusetts (USGS)

Townsend is located in an area with a PGA of 16 %g with a 2% probability of exceedance in 50 years (Figure 4-7). Compared to the rest of the United States, Massachusetts overall has a low risk of earthquakes. However, a serious earthquake in Massachusetts is possible. No earthquake epicenters have been recorded within Townsend.

It can be assumed that 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. These events can strike without warning and can have a devastating impact on infrastructure and buildings constructed prior to earthquake resistant design considerations. 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. Based on the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, the degree of exposure "depends on many factors, including the age and construction type of the structures where people live, work, and go to school; the soil type these buildings are constructed on; and the proximity of these building to the fault location." Furthermore, the time of day exposes different sectors of the community to the hazard.

Earthquakes often trigger fires and the water distribution system may be disrupted, thus posing a risk for public health and safety. 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).

Potential earthquake damage was modeled for Townsend using Hazus. 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 Townsend was outlined by the census tracts in the Town. The arbitrary event scenario was used for Townsend. This scenario 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 Townsend 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 4-15. Magnitude 5.0 Earthquake Damage

Infrastructural Damage from a Magnitude 5.0 Earthquake on Buildings in Townsend				
Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged	Percent of Buildings Damaged	Total Value of Building Damage[1]
Residential	2,991	1,382	46.2%	$87,488,800
Commercial	177	137	77.4%	$24,682,300
Industrial	61	48	78.7%	$5,694,600
Others	40	29	72.5%	$6,656,600
TOTAL	**3,268**	**1,596**	**48.8%**	**$124,522,300**

[1]Includes Minor, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

Table 4-16. Magnitude 7.0 Earthquake Damage

Infrastructural Damage from a Magnitude 7.0 Earthquake on Buildings in Townsend				
Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged	Percent of Buildings Damaged	Total Value of Building Damage[1]
Residential	2,991	2,981	99.7%	$752,188,100
Commercial	177	177	100%	$154,848,300
Industrial	61	61	100%	$35,500,200
Others	40	40	100%	$42,445,700
TOTAL	**3268**	**3259**	**99.7%**	**$984,982,300**

[1]Includes Minor, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

In addition to the infrastructural damage, Hazus also calculated the potential social impact, property damage, and business interruption loss. A full Hazus risk response report for each earthquake category can be found in Appendix B. Earthquakes are classified as a low frequency event in Townsend. As defined by the 2013 State Hazard Mitigation Plan, these events occur from once in 50 years to once in 100 years, or 1% to 2% per year. According to 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

Landslides 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 4-28 below.

Table 4-17. 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 Townsend is classified as having a low risk for landslides. No significant landslides have been recorded for Townsend or Middlesex County (EEA and EOPSS, 2018). 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 Townsend. According to the 2013 State Hazard Mitigation Plan, these events occur from once in 50 years to once in 100 years, or 1% to 2% per year.

4.6 Fire Related Hazards

Townsend is more likely to experience a brushfire compared to a wildfire (or a fire with a large impact area). wildfires and brushfires can occur in the vegetative wildland, including grass, shrub, leaf litter, and forested tree fuels. Fires can be caused by natural events, human activity or in an intentional controlled manner, as in the case of prescribed fire (MEMA and DCR, 2013, 252). 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…. 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."*

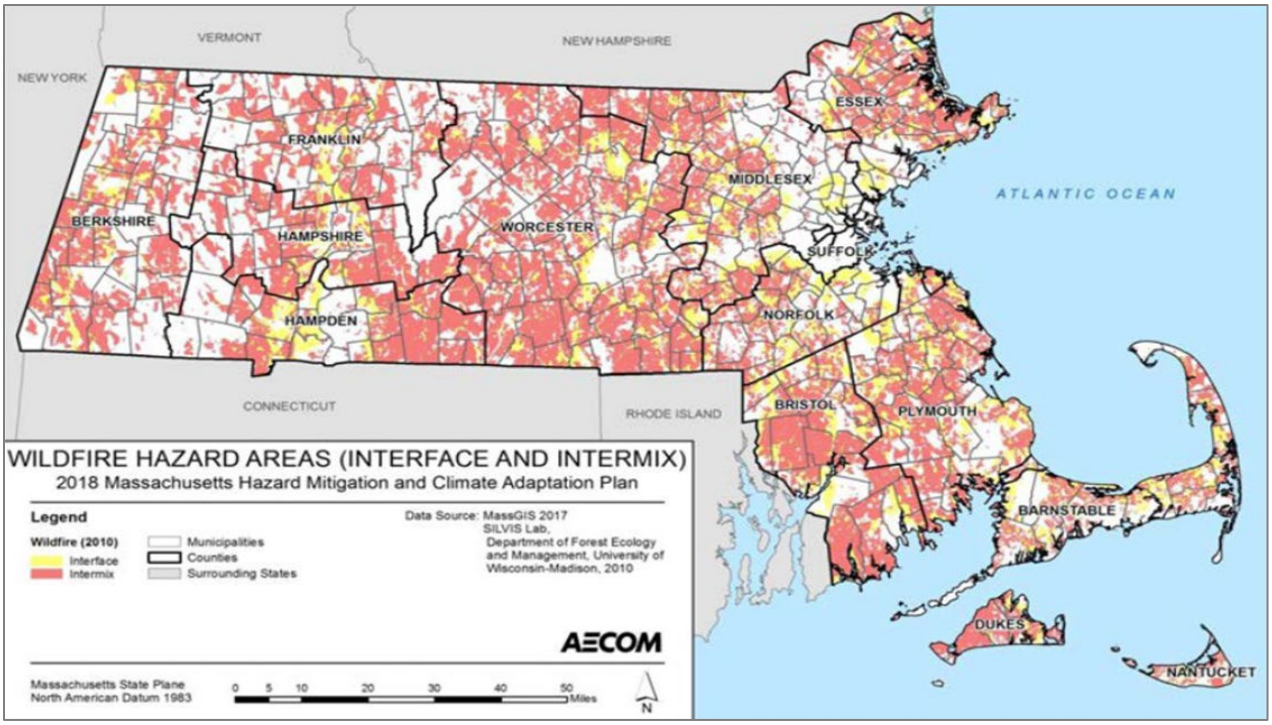


Figure 4-8: Wildfire Hazard Areas Statewide

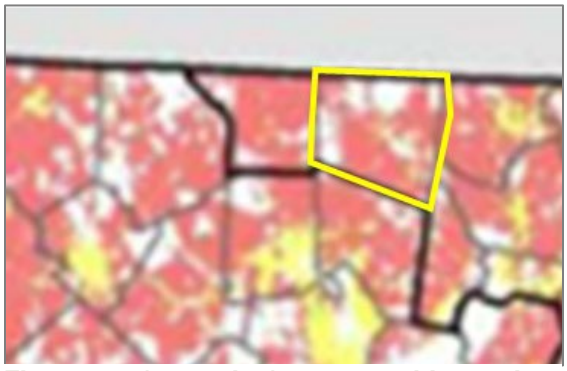


Figure 4-8 (extension): a zoomed-in version of the Wildfire Hazard Area Map, showing Townsend outlined in yellow

All individuals whose homes or workplaces are located in brush fire hazard zones are exposed to this hazard. The most vulnerable members of this population are those who would be unable to evacuate quickly (EEA EOPSS, 2018). Secondary effects from brush fire include contamination of reservoirs, destroyed power, gas, water, broadband, and oil transmission 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 brush fires burn ground vegetation and ground cover.

Brush fires can lead to property damage and injury. Usually the heavily wooded areas are more sensitive to brushfires. The fire department has equipment and resources to respond to fires in these and other areas. However, ongoing maintenance in the more forested areas of Town would aid in the reduction of brush fire spread. Although they are usually minor, the Townsend Fire Department responds to a fair amount of fires annually. In 2018, Townsend experienced 17 fires, which included 14 structure fires. This number was lower than the 23 fires experienced in 2017. Brush fires are classified as medium frequency events in Townsend. As defined by the 2013 State Hazard Mitigation Plan, these events occur from once in five years to once in 50 years, or 2% to 20% per year.

Middlesex County ranked first out of the fourteen Massachusetts counties in total reported fires. Middlesex County fire departments reported 5,432 fires to the Massachusetts Fire Incident Reporting

System (MFIRS) in 2018. The 3,674 structure fires, 397 motor vehicle fires, 671 brush fires, 420 outside rubbish fires, 132 special outside fires, two cultivated vegetation or crop fires, and 136 unclassified fires caused seven civilian deaths, 35 civilian injuries, 110 fire service injuries and an estimated dollar loss of $39.2 million. Middlesex County's fires accounted for 21% of the 25,504 Massachusetts fires reported in 2018 (MFIRS, 2018). Figure 4-9 shows the number of fires that different towns in Middlesex county have experienced in 2018.

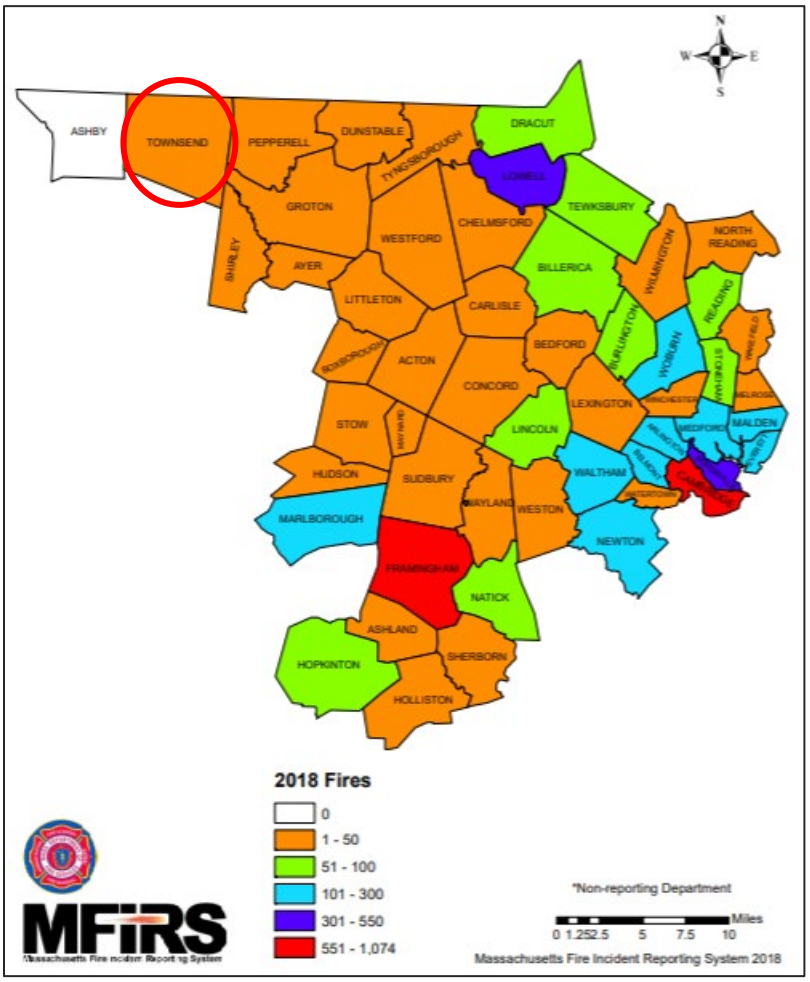


Figure 4.9. Middlesex County Fires: Townsend is outlined in red (MFIRS, 2018)

