














Town of Dunstable

Hazard Mitigation Plan (HMP) 2024 Update and Municipal Vulnerability Preparedness (MVP) Summary of Findings Report

DRAFT March 27, 2024

Town of Dunstable Massachusetts

MVP Municipal Vulnerability Preparedness

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1. Introduction

The Town of Dunstable prepared this Hazard Mitigation Plan and Municipal Vulnerability Preparedness Summary of Findings Report (HMP-MVP) to create an action roadmap to reduce the impacts of natural hazards and climate change within the community. This Chapter further discusses HMP-MVP components and local goals for hazard mitigation.

1.1. What is Hazard Mitigation Planning?

Hazard mitigation planning is an iterative process that seeks to reduce the impact of natural hazards on people and property. Dunstable has assessed a variety of natural hazards that pose a risk to the health and welfare of residents, identified specific vulnerabilities associated with those hazards including potential future impacts due to climate change, and identified local capabilities and specific mitigation actions to protect homes, businesses, and the critical infrastructure that keeps the town running. This process is tailored to address the issues affecting Dunstable residents now and into the future and is crucial to building community resilience. Below are some key words necessary for understanding this Hazard Mitigation Plan. These definitions come from the Federal Emergency Management Agency (FEMA) or the 2023 ResilientMass Plan:

- **Natural Hazards** are a source of harm or difficulty created by a meteorological, environmental, or geological event (such as extreme wind events, tornadoes, winter weather as well as earthquakes, flooding, and fires). (FEMA)
- **Hazard mitigation** is any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. An example of hazard mitigation is elevating or strengthening a bridge to reduce damage, disruption, or loss from a flood or earthquake. It also includes developing regulations to require new construction to include new methods and procedures to reduce risks from current hazards and increasing risks from climate change. (2023 ResilientMass Plan)

- **Vulnerability** is a description of which community "assets" (people, structures, systems, natural resources, cultural resources, historic resources, the economy, and activities that have value to the community) are at risk from the effects of a natural hazard. (FEMA)
- **Impacts** are the consequences or effects of each hazard on the participant's assets identified in the vulnerability assessment. For example, impacts could be described by referencing historical disaster damages with an estimate of potential future losses (such as percentage of damage vs. total exposure). (FEMA)
- **Climate Change** refers to "changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changing risk of certain types of severe weather events, and changes to other features of the climate system." (FEMA, U.S. Global Change Research Program, 4th National Climate Assessment).
- **Resilience** is the capacity of individuals, communities, businesses, institutions, and governments to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruptions to everyday life, such as hazard events. (2023 ResilientMass Plan)

1.2. What is a Municipal Vulnerability Preparedness Plan?

A Municipal Vulnerability Preparedness (MVP) plan identifies priority action items to address vulnerabilities and utilize strengths in preparation for climate change. In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) initiated the state's MVP grant program to help communities become more resilient to the impacts of climate change. The program has two grant phases:

1. The first grant phase is the **Planning Grant**, which funds the vulnerability analyses, engagement, and planning processes. Municipalities convene a team of municipal staff, engage stakeholders in a Community Resilience Building (CRB) Workshop, and engage community members in developing the plan. The Community Resilience Building Workshop was developed by the Nature Conservancy and provides a process for developing resilience action plans with stakeholder input. **The Community Resilience Building Workshop's central objectives are to:**
    a. **Define top local natural and climate-related hazards of concern**
    b. **Identify existing and future strengths and vulnerabilities**
    c. **Develop prioritized actions for the Community**
    d. **Identify immediate opportunities to collaboratively advance actions to increase resilience**

2. The second phase of the MVP program is the **Action Grant**, which funds the implementation of priority climate adaptation actions described in the MVP plan. The MVP

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

1.3. Combining Hazard Mitigation and Municipal Vulnerability Preparedness Planning in Dunstable

The Town of Dunstable received an MVP Planning Grant from the Executive Office of Energy and Environmental Affairs (EEA) to simultaneously undertake the MVP Community Resilience Building process in coordination with preparing an approved HMP. This combined approach enabled Dunstable to consider the impacts of climate change in addition to historic hazard events as part of its planning process. Also, many of the required steps of the MVP process satisfy FEMA requirements for updating an HMP. For example, an MVP requires convening a Core Team and hosting a CRB Workshop and Public Listening Session, which are not required specifically by FEMA, but do meet the public input needs of the hazard mitigation planning process (see Figure 1.1). The Town prepared this joint MVP-HMP in accordance with FEMA guidelines for hazard mitigation planning (Title 44 Code of Regulations (CFR) 201.6) and with EEA's requirements for MVP plans. By completing a joint HMP-MVP, Dunstable was able to fulfill the requirements and enhance the impact of both processes.