4.7 Extreme Temperatures

4.7.1 Extreme Cold

Massachusetts has four clearly defined seasons. Extreme temperatures fall outside of the ranges typically experienced during these seasons. Extreme temperatures are considered a town-wide hazard in Townsend and generally last from an afternoon to a few days. Extremely cold temperatures are measured using the Wind Chill Temperature Index provided by the National Weather Service (NWS). The updated index was implemented in 2001 and helps explain the impact of cold temperatures on unexposed skin. Figure 4-10 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 Townsend, 15% of the population is over 65 years old and 7% of the population has a disability (US Census Bureau, 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

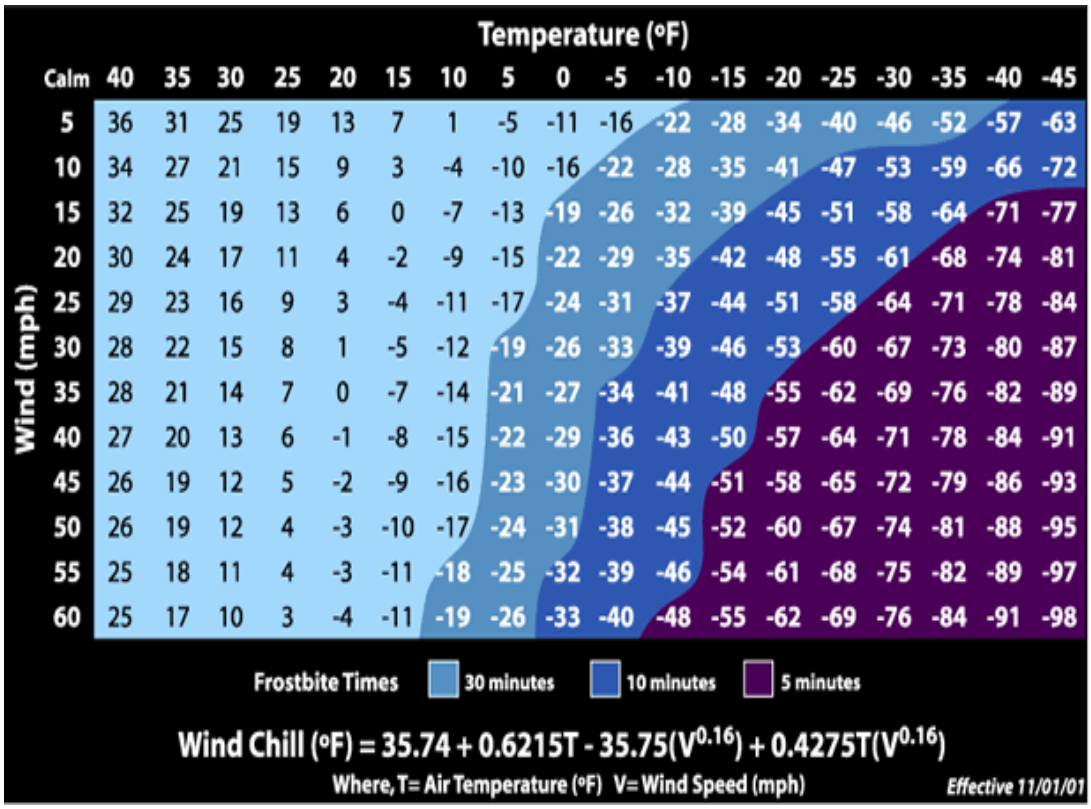


Figure 4-10. Windchill Temperature Index and Frostbite Risk

(NOAA, n.d.)

NOAA's National Centers for Environmental Information Storm Events Database provides data for extreme cold events (NOAA, 2019a). Between 2000 and 2019, Middlesex County experienced three extreme cold and will chill events, which caused no deaths, injuries, or property damage.

4.7.2 Extreme Heat

The NWS issues a Heat Advisory when the Heat Index (Figure 4-11) is forecast to reach 100-104˚F for two or more hours (NOAA, n.d.). 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. From 1979-2012, excessive heat exposure caused in excess of 8,000 deaths in the United States (MEMA and DCR, 2013). During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Relative Humidity (%) \ Temperature (°F)	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.

Figure 4-11. Heat Index Chart

(NOAA, n.d.)

The Town of Townsend 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 (NOAA, 2019a). Between 2000 and 2019, Middlesex County experienced three extreme heat days, which did not result in injury or property damage. One event did result in a fatality in 2013. Please refer to Table 4-29 for more information.

Table 4-29. Middlesex County Heat Occurrences, 2000-2019

Date	Deaths	Injuries	Damage ($)
7/6/2010*	0	0	0
7/7/2010	0	0	0
7/5/2013	1	0	0
Total	1	0	0

**Excess Heat Occurrences (105°F+) (NOAA, 2019a)*

Increased temperatures will impact all locations within Townsend. Extreme temperatures can create "heat islands" as dark-colored asphalt and roofs store the heat from the sun. 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.

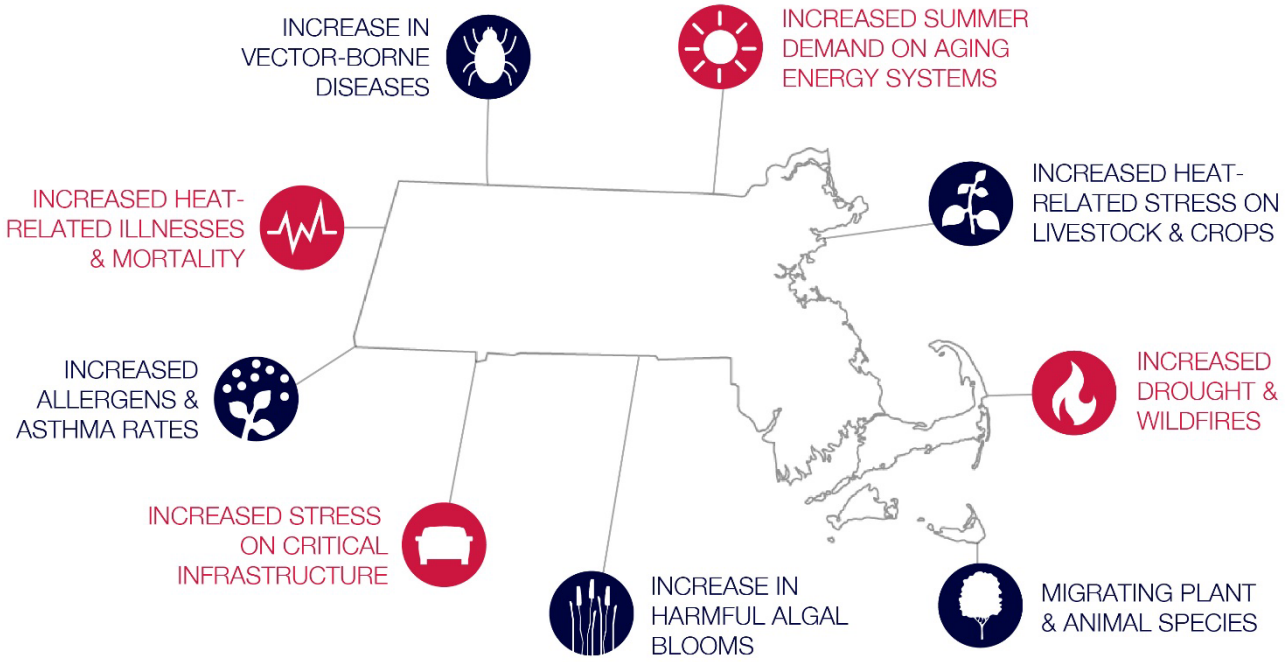


Figure 4-12. A diagram of possible impacts from extreme temperatures

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
- Residents experiencing homelessness
- Individuals with respiratory conditions
- The general public who may overexert themselves during extreme heat events

On July 6, 2013, a postal worker in MA 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. In Townsend, children under eighteen years old make up 23% of the population, and 15% are over 65 years old (US Census Bureau, 2018). 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 (MEMA and DCR, 2013).

Based on Figure 4-13 below, compiled by the Massachusetts Department of Public Health Bureau of Environmental Health (DPH, 2019), Townsend has a population density of 280 residents per square mile. The total number of population vulnerability measures in each Census Tract is 2. These population vulnerability measures include low income, low English proficiency, non-white (Hispanic and non-Hispanic ethnicities), and elderly residents.

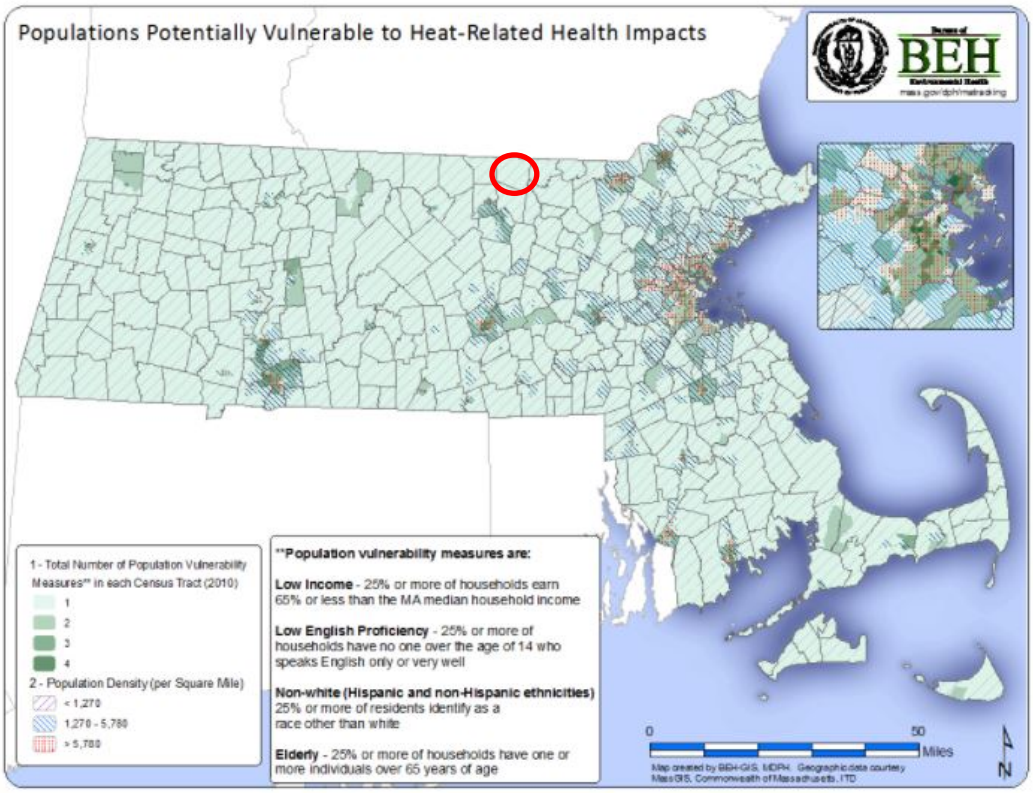


Figure 4-13. Populations Potentially Vulnerable to Heat Related Health Impacts (Townsend is outlined in red; DPH, 2019)

Extreme temperatures are classified as medium frequency events. As defined by the 2013 State Hazard Mitigation Plan, these events occur from once in 5 years to once in 50 years, or 2% to 20% per year. According to the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 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 4-13). 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).

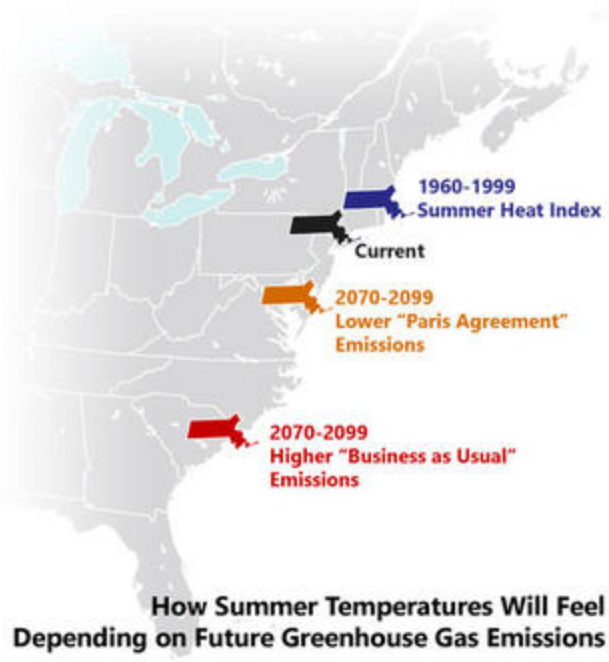


Figure 4-14: A diagram showing how Massachusetts' climate could change due to increasing temperatures.
Source: MassAudubon

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). Water supply was the largest concern related to drought during Townsend's CRB Workshop.

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, 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 seven regions. Townsend is located within the Northeast region (EEA and MEMA, 2013).

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 draft 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 MEMA, 2013).

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. In its updated Drought Management Plan of 2019, the Drought Management Trask Force has eliminated the precipitation index that is based on percent of normal precipitation.

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 MEMA, 2013).

Figure 4-15 illustrates statewide drought levels in Massachusetts from 1850 to 2012, using the Standardized Precipitation Index (SPI). Table 4-30 below summarizes a history of Massachusetts droughts between 1879 and 2017.

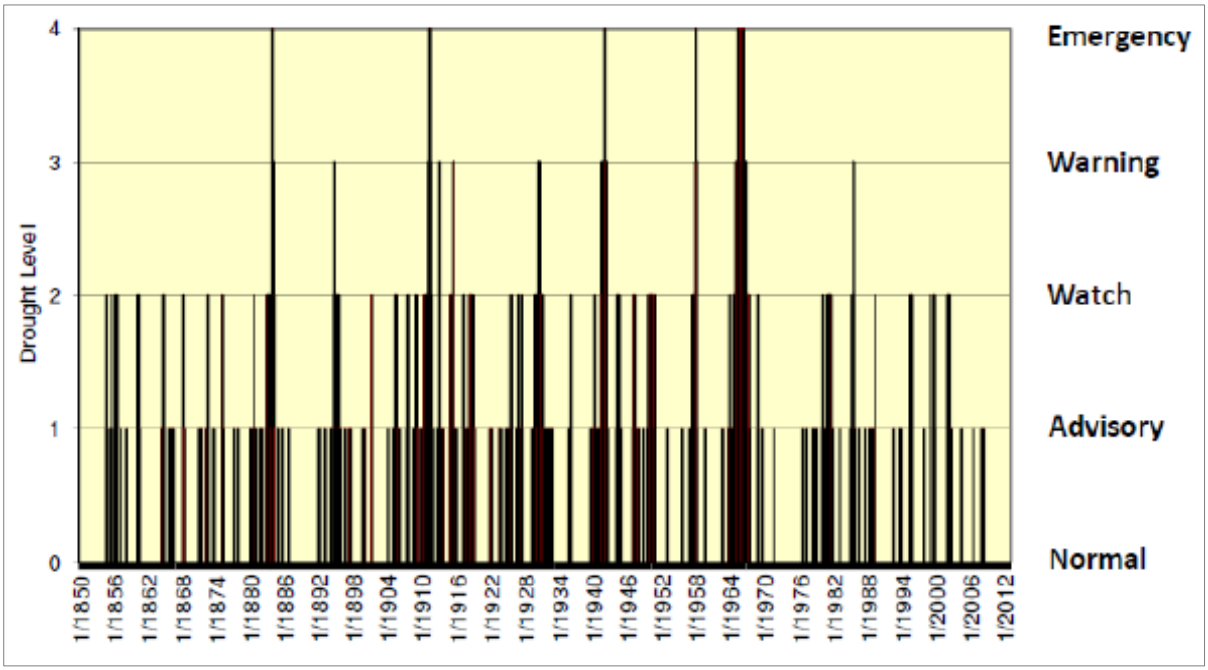


Figure 4-15. Statewide Drought Levels Using SPI Thresholds, 1850 to 2012.
(EEA and MEMA, 2013)

Table 4-18. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (years)	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.
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)
2016-2017	Statewide	–	Level 3 drought (out of 4 levels).

(EEA and EOPSS, 2018)

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 MEMA, 2013). 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 two percent chance of being in a drought Warning level (EEA and MEMA, 2013; 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. The overall frequency of being in a Drought Watch is eight percent on a monthly basis over the 162-year period of record (EEA and MEMA, 2013). There were six drought watches in Massachusetts in 2002, five drought watches in 2016, and two drought watches in 2017 (DCR, 2017b). Figure 4-16 presents an example of drought conditions in the six drought regions.

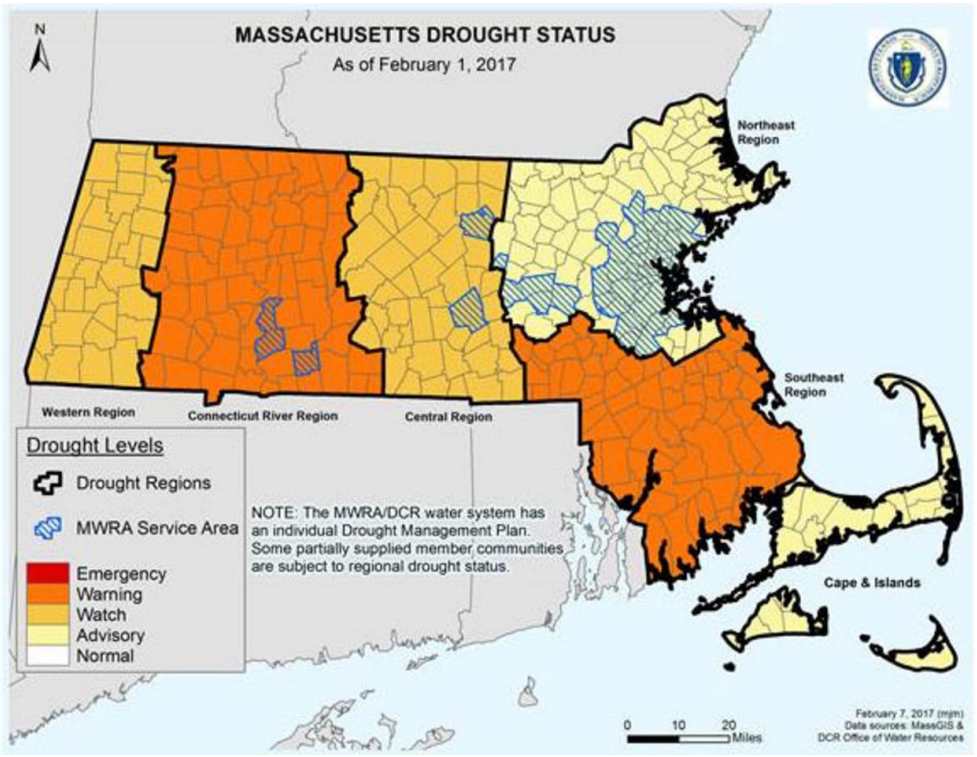


Figure 4-16. Massachusetts Drought Status, February 2017
(DCR, 2017b)

Drought is a potential town-wide hazard in Townsend. 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 Townsend's water resources. It could also have significant adverse impacts to the Town's water supply. The Town currently works with its residents to conserve water, especially during times of drought or low water levels.

Droughts are classified as a low frequency natural hazard event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, these events can occur from once in 50 years to once in 100 years, or 1% to 2% 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). The occurrence of droughts lasting one to three months could increase by as much as 75% by the end of the century, under the high emissions scenario (EOEEA 2011).

5.0 EXISTING MITIGATION MEASURES

Townsend is already taking measures to mitigate local hazards and prepare for climate change. Chapter 5 documents the Town's current operations and discusses potential improvements. FEMA's *Local Mitigation Planning Handbook* categorizes hazard mitigation measures into four types as displayed in Table 5-1 (FEMA, 2013). Townsend uses multiple types of mitigation actions to improve preparedness and resilience from different angles.

Table 5-1. FEMA's Types of Mitigation Actions

Measure	Action	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 bylaws • Subdivision regulations • Development review • Building codes and enforcement • NFIP Community Rating System • Capital improvement programs • Open space preservation • Stormwater management regulations and master plans
Structure and Infrastructure Projects	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
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. • StormReady • Firewise Communities

(*FEMA*, 2013)

Townsend proactively prepares for natural hazards through all types of mitigation measures. The Town's ongoing hazard mitigation and climate adaptation plans are presented below by hazard type. The hazard mitigation measures were identified through research, feedback from the Core Team, CRB Workshop participants, and additional stakeholders' interviews. The mitigation actions are presented on the right and possible improvements are presented on the left.

5.1 Multi-Hazard Mitigation Measures

Some actions help mitigate the impacts of more than one hazard. For example, an emergency planning committee meets to prepare for more than a single hazard event. The mitigation measures that help improve resilience and mitigate more than one hazard are covered in this section.

	Recommended Improvements
Northern Middlesex Regional Emergency Planning Committee – Under the Emergency Planning and Community Right to Know Act of 1986, communities are required to establish emergency planning committees to develop a response plan for chemical emergencies. Townsend is a part of Northern Middlesex Regional Emergency Planning Committee (REPC), which includes Ashby, Ayer, Dunstable, Groton, Harvard, Littleton, Pepperell, Shirley, Townsend, Westford. In accordance with this legislation, the Townsend has identified locations where hazardous materials are stored, used, and transported. Townsend Emergency Management Agency (TEMA) is the lead.	None at this time
Nashoba Valley Regional Emergency Communications Center (RECC) – Townsend is included as part of the Nashoba Valley RECC, along with the municipalities of Devens, Harvard, Lancaster, Lunenburg, Bolton, and Berlin. The Nashoba Valley RECC has been awarded approximately $5.6 million in funding from the State 911 Department Development Grants since 2009 (MA State 911 Department, 2020).	None at this time.
Comprehensive Emergency Management Plan (CEMP) - Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. This plan addresses mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. Included in this plan is important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Townsend has a CEMP that is currently being updated and scheduled to be ready by the end of 2020. The Town plans to establish a Local Emergency Planning Committee once the CEMP is finalized.	None at this time
List of Critical Facilities – The list of critical facilities was updated during this planning process.	Maintain an updated list of critical facilities

	Recommended Improvements
Volunteer Emergency Response – The Townsend Emergency Management Agency (TEMA) is a group of volunteers that help with emergency response. A Certified Emergency Response Team (CERT) or team of trained volunteers is being organized by the Fire Department.	Need to expand the volunteer base training
Worcester Regional Medical Reserve Corp (WRMRC)– The WR MRC is one of 38 medical reserve corps units in Massachusetts. WRMRC is a non-profit volunteer run organization that provides medical care, counseling, and other community services after a disaster. Townsend is in the WRMRC region.	None at this time
Emergency Shelters – The Hawthorne Brook Middle School is the Town's designated ADA approved FEMA shelter. If needed, North Middlesex Regional High School and Squannacook Early Childhood Center can be used as a shelter. The Water Department Garage is a storage area, which is in the floodplain. Emergency supplies are stored in the storage area.	– Expand outreach about location and accessibility of emergency shelters. – Develop a plan for pet-friendly shelter. – Find a new storage area or relocate out of the floodplain.
Backup Generators – The Town received grant funding to purchase several generators within the last five years. Most of the municipal buildings in the Town have backup emergency generators, including the Senior Center, Town Hall, Fire Stations, Schools, and the Police Station. A mobile generator is available if needed for residential homes or command posts.	Install backup generators at critical facilities, including water and wastewater pump stations, well houses, food pantry, and private entities (gas stations and grocery stores)
Building Permits – Permits are required from the Building Department to ensure the building code and utility connections are properly made. Permits are also sent to the Water and the Fire Department to inspect certain aspects of all new construction for proper water connections and fire prevention safety.	None at this time
Multi-Department Review of Developments – Depending upon the type of development, extent of construction, and location, multiple departments, including the Planning Board, Building Department, Board of Health, Highway Superintendent , Conservation Commission, the Fire Department, Board of Selectmen, Police Department, Historic commission, and Townsend Housing Authority, and Zoning Board of Appeals, may review site plans prior to approval.	Develop a climate resilience guidebook for new developments
Massachusetts State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.	– Advocate for climate resilience to be integrated into the State Building Code – Seek to advance the sustainable Development Principles

	Recommended Improvements
Open Space and Recreation Plan (OSRP) 2013 –The Town has a wealth of conservation areas and recreation spaces. The OSRP aims to maintain, promote use, and increase the number of these spaces.	Update the OSRP and integrate climate resilience and hazard mitigation.
Zoning Bylaws – Chapter 145 of the Town Code of Bylaws, Zoning regulates the land use, size, height, bulk, location and use of development. Zoning regulates or guides landscaping, open space, vehicle parking and loading. Zoning can be used as a tool to promote affordable housing, proper communication facilities, and smart development.	Update Zoning Bylaws to incorporate climate resilience
Rules and Regulations for Site Plan Review – Procedures and guidelines set forth by the Planning Board corresponding to the Section 145-42 of the Townsend Zoning Bylaws. Special permits are required for construction of large residential, commercial, institutional, municipal, and industrial developments or expansions.	Update with climate resilience
Code Red – The Town has applied for a grant for the Code Red community-wide alert system.	None at this time.
Massachusetts Municipal Association (MMA) Best Practice Series – Townsend participates in the MMA Best Practice Series. MMA works with the Highway Department to promote the public works profession, invest in professional development for department staff, and attract qualified candidates to available positions.	None at this time
Senior Center Emergency Response – The Senior Center has a standard medical protocol for responding to and recovering from extreme events. The Center has worked intermittently with DCR on creating a walking trail from the senior housing complexes to the senior center. The Senior Center communicates with its community through their newsletter, Facebook page, meetings, phone call chains, and presentations at the Senior Center. The Police also work with the Senior Center to reach elderly residents.	None at this time
Unitil Grid Resiliency – Unitil has made system reliability and resiliency central to its operations and implements approaches that minimize storm impacts and the length of restoration.	None at this time.
Massachusetts Municipal Address Standard – The Town is in the process of adopting the Address Standard. The Town will create a committee to apply the standard by addressing new properties and searching existing Town addresses, including common drives, to correct any issues with ambiguities. This work will ensure that Emergency Management Services will be able to find the	None at this time.

	Recommended Improvements
correct address in an emergency situation. The Committee will include representatives from the Fire-EMS Department, Police Department, Building Department, Highway Department, Planning, and Assessing. This action item was started in 2020 and is still in-progress.	
Community Outreach and Education – The Town communicates with residents through a variety of means, including online, social media, newspaper press releases, local access TV, and electronic signs at the entrance to town. Seniors can be reached through volunteers at the Senior Center.	- Expand outreach and education program and improve outreach to populations that may be more vulnerable. - Create partnership with regional and municipal governments, non-profits, business, and other stakeholders.
Buried Utility Lines – All new developments are required to place utility lines underground. The School IT director noted that there are buried fiber cable IT infrastructure between Squannacook and Spaulding schools.	Underground utility lines when doing roadway construction

5.2 Existing Town-Wide Mitigation for Flood Related Hazards

Townsend employs a number of practices to help minimize potential flooding, reduce impacts from flooding, and to proactively maintain existing drainage infrastructure. Existing Town-wide mitigation measures described below on the left and recommend improvements are on the right

	Recommended Improvements
Participation in the NFIP – Townsend participates in the National Flood Insurance Program (NFIP) (FEMA, 2019c). The NFIP is a Federal program administered by FEMA. Property owners in participating communities are eligible to purchase insurance for flood loss protection. Eligible communities must adhere to state regulations and adopt community floodplain management regulations to reduce potential future flood damages. NFIP offers flood insurance to communities that comply with the minimum standards for floodplain management. Townsend participates in the NFIP with 26 policies in force as of March 3rd, 2020 (DCR, 2020). FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website. The Town complies with the NFIP by enforcing floodplain regulations.	None at this time

	Recommended Improvements
NFIP uses a Community Rating System (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. Townsend is not currently eligible to participate in the CRS Program (as of May 2019) (FEMA, 2019c).	
FEMA Flood Insurance Maps (FIRMs) – FIRMS or flood maps denote areas of the 100-year and 500-year floodplain, which is used for the NFIP and other regulatory controls. For example, the Building Inspector and the Townsend Conservation Commission enforce a federal law requiring elevation above the 100-year flood level of new and substantially improved residential structures in the floodplain. The floodplain notations are also used in wetland protection and floodplain control regulation. The FEMA FIRMS were last updated in 2010.	Update FEMA FIRMS and regulations referencing the old map
Street Sweeping – The Highway Department is responsible for street sweeping, which occurs once a year in the spring. Sweeping begins in the center of the Town, followed by densely populated residential areas.	None at this time
Stormwater System Maintenance – The Water and Sewer Department regularly clears debris from catch basins on a three-year cycle. There are 750 catch basins; 250 basins are cleaned each year. Areas with flows are cleaned first each year. Catch basin maintenance has been reduced after the Town stopped use sand to deice roads. Culverts require repair and upgrades.	Improve maintenance of private stormwater systems Enlarge undersized culverts to alleviate flooding
Maintenance of Public Water Bodies –Squannacook River is cleared of debris and trash periodically by volunteers. There are no municipal maintenance programs to clean available for other water bodies. The last cleaning was in 2017 and was organized by the Nashua River Watershed Association and the Conservation Commission.	– Improve regular maintenance of public water bodies including removal of debris, efficient management of invasive species – Consider regional partnerships with neighboring towns.
NPDES Phase II Stormwater Program or Municipal Separate Storm Sewer System (MS4) Permit– The Town continues to implement NPDES stormwater program that includes measures for public education and outreach, illicit discharge detection and elimination, construction and post-construction controls, and Town-wide good housekeeping and stormwater maintenance procedures. The Town also has a Stormwater Management Plan	None at this time

	Recommended Improvements
as part of their Small Municipal Separate Storm Sewer Systems (MS4) permit.	
Massachusetts Stormwater Management Standards and Handbook – Massachusetts administers stormwater standards through provisions of the Wetlands Protection regulations, 310 CMR 10.00 for wetland notices of intent and surface water discharge permits. The local Planning Board regulates this at the local level. The Massachusetts Stormwater Handbook provide guidance on how to meet the regulations and manage stormwater pollution and is being currently updated by MassDEP.	Advocate that climate resilience be incorporated to the MA Stormwater Handbook and Standards
Stormwater Bylaw & Regulations – Chapter 85 of the General Bylaws is the NPDES Phase II Stormwater Bylaw. The Stormwater Bylaw and corresponding Stormwater Regulations (Chapter 275, Article V) require proper planning, implementation, and maintenance of stormwater management and erosion control measures. The Stormwater Bylaw and Regulations establish the minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff and nonpoint source pollution associated with new development and redevelopment.	Review Stormwater Bylaw and Regulations for opportunities to incorporate climate resilience and encourage nature-based stormwater controls
Floodplain District (FD) – The Town's Floodplain District (Section 145-45) covers the area defined by the 100-year floodplain on the FEMA FIRMs. The Floodplain District regulates development activities within a flood zone enhancing federal/state laws. Development within the floodplain may be approved by the Board of Appeals, which receives recommendations from the Board of Health, Conservation Commission, Planning Board, and the Building Inspector. The Floodplain District is enforced by the Building Inspector (municipal staff) and regulated by Board of appeals.	Update the Floodplain District language when the FEMA Firms are updated Consider expanding the Floodplain District to cover the 500-year floodplain to account for climate change
Massachusetts Wetlands Protection Act and Local Wetlands Protection – The Commonwealths' Wetlands Protection Act (Chapter 131, Section 40 MGL) regulates the protection of resource areas in and around wetlands, including land subject to flooding. This regulates development and activity within a 100-foot buffer around wetlands, and a 200-foot buffer around riverfront areas. The Wetlands Protection Act is locally enforced by the Conservation Commission. The Town further regulates wetlands through the Town Wetlands Bylaws (Chapter 138) and corresponding Wetland Regulations (Chapter 150, Article 1).	Review and update the local Wetlands Protection Bylaw and corresponding Regulations with climate change resiliency language

	Recommended Improvements
Beaver Management – The Town use beaver deceivers to mitigate flooding caused by beaver dams. The Town hires a beaver trapper when necessary.	Beaver deceivers are needed on Ash Street and Hoghill Road

5.3 Existing Dam Mitigation Measures

There are seven dams in Townsend and more information is available in Chapter 4. Three dams are privately owned and two are owned by the Commonwealth. The Town owns one dam and one dam's ownership is unknown. Flood mitigation measures could also help mitigate potential flooding from dam overtopping.

	Recommended Improvements
Dam Maintenance – The dam owned by Townsend is non-jurisdictional and does not require an emergency action plan. Townsend does not have dedicated budget for maintenance of the dams.	Inspect and complete regular dam maintenance Identify the owner of the Graves Pond Dam
DCR Dam Safety Regulations and Inspections – 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. Jurisdictional dam inspections are due in 2020 and 2021.	Ask private dam owners for the most recent emergency action plan and inspection reports
Permits Required for Construction – State law requires a permit for the construction of any dam.	None at this time

5.4 Existing Town-Wide Mitigation for Wind-Related Hazards

Townsend minimizes the impact of high winds through enforcing the Massachusetts Building Code and conducting tree maintenance. Existing Town-wide mitigation measures described below on the left and recommend improvements are on the right.

	Recommended Improvements
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. The Town follows State Building Code and handles wind related damages based on need.	None at this time

Tree Maintenance – Unitil has a tree maintenance program to protect power lines. Emergency tree pruning is done by the Tree Warden.	– Develop a tree maintenance plan to balance necessary trees and minimizes excessive tree cutting – Implement tree replacement policy for every removed tree. – Enforce permitting for tree removal.

5.5 Existing Town-Wide Mitigation for Winter-Related Hazards

Townsend mitigates and responds to winter related hazards. Existing Town-wide mitigation measures described below on the left and recommend improvements are on the right.

	Recommended Improvements
Snow Emergency Parking Bans – The General Bylaws, Chapter 112- Section 20 covers the Town's emergency parking restrictions. The Town's winter parking ban goes into effect every year and continues through April 1st and prohibits the parking of motor vehicles on any public way at any time between the hours of 11pm and 7am. The parking ban allows the Highway Department to plow more efficiently and in timely manner. Illegally parked vehicles are ticketed by the Police Department.	None at this time
Snow Plowing and Deicing Operations – The Highway Department provides standard snow plowing operations on main arterials, including salting. Snow plowing occurs after 2" of snowfall. Roads are pretreated with salt-mix before a snowstorm. At the end of the storm, roads are treated with salt again. Although fleet inventory is adequate, the old equipment needs to be upgraded.	Replace old equipment
Fuel Assistance – Fuel assistance is available to renters and homeowners meeting income guidelines through the NEFWC (New England Farm Workers' Council) Fuel Assistance Program.	None at this time

5.6 Existing Town-Wide Mitigation for Drought-Related Hazards

The public drinking water supply is vulnerable to drought. The Town regularly restricts water use during the summer.

	Recommended Improvements
Water Restriction –Townsend restricts outdoor water use from May 1st to September 30th every year.	– Educate residents on water conservation techniques – Implement rainfall capture methods and graywater recycling. – Prepare to support private well users during drought
Backup water supply – Townsend has redundant wells and an emergency connection with Pepperell.	Consider creating an interconnection with Groton

5.7 Existing Town-Wide Mitigation for Fire-Related Hazards

Townsend mitigates and responds to fire related hazards through several mitigation action. Existing Town-wide mitigation measures described below on the left and recommend improvements are on the right.

	Recommended Improvements
Open Burning Permits – The Department of Environmental Protection (MassDEP) regulation (310 CMR DEP 7.07) allows open burning from January 15th to May 1st and is to be conducted between 10 am and 4 pm. Open Burning Permits can be obtained at the Fire-EMS Central Station.	None at this time
Public Education – The Fire Department offers public education in schools and at the Senior Center.	Expand outreach into new forums and update materials, as needed
Fire Department Services – There are currently multiple fire stations in Townsend. The Fire Department is active and involved in emergency management.	Purchase mobile emergency response center
Statewide Fire Mobilization Plan – The state has a Fire Mobilization Plan (FMP). Townsend falls under Central Region 3, District 8 (Northern Worcester). The FMP is a protocol to respond to building fires, wildfires, arranging ambulances, and details about 10 alarm run cards. The Town also participates in informal mutual aid agreements.	– Formalize and document mutual aid agreements – Explore State funded programs – Check eligibility of Volunteer Fire Assistance (VFA) program to be prepared for local forest fires.
"Senior SAFE" program – Townsend received a grant funding to employ a Senior SAFE Program, which aids in providing fire safety education to seniors through the fire department. It also aims to improve safety in senior housing.	Look to secure other grants for continued outreach to vulnerable populations.
Brush Clearing – The Town conducts limited brush clearing to provide access to emergency service vehicles. The Commonwealth owns and clears the state forests and properties.	None at this time

5.8 Existing Town-Wide Mitigation for Extreme Temperature-Related Hazards

Townsend does not have any local measures to mitigate extreme temperature related hazards.

Recommended Improvements

– Develop a tree planting program and plant trees in areas with less tree canopy
– Use reflective material for municipal building rooftops and other large impervious areas
– Add cooling centers, and drinking water resources at multiple locations for hot summer days
– Consider renewable energy powered infrastructure to reduce carbon footprint
– Provide public education on extreme heat effects and how to mitigate them; by staying hydrated for example
– Maintain current natural resources

5.9 Existing Town-Wide Mitigation for Geologic Hazards

Townsend does not have any local measures to mitigate geologic hazards but does enforce the Massachusetts State Building Code.

Massachusetts State Building Code for Seismic Standards – 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.

Section 1612.2.5 establishes seismic hazard exposure groups and assigns all buildings to one of these groups according to a 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.

Recommended Improvements

– Provide public education on Great ShakeOut earthquake drills following UGSG Guidelines
– Prepare for 911 dispatch regionally in case of emergency

5.10 Existing Town-Wide Climate Mitigation Measures

Climate mitigation measures reduce greenhouse gas emissions through the improving energy efficiency, reducing energy usage, investing in renewable energy, and carbon sequestration strategies. Climate mitigation strategies will reduce the intensity of climate change over the next century.

Townsend Energy Committee – The committee was formed in August 2010 by the Board of Selectmen The goal of the committee is to provide advisory services and oversight of the energy use in the Town, under the Green Communities Designation, as well as to regularly analyze new opportunities with the potential for the Town to reduce energy costs and consumption.

Green Communities Program – Townsend was designated as a Green Community on December 13, 2012. As part of this designation, The Town is committed to adhering to several different criteria to help improve efficiency and reduce carbon

Recommended Improvements

– Seek funding and grant opportunities to support the Energy Committee in maintaining their commitments to energy reduction
– Seek funding to reduce carbon footprints

Develop a municipal energy plan to identify opportunities to expand climate mitigation program

	Recommended Improvements
footprint. Townsend used its Green Community Grant for: conservation measures, controls, and retro-commissioning; energy-efficient variable speed drive water pump replacements; energy efficient lighting upgrades; insulation; and energy efficient vehicle purchase.	
Montachusett Region Comprehensive Economic Development Strategy – Townsend is seeking to develop a Downtown Revitalization Strategy that would include sustainable strategies such as re-using vacant buildings and improving the pedestrian experience through walkability, wayfinding, and amenities.	None at this time.
Montachusett Regional Planning Commission Unified Planning Work Program – A walkability study in Townsend was recently approved under this program. This work will involve identifying projects that will improve the accessibility and safety of various modes of travel in Town Center and surrounding areas, to complement Complete Streets Policies. The proposed methodology includes a focus on improving walkability and cycling	None at this time.
Unitil Sustainability Practices – Unitil has identified practices and priorities to increase sustainability, including recycling, use of renewables, distributed energy resources and storage alternatives, and increased energy efficiency.	None at this time.
Complete Streets Funding Program – The MassDOT Complete Streets Funding Program provides technical assistance and construction funding to eligible municipalities. Eligible municipalities must pass a Complete Streets Policy and develop a Prioritization Plan. The Town of Townsend adopted the implementation plan in 2017 that allows the Town to get grant funding on their prioritization plan. Current Greenville Road Bridge project is a result of that funding program.	–Continue to implement Complete Street Plan and build a multi-modal transportation system – Apply for funded projects.
Safe Routes to School Program – Townsend is participating.	None at this time.

5.11 Mitigation Capabilities and Local Capacity for Implementation

Under the Massachusetts system of "Home Rule," the Town of Townsend is authorized to adopt and from time to time amend a number of local bylaws and regulations that support the Town's capabilities to mitigate natural hazards. These include the Zoning Bylaws, Stormwater Bylaws, Site Plan Review Regulations, Wetlands Bylaws. Local bylaws may be amended to improve the Town's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission. The Town of Townsend 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 ability to expand on and improve the existing policies and programs listed above.

6.0 STATUS OF MITIGATION MEASURES FROM THE 2015 DRAFT PLAN

6.1 Implementation Progress on the Previous Plan

The Town of Townsend has taken steps to integrate findings from the 2015 HMP into the following policy, programs, and plans: the Student Awareness of Fire Education (SAFE) and Senior SAFE Programs, the work of the Townsend Emergency Management Agency (TEMA) volunteer program, the 2017 adoption of the Complete Streets Implementation Plan, the ongoing update of the Town's Comprehensive Emergency Management Plan (scheduled to be completed by the end of 2020), the ongoing update of the Master Plan, the in-progress adoption of the Massachusetts Municipal Address Standard, and the ongoing Downtown Revitalization Strategy in Townsend's Downtown Commercial District. Please refer to Chapter 5 for more information on existing mitigation measures.

Townsend staff and Core Team members reviewed the mitigation measures identified in Montachusett Region Natural Hazard Mitigation Plan 2015 Update. Core Team members provided information on whether the priority mitigation action had been implemented or deferred. The deferred measures were evaluated by the Core Team to determine if the measure should be carried forward into the 2020 HMP-MVP Plan. The decision to retain a measure was based on the members' assessment of the continued relevance or effectiveness at addressing vulnerabilities. In some cases, an action was deferred because of the lack of funding or resources. Table 6-1 summarizes the status of the mitigation measures, along with the priority of these measures. The plan is intended to assist the Town in prioritizing the proposed measures, which will provide guidance on how to best allocate the Town's limited resources.

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Mitigation Measure	2020 Status Update	Include in 2020 Plan?
Identify existing shelters that are earthquake resistant as well as outside of floodplain (and dam inundation) areas to ensure that shelters are available to the public to reduce or eliminate risk to human life.	**Not done yet.** The FEMA designated and back up shelters are not in the floodplain. The Regional High School is newly built and would adhere to the latest earthquake standards.	Yes, in the Chapter 7 Priority List with amendment for Town to review the ERPs for Significant Hazard Dams, which will list downstream impacts
Increase awareness by educating property owners on actions that they can take to reduce risk to property by hosting an open house at the Fire Department, develop and distribute an educational pamphlet on Fire Safety and Prevention (SAFE PROGRAM) and wildfire prevention.	**In progress.** This is part of SAFE program.	Yes, in the Ch. 5 Existing Mitigation Measures

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Mitigation Measure	2020 Status Update	Include in 2020 Plan?
Increase hazard education and risk awareness to public by collecting, updating, and disseminating information on local radio/TV stations to educate the public and alert them of emergency information including shelter locations and other instructions related to all natural hazards	In progress. The Town does it informally in public gatherings through handouts/brochures.	Yes, in the Ch. 5 Existing Mitigation Measures
Inventory supplies at existing shelters and develop a needs list and storage requirements to ensure the available of adequate supplies during a natural hazard. Supplies must be adequate to eliminate or reduce risk to human life.	In progress. The storage facility was undergoing a restructure prior to the COVID-19 outbreak.	Yes, in the Chapter 7 Priority List
Develop a plan to provide access to water, information, shelter and food stores to people in remote locations of the town in the event of a severe winter storm and integrate this information into community comprehensive plans.	Not done yet. There is no official formal plan. Senior Center and the Police Department do the outreach program.	Yes, in the Chapter 7 Priority List.
Identify all structures throughout the town that need to be elevated above the Base-Flood Elevation. Once identified educate those property owners regarding their options for mitigation.	Not done yet. The flood maps need to be updated.	Yes, in the Chapter 7 Priority List with amendments to encourage properties in the floodplain to do their own assessment and upgrades
Develop a priority list and possibly seek funding through the Hazard Mitigation Grant Program (HMGP) for the replacement of undersized culverts throughout Town to reduce or eliminate flooding risk.	Not done yet.	Yes, in the Chapter 7 Priority List.
Educate property owners regarding options for mitigating their properties from flooding through outreach programs that address measures that residents can take i.e installing backflow valves, securing debris, etc.)	In progress. The Town does it informally in public gatherings through handouts/brochures.	Yes, in the Community Outreach section of Chapter 8

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Mitigation Measure	2020 Status Update	Include in 2020 Plan?
Continue participation in the National Flood Insurance Program to enable property owners to purchase insurance protection against flood losses.	In progress. Need to update the floodplain map and the insurance program.	Yes, in the Ch. 5 Existing Flood Hazard Mitigation Measures
Evaluate and relocate furnaces, water heaters, and electrical equipment in municipal owned buildings that are located in areas prone to flooding to reduce flood damage.	Not done yet. The Water Department Garage is the only town-owned critical facility in the floodplain.	Yes, in the Chapter 7 Priority List and amend to focus on the Water Department Garage
Identify areas with potential for brush fires to track community vulnerability by developing and maintaining a data base.	Not done yet. State DCR identifies the areas. The Town does not have access to any database.	Yes, in the Regional Coordination section of Chapter 7
Identify shelters and publicize locations to the general public during hazard events to reduce and or eliminate risk to human life.	In progress. Shelters have been identified.	Yes, in the Community Outreach section of Chapter 8
Utilize interactive mapping application prepared by MRPC/CMRPC to update critical infrastructure and simulate real time evacuation scenarios to mitigate hazards to the public.	Not done yet. The critical facilities list is updated. Mapping is currently underway; new mapping equipment procured after 2015.	Yes, in the Chapter 7 Priority List and amend to focus on simulation only.
Install "beaver diverters" and water control devices to mitigate flooding caused by beaver dams.	In progress. The Town does is under emergency circumstances. Three or more diverters throughout the town, but The Town needs more of them on Ash Street, Hoghill Road and few other locations.	Capture in the Ch. 5 Existing Flood Hazard Mitigation Measures
Hire trapper for removal of beavers to mitigate flooding caused by beaver dams.	In progress. The Town has done that twice in the last three years. Ongoing measure.	Capture in the Ch. 5 Existing Flood Hazard Mitigation Measures
Implement recommendations regarding natural hazard mitigation in existing planning documents including the implementation element of the master plan, five-year action plan of the open space and recreation plan and the emergency evacuation plan	In progress. The Town is in the process of writing a new master plan and emergency management plan.	Yes, in the Chapter 7 Priority List

7.0 HAZARD MITIGATION AND CLIMATE ADAPTATION 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 a multi-faceted 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 mitigation measures and the capacity of the Town to respond to extreme events
- Updates from the previous HMP plan
- Input from stakeholders

Stakeholders were engaged through Core Team meetings, the CRB Workshop, expert interviews, and the Public Listening session. The full list of action items from the CRB Workshop are available in Appendix C and were integrated into the final list of action items vetted by the Core Team. Table 7-1 below represents the Town's high and medium priority action items. Each of these action items was analyzed for its overall benefit, estimated cost, timeframe, and implementation responsibility, which informed prioritization. A description of each prioritization category is included below.

General Objective – An overarching aim related to one or several mitigation actions. The general objective may be achieved through a combination of mitigation actions.

Mitigation Action - A brief description of each mitigation measure identified in this plan.

Primary 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. Some action items may require collaboration with State departments or private entities. Section 7.2 specifically addresses regional collaboration.

Implementation Time Frame – The time frames represented below are assigned based on the estimated length of time necessary to complete the project. The timeframes are divided into categories and are noted in years.

- 1-3 years
- 3-5 years
- 5-10 years
- 10+ years

Estimated Implementation Cost – Approximate implementation costs are provided as an estimate for all mitigation measures. All cost data would need to be updated at the time of design and construction. Where applicable, costs have been divided between preliminary assessments and cost of construction.

- $: <$10,000
- $$: $10,000-$100,000
- $$$: $100,000-$250,000
- $$$$: $250,000-$500,000
- $$$$$: $500,000+

Priority – Designation of high, medium, or low priority was based on overall potential benefits. A High Priority action is very likely to have political and public support and necessary maintenance can occur following the project. A Medium Priority action may have political and public support and necessary maintenance had potential to occur following the project. A Low Priority action may not have political and public support for implementation or the necessary maintenance support following the project.

Residents were asked how Townsend should prioritize climate adaptation and hazard mitigation measures. Most residents felt the impact to public safety should be considered first, followed by funding and time frame (see Appendix D for more details).

Potential Funding Sources – Sources of funding are identified in Table 7-1 and further summarized in Table 7-2. The "Potential Funding Sources" column in Table 7-1 focuses on projects that would be competitive for each funding source. The Town's General Fund is considered a default potential funding source, unless the Town can pursue additional funding.

While acronyms are used in Table 7-1, the full names of potential funding sources can be found in Table 7-2. An additional description of municipal funding is available in Section 7.3.

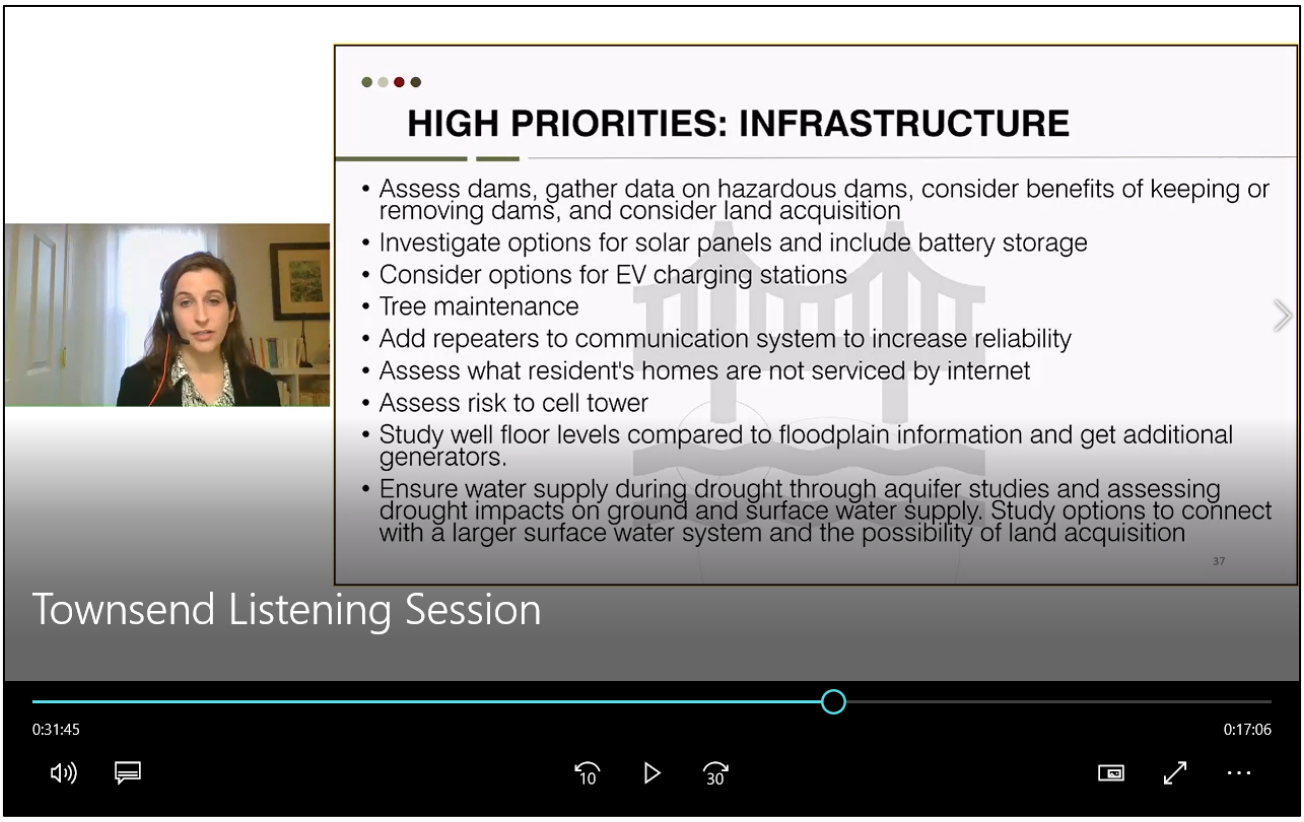


Figure 7-1. Infrastructural high priority action items were presented during Townsend's Virtual Public Listening Session Webinar

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
Dam Safety	Document dam conditions, ERPs, and potential impact and consider removing/ restoring dams based on their current functionality.	• **Water Department** • Planning • Private dam owners • DCR • Dep. of Fish and Game	1-3	$$	H	EEA Dam and Seawall Repair Program, MET
	Pursue land acquisition in the floodplain once the non-functional dams are removed.	• **Conservation commission** • Water Department • Planning and Development	5-10	$$$$$	M	LAND Grant
Electricity and Communication Infrastructure	Study feasibility of solar panel installations on Town buildings, parking lot at the high school and behind the library. Install solar panels with battery storage.	• **Energy Committee** • Planning and Development • Emergency Management	Study – 1-3 Implementation – 5-10	Study - $$ Installations - $$$$	H	Green Communities Grant program, MVP Action Grant
	Install electric vehicle charging stations in public areas.	• **Energy Committee** • Planning and Development • Emergency Management	3-5	$$$	H	MassEVIP, Green Communities Grant program

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	Assess risk to cell tower to avoid any potential interference during emergency communications. Add repeaters to communication system to increase reliability.	• Unitil • Emergency Management • Planning and Development • Cell phone companies	Assessment – 1-3 Installation – 3-5	Study - $ Installations - $$	H	Private funds, general funds
	Replace communications tower on Bayberry Road.	• Emergency Management	5-10	$$$$$	M	Private funds, general funds
	Develop a list of residents without efficient internet connections. Improve internet access and infrastructure.	• Comcast • Emergency Management • Planning and Development	1-3	$	H	Private funds, general funds
	Employ efficient communication systems to ensure public safety during emergency through AM radio network, reverse 911/ CodeRED, or cell towers on wheels.	• Emergency Management	1-3	$$	H	Private funds, general funds

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
Public Water Supply	Study well floor elevations and compare them with the new floodplain information to check if well stations need to be raised.	• **Water Department**	1-3	$	H	FEMA BRIC
	Buy backup generators for pump stations and well houses.	• **Water Department** • Planning and Development	3-5	$$	H	General Fund
	Conduct aquifer study to find out the impact of drought on ground and surface water supply. Study other feasible water supply connections or rehabilitating Cross St Well.	• **Water Department**	1-3	$	H	Water Management Act Grant, MVP Action Grant, DWSRF, 604b
	Ensure water supply during times of drought by connecting with a larger surface water system.	• **Water Department** • Emergency Management • Planning and Development	1-3	Study - $	H	DWSRF, Water Department
	Study feasibility of land acquisition around Town wells.	• **Planning and Development** • Water Department	1-3	$	H	Land and Water Conservation Fund
Culverts and Stormwater Drainage	Identify culverts that are not adequately sized or are in poor condition.	• **Highway Department** • Water Department	1-3	$	M	General Fund

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	Replace undersized culverts, possibly starting on Old Meeting House Road. Properly sized culverts can improve flow and wildlife passage.	• **Highway Department** • Water Department	1-3	$$$$	H	FEMA BRIC, DER Culvert Replacement Municipal Assistance Grant
	Install rain gardens to filter storm drainage, with particular attention to Town wells.	• **Water Department**	3-5	$$	M	MVP Action Grant
	Enforce regulations to monitor the effectiveness of private stormwater system (detention pond, bioretention) maintenance.	• **Planning and Development** • Water Department	3-5	$	M	General Fund
Roads, Bridges, and Public Transit	Develop designs for cloudburst streets and sidewalks with creative storage for runoff in the floodplain areas near the river.	• **Highway Department** • Emergency Management	5-10	$$- Study $$$$$ - Implementation	M	MVP Action Grant, MassDOT STIP
	Develop plans to raise roads (coordinated with below-grade utilities) using pervious pavement in low-lying places.	• **Highway Department** • Emergency Management • Planning and Development	5-10	$$- Study $$$$$ - Implementation	M	FEMA BRIC, Chapter 90 Program

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	Meadow Road for example.					
	Conduct studies to increase walkability in the center of the Town.	• Highway Department • **Energy Committee** • **Planning and Development**	1-3	$$	M	General Fund, Complete Streets
	Assess the condition and resilient design options for the two structurally deficient bridges identified by MRPC in 100-year flood zones.	• **Highway Department** • Emergency Management	3-5	$$- Study $$$$$ - Implementation	M	Municipal Small Bridge Program, STBG
Private Wells and Septic Systems	Assess current zoning and employ BOH regulations for best practice and sustainable development. Consider cost to track reporting.	• **Board of Health** • Water Department • Highway Department • Planning and Development	3-5	$$	M	EEA Planning Assistance Grant, MVP Action Grant
	Integrate public education and outreach related to water testing and arsenic in public wells.	• **Board of Health** • Water Department • Highway Department	1-3	$	M	General Fund
	Develop an inventory of all the private wells that will be impacted by stormwater drainage and designate	• **Board of Health** • Water Department • Highway Department	1-3	$$	M	604b

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	recharge areas for those wells.					
	Assess all the water supply networks to create a list of faulty ones.	• Board of Health • Water Department • Highway Department	1-3	$	M	General Fund
Shelters	Designate cooling centers for residents, especially for vulnerable populations. Designate a pet-friendly shelter.	• Emergency Management	3-5	$$	M	General Fund
	Provide transportation to shelters for isolated residents.	• Public Health • Emergency Management	1-3	$	M	Community Transit Grant Program
	Inventory supplies and storage capacity at shelters to identify shortages.	• Public Health • Emergency Management	1-3	$	M	EMPG
Residents at Risk of Isolation	Develop a plan to provide essential goods to people in remote locations as part of Comprehensive Emergency Response Plan update.	• Emergency Management • Public Health	1-3	$	H	MVP Action Grant
	Work with local partners to conduct in-home visitation services for	• Emergency Management • Public Health	1-3	$	H	General Fund

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	medical assistance and regular check-ins.					
Residents with Limited English Fluency	Conduct language classes for adults. Work with local faith-based groups to teach classes, host adult language classes at the Public Library or Senior Center.	• **Planning and Development** • Public Library • Senior Center • Housing Authority	1-3	$	H	General Fund, Private Funds
	Access available resources from neighboring communities.	• **Planning and Development**	1-3	$	H	General Fund
	Translate important documents and emergency communications into other languages.	• Planning and Development • **Emergency Management**	1-3	$	H	General Fund
	Seek funding to create an ongoing collaboration to reduce burden on current translators.	• **Planning and Development**	1-3	$	H	General Fund
	Have translators ready to translate materials in a crisis and develop infographic signage.	• **Emergency Management** • Planning and Development	1-3	$	H	General Fund
Residents with Barriers to	Develop flood protection	• Planning and Development	1-3	$	M	FMA

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
Preparing or Adapting (could include low-income residents)	strategies for housing along the river.	• Building				
	Work with local volunteers to provide support to residents living in subsidized housing. Assess options for a formal program with Town staff, including helping with resume building and job searches.	• Housing Authority • Planning and Development	1-3	$$	M	CDBG, CCP, MassWorks
	Seek grant funding for flood hazard mitigation and assistance for low-income residents.	• Housing Authority • Planning and Development	1-3	$	M	FMA, MVP Action Grant
	Include more local services in future affordable housing projects.	• Housing Authority • Planning and Development	1-3	$	M	MassWorks
Municipal Buildings and Services (Police, Fire, Highway Department)	Relocate the Water Department Garage out of the floodplain or fortify. Improve municipal properties with climate resilient features (i.e. green infrastructure and cool roofs).	• Emergency Management • Building	1-3	$$	H	FEMA BRIC, MVP Action Grant

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	Secure memoranda of understanding with similar departments in adjacent Towns.	• Emergency Management • Planning and Development • Police Department • Fire Department • Highway Department	1-3	$	H	General Fund
	Improve use of communication technology during extreme events (remote access, sustained internet access, ability to transfer phones).	• Emergency Management • Planning and Development	1-3	$$	H	General Fund, Private Funds
	Consider options for interconnectivity and regional collaboration (for example, regionalized police services with opportunities for training and growth or a mobile emergency response center).	• Emergency Management • Police Department • Planning and Development	1-3	$$	H	General Fund
	Employ additional staff or training to improve services.	• All departments	1-3	$$	H	General Fund

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
Local Businesses	Introduce new businesses owners to the community by organizing community events and identifying local resources in order to improve the Town's financial health.	• Housing Authority Planning and Development	1-3	$	M	General Fund
	Create an economic center to help make business plans.	• Planning and Development	5-10	$$	H	MassWorks
	Hire a local Planner to focus on economic revitalization.	• Planning and Development	1-3	$	H	General Fund
	Education for business owners related to reducing toxic chemical use, energy efficiency, water recycling in manufacturing, and carbon labeling of products. Share available best practices for resilient businesses and retail.	• Planning and Development	1-3	$	M	MVP Action Grant
Food Security (supply, delivery, and local farmers)	Create an Agricultural Advisory Committee and develop	• Planning and Development	1-3	$	H	FMPP

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	programs and incentives for local farms.					
	Organize farmers markets and public outreach for gardening programs.	• **Planning and Development**	1-3	$	H	RFSP
	Invest in a generator and walk-in refrigerator for Food Bank in one centralized location.	• **Emergency Management**	1-3	$$	H	General Fund
	Turn land into victory garden-style space for apartment residents.	• Planning and Development • **Open Space and Recreation**	1-3	$	H	LAND
State Forests	Study existing species as part of a forest health assessment. Identify species that can tolerate warmer conditions.	• **Tree Warden** • Conservation Commission • Open Space and Recreation	1-3	$	M	General Fund
	Assess wildfire risk and plan for fire mitigation.	• Conservation Commission • Tree Warden • **Fire Department**	1-3	$	M	FP&S, SAFE, Senior SAFE
Street Trees	Create a replacement plan for lost trees. Investigate appropriate replacement species that will be able to	• Conservation Commission • Planning and Development • Open Space and Conservation • **Tree Warden**	1-3	$	M	MVP Action Grant

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	withstand future warmer climate.					
	Build a Town Committee that will involve local families and kids and help with planting.	• Conservation Commission • **Tree Warden** • Planning and Development	1-3	$	M	Community Forest Grant Program
	Increase public awareness of Scenic Roads Act and on benefits of trees.	• **Conservation Commission** • Tree Warden • Open Space and Recreation	1-3	$	M	Community Forest Grant Program
	Design new street trees with adequate planters, root space, continuous planting subsoil.	• Conservation Commission • **Tree Warden**	3-5	$$	M	TD Green Space Grant
Parks and Open Spaces	Work with the Townsend Open Space and Recreation Commission to assess parks that are not included in the OSRP.	• **Open Space and Recreation** • Recreation Commission	1-3	$	M	CPA
Waterbodies and Wetlands	Preserve and protect wetlands.	• **Conservation Commission** • Planning and Development	1-3	$$	H	EEA Planning Assistance Grant
	Allow developments that protect the wetlands.	• **Conservation Commission** • Planning and Development	1-3	$	H	EEA Planning Assistance Grant
	Strengthen Zoning Bylaws to protect wetlands.	• Conservation Commission	1-3	$	H	EEA Planning Assistance

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
		• **Planning and Development**				Grant, MVP Action Grant
	Acquire land in the wetland areas to prevent development.	• **Conservation Commission** • Planning and Development	5-10	$$$$	H	LAND Grant, MVP Action Grant
	Develop plans for bank restoration and stabilization to protect waterways and support habitat.	• **Conservation Commission** • Planning and Development	1-3	$$	H	MVP Action Grant
Future Development, Regulatory Tools, and Planning	Protect against commercial uses in the Aquifer Protection Overlay district.	• **Planning and Development**	1-3	$	H	General Fund
	Update the FEMA FIRMs.	• **Emergency Management** • Planning and Development	1-3	$	H	General Fund
	Study options for regulations, waivers, zoning, low impact development, transfer of development rights to protect aquifers and incorporate other climate resilient measures.	• **Planning and Development** • Water Department	1-3	$	H	MVP Action Grant, EEA Planning Assistance Grant
	Update Master Plan and Open Space and Recreation Plan with climate resilience and	• **Planning and Development**	1-3	$	H	MVP Action Grant

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	hazard mitigation strategies.					
	Update CEMP and simulate real time evacuation scenarios with tool from MRPC.	• **Emergency Management**	1-3	$	H	EMPG
	Assess options for encouraging properties inside the floodplain to elevate buildings and critical components. Require resilient design specifications as a part of the Flood District permitting process for major redevelopment and new development.	• **Planning and Development**	1-3	$	H	FMA, EEA Planning Assistance, MVP Action Grant
	Increase public education and awareness of Massachusetts sustainable development principles, green building design and architecture, Scenic Roads Act, and resilient stormwater management strategies.	• **Planning and Development**	1-3	$	M	General Fund
Invasive Species and	Increase public education and awareness	• **Public Health** • Planning and Development	1-3	$	M	MVP Action Grant

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
Vector-Borne Diseases	related to tick exposure and protection against disease.					
	Pursue removal of invasive species with volunteers and local groups.	• **Open Space and Recreation**	1-3	$$	M	General Funds, Private Funds
	Reduce mosquito habitat through outreach and by removing standing water and regular cleaning of catch basins.	• **Open Space and Recreation** • Water Department	1-3	$$	M	MVP Action Grant, General Funds, Private Funds
	Host community education programs on how to use trails safely, share regular webinars on topics related to open space resources. Assess options for collaborating between departments to maintain these resources.	• **Open Space and Recreation** • Planning and Development	1-3	$$	M	MVP Action Grant
	Address cynobacteria or algal blooms on local surface water bodies. Assess impacts of climate change on these conditions and study best	• **Water Department**	3-5	$$	M	MassDEP Water Quality Monitoring Program, DWSRF

Table 7-1. Priority Hazard Mitigation and Climate Adaptation Actions

General Objective	Mitigation Action	Implementation Responsibility	Time Frame (years)	Estimated Cost	Priority	Potential Funding Sources
	practices for management.					

Note: "Emergency Management" refers to both the Townsend Fire-EMS Department and the Police Department

7.2 Regional Partnerships

Mitigating natural hazards is not confined to a local issue. The drainage systems that serve these communities are often complex systems of storm drains, roadway infrastructure, pump stations, dams, and other facilities owned and operated by a wide variety of agencies, including Massachusetts Department of Transportation (MassDOT), Massachusetts Emergency Management Association (MEMA), and the Department of Conservation and Recreation (DCR). The planning, construction, operation, and maintenance of these structures are integral to the hazard mitigation and climate adaptation efforts of communities. Much of the State Forests in Townsend are maintained by DCR. The Town will strive to share and obtain vulnerability data in coordination with these agencies. These agencies also operate with the same budgetary and staffing constraints as communities. Similarly, to municipalities, they must make decisions about numerous competing priorities. In order to implement many of the mitigation measures identified by the Town, all parties will need to work together towards a mutually beneficial solution.

7.3 Potential Funding Sources

The identification of funding sources 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 a combination 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 potential funding sources in more detail.

Traditional funding sources within the Town of Townsend, such as funding from the operating and capital budgets, may be able to cover some of the costs associated with the action items detailed in Table 7-1. State revolving funds and other no- or low-interest loans may also be of interest. There is a great variety of 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 options related to action items developed by Townsend are listed in Table 7-2 below.

Table 7-2: Potential Funding Sources

Category	Grant	Description	Limitations & Stipulations
Community Development	MassWorks Infrastructure Program	Provides grants to communities to help them prepare for success and contribute to the long-term strength and sustainability of the Commonwealth. For public infrastructure projects that support and accelerate housing production, spur private development, and create jobs.	None
Community Development	EEA Planning Assistance Grants	Funds zoning for sustainable housing production, regulations that reduce energy use and GHG emissions, and zoning that results in permanent land conservation.	None
Community Development	HUD Community Development Block Grant Programs (CDBG)	To develop viable communities by providing decent housing and a suitable living environment, and expanding economic opportunities.	None
Community Development	Regional Food System Partnerships (RFSP)	Supports partnerships that connect public and private resources to plan and develop local or regional food systems.	Does not fund production- or equipment-related expenses, construction or land purchase. See website for additional limitations.
Community Development	Farmers Market Promotion Program (FMPP)	Funds projects that develop, coordinate and expand direct producer-to-consumer markets to help increase access to and availability of locally and regionally produced agricultural products by developing, coordinating, expanding, and providing outreach, training, and technical assistance to domestic farmers markets, roadside stands, community-supported agriculture programs, agritourism activities, online sales or other direct producer-to-consumer market opportunities.	25% match required.
Community Development	Community Preservation Act (CPA)	Cities and towns that adopt the Community Preservation Act (CPA)	Only communities that have adopted CPA

Table 7-2: Potential Funding Sources

Category	Grant	Description	Limitations & Stipulations
		generate monies for their local Community Preservation funds through the implementation of a local CPA property tax surcharge of up to 3% and through the receipt of annual matching of funds, at variable rates, from a statewide CPA Trust Fund created by the Act.	are eligible to receive these matching funds each year.
Emergency Management and Planning	Flood Mitigation Assistance Grant Program (FMA)	Implement cost-effective measures that reduce or eliminate the long-term risk of flood damage.	For buildings and other structures insured under the National Flood Insurance Program (NFIP).
Emergency Management and Planning	Hazard Mitigation Grant Program	Provides funding after a disaster to significantly reduce or permanently eliminate future risk to lives and property from natural hazards.	None
Emergency Management and Planning	Building Resilient Infrastructure & Communities (BRIC)	Provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event, with a focus on infrastructure projects and "community lifelines." Replaced FEMA's Pre-Disaster Mitigation (PDM) Program.	None
Emergency Management and Planning	Fire Prevention and Safety Grant (FP&S)	Part of the Assistance to Firefighters grant – supports projects that enhance the safety of the public and firefighters from fire and related hazards.	None
Emergency Management and Planning	MEMA Citizen Corps Program (CCP) Grant	Supports local Community Emergency Response Teams (CERT) and Volunteers in Police Service (VIPS) in preparing for all-hazards. Can be used for planning activities, equipment, training, and exercises.	None
Energy	MA DOER Green Communities Designation and Grant Program	The designation allows communities to access grants for clean, affordable, and resilient energy projects.	None

Table 7-2: Potential Funding Sources

Category	Grant	Description	Limitations & Stipulations
Energy	MA Electric Vehicle Incentive Program (MassEVIP) Fleet Incentives	Helps eligible public entities acquire electric vehicles and install charging stations.	None
Environment	Community Forest Grant Program	Funding to establish community forests.	None
Environment	Culvert Replacement Municipal Assistance Grant Program	Grant to replace undersized, perched, and/or degraded culverts located in an area of high ecological value.	None
Environment	604b Grant Program	Water quality assessment and management planning.	None
Environment	EEA Massachusetts Land and Water Conservation Fund Grant Program	Funding for the acquisition, development, and renovation of parks, trails, and conservation areas.	Municipality must have an OSRP
Environment	EEA Local Acquisitions for Natural Diversity (LAND) Grant Program	Helps cities and towns acquire land for conservation and passive recreation.	Reimbursement rate: 52-70%
Environment	Federal Land & Water Conservation Fund	Funding for the acquisition, development, and renovation of parks, trails, and conservation areas.	Municipality must have an OSRP
Environment	MassTrails Program	Trail protection, construction, and stewardship projects.	None
Environment	Municipal Vulnerability Preparedness (MVP) Action Grant Program	Provides support to implement climate change resiliency priority projects.	None
Environment	Natural Resource Damages Program	Funding for restoration projects. Funding comes from settlements, so it is does not follow a set schedule.	None
Environment	MS4 Grant Program	Meeting the requirements of the 2016 MS4 permit and reduce stormwater pollution through partnerships.	Two or more municipalities subject to the 2016 Small MS4 General Permit must apply together
Environment	Massachusetts Environmental Trust (MET)	Grants to support projects that protect and restore natural resources, including dam removal.	None
Environment	MA DEP Water Management Act Grant	Funds planning projects to identify implementation actions to improve	None

Table 7-2: Potential Funding Sources

Category	Grant	Description	Limitations & Stipulations
		ecological conditions, conservation projects and drought resiliency planning, and withdrawal mitigation projects that increase porosity and water quality.	
Environment	MassDEP Water Quality Monitoring Grant Program	Enhance MassDEP surface water quality assessment data by building or expanding capacity for bacteria monitoring data collection.	None
Environment	EPA Drinking Water State Revolving fund (DWSRF)	A federal-state partnership to help ensure safe drinking water and provide financial support to water systems.	None
Environment	TD Green Space Grant	Supports green infrastructure development, tree planting, forestry stewardship, and community green space expansion as a way to advance environmental and economic benefits toward a low-carbon economy.	$20,000 is available. The program's annual themes may vary. Applicants are encouraged to apply with community partners.
Public Safety	EEA Dam and Seawall Repair or Removal Program	Grants for the repair or removal of dams, seawalls, and levees. Intended to promote public health, public safety, and ecological restoration.	None
Public Safety	Emergency Management Performance Grant (EMPG)	Supports local emergency management agencies in implementing the National Preparedness System and national Preparedness Goal of a secure and resilient nation. Funds projects related to logistics/distribution management planning, evacuation plan/annex, disaster financial management, catastrophic disaster housing, resilient communities, and implementing community lifelines.	Reimbursable
Public Safety	Public Assistance Program	The state reimburses governments and other applicants for disaster related costs.	75% reimbursable
Public Safety	Senior SAFE	Supports fire and life safety education for seniors.	None

Table 7-2: Potential Funding Sources

Category	Grant	Description	Limitations & Stipulations
Public Safety	Student Awareness of Fire Education (S.A.F.E.)	Grants for local fire departments to teach fire and life safety to schools.	None
Public Works & Transportation	Chapter 90 Program	Reimbursable grants for capital improvements such as highway construction, preservation and improvement projects that extend the life of capital facilities.	None
Public Works & Transportation	Community Transit Grant Program	Funding to meet the transportation and mobility needs of seniors and people with disabilities.	Depends on project type
Public Works & Transportation	Complete Streets Funding Program	Technical assistance and construction funding.	Must pass a Complete Streets Policy and develop a Prioritization Plan
Public Works & Transportation	Municipal Small Bridge Program	Funding for small bridge replacement, preservation, and rehab projects.	Bridges with spans between 10’ and 20’
Transportation	Surface Transportation Block Grant Program (STBG)	Includes funding for bridge projects on any public road and facilities for nonmotorized transportation.	None
Transportation	MassDOT State Transportation Improvement Program (STIP)	Funding for bicycle paths, bridges, roadways, sidewalks, and transit investments.	None

8.0 PLAN ADOPTION AND MAINTENANCE

8.1 Plan Adoption

The Town of Townsend 2020 HMP-MVP Plan was adopted by the Board of Selectmen on February 16, 2021. The plan was approved by FEMA on February 24, 2021 for a five-year period that will expire on February 24, 2026. See Appendices E and F for documentation.

8.2 Plan Implementation

The Core Team will use Table 7-1 as a guide for taking action to mitigate hazards and improve the Town's climate resilience. The time frame, responsible department, and funding mechanisms in Table 7-1 and 7-2 lay out an implementation plan for the Core Team. The Core Team will be held accountable through the tracking mechanisms explained in the following sections. The HMP-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. This can be achieved through a combination of two methods:

1. The Core Team, coordinated by Beth Faxon, will meet annually or on an as-needed basis, whichever is most frequent, to monitor plan implementation. The Core Team will be amended as needed. These meetings will provide an opportunity for regular check-ins, identifying overlaps and capital planning needs related to hazard mitigation, and forward-looking discussions regarding next steps.

2. The coordinator of Core Team, Beth Faxon, will also prepare and distribute a survey every two years. The survey will be made available to all Core Team members and any other interested local stakeholders. The questions in the survey will reference the tables of existing and proposed action items listed in the HMP-MVP Plan. The survey will assist in determining any necessary changes or revisions to the plan that may be needed. In addition, it will provide written documentation of status updates, progress, and accomplishments related to the action items listed in the HMP-MVP plan. The surveys will also help document new hazards or problem areas that have been identified since the 2020 Plan. The information collected through the survey will be used to formulate an update and/or addendum to the plan. The survey may also be collectively filled out at a Core Team meeting.

8.3.1 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 and implementation cycle. 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 website. All public meetings related to the HMP-MVP Plan

will be publicly noticed in accordance with Town and State open meeting laws. Several topics were identified as areas where community engagement and education should continue or be improved:

- Work with property owners to reduce risk to flooding, fires, and other hazards.
- Provide announcements through more diverse communication channels.
- Spread information about location shelters, evacuation routes, and other mitigation measures.
- Develop messaging for water conservation.
- Expand awareness of volunteer opportunities.

8.3.2 Integration of the Plans with Other Planning Initiatives

Upon approval of the Town of Townsend 2020 HMP-MVP Plan by FEMA, the Core Team will make the plan available to all interested parties and departments with 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:

- Highway Department
- Water Department
- Conservation Department
- Cemetery and Parks Department
- Townsend Emergency Management Agency
- Land Use Department
- Police Department
- Fire-EMS Department
- Board of Health
- Building Department

Appropriate sections of the HMP-MVP Plan will be integrated into other plans, policies and documents as those are updated and renewed. This may include updates to:

- The Townsend Master Plan
- Open Space and Recreation Plan
- Comprehensive Emergency Management Plan

Coordination with the Montachusett Regional Planning Committee, local organizations, businesses, watershed groups, and State agencies will be required for successful implementation and continued updating.

8.4 Process of Updating

By maintaining the 2020 HMP-MVP Plan, the Town will have a competitive application when applying to FEMA for funding. Once 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 requirements. The update to the Town of Townsend 2020 HMP-MVP Plan 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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