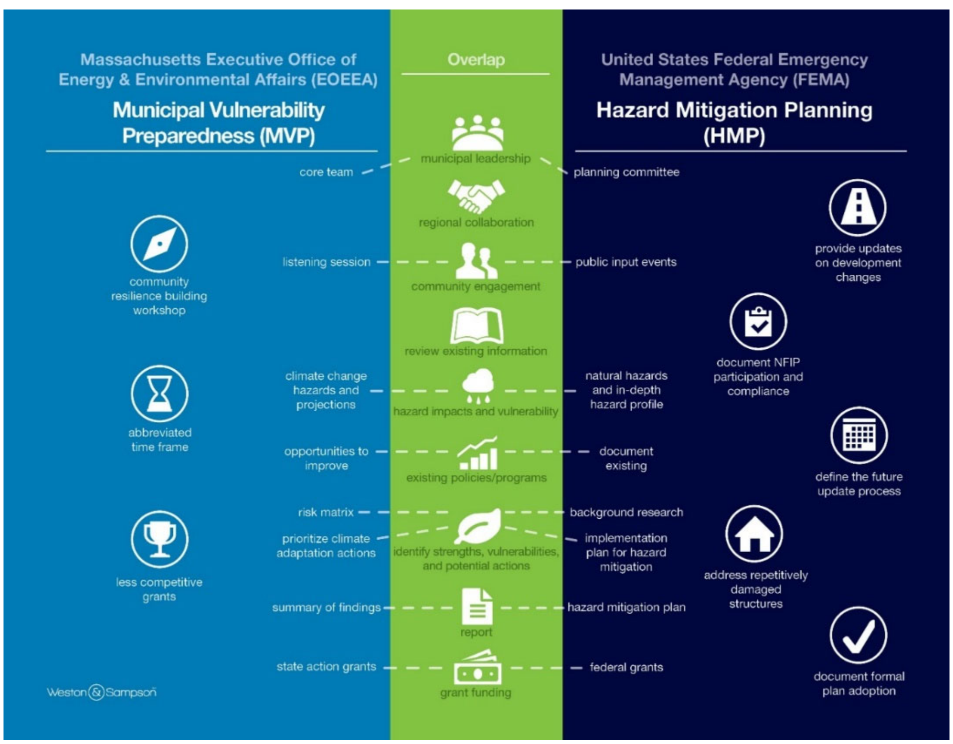

Figure 1.1: Comparison of the MVP and HMP Processes

1.4. Benefits of Hazard Mitigation Planning

Completing the HMP-MVP provides many benefits to Dunstable:

1. **Increasing public awareness of natural hazards that may affect the community reduces overall risk.** By providing education and outreach, individuals are able to understand how natural hazards may affect their lives and what the region, the Town, and they as individuals can do and are doing to minimize impacts of those hazards.
2. **Proactive planning creates efficiency beyond town limits.** Developing an HMP allows state and local governments to work together and combine hazard risk reduction with other community goals and plans.
3. **The community's greatest vulnerabilities can be prioritized to receive resources.** Developing a plan of hazard mitigation measures considers a prioritization process that reflects the cost and benefit of safety, property protection, technical, political, legal, environmental, economic, social, administrative, and other community objectives, quantitatively and/or qualitatively.
4. **The implementation of an HMP saves taxpayer money.** According to FEMA, one dollar spent on federal hazard mitigation grants saves an average of six dollars on disaster response (NIBS, 2019).
5. **Maintaining a FEMA compliant HMP also makes the municipality eligible for federal grant funding (FEMA, 2020).** Hazard mitigation funding is available through the Federal Emergency Management Agency (FEMA). To be eligible for FEMA Grants, local governments must prepare an HMP that meets the requirements established in the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000. The HMP also ensures that federally funded projects reflect a community's priorities and offer solutions to specific threats. Please refer to Chapter 5 for more information on FEMA grants and other potential funding sources.
6. Undertaking the MVP Community Resilience Building Process and **obtaining Community Designation makes Dunstable eligible for funding MVP action grant funding.**
7. In addition, by obtaining Community Designation under the MVP Program, **Dunstable receives increased standing for other state grants.**

1.5. Dunstable's Natural Hazard Mitigation & Climate Adaptation Goals

Dunstable's Core Team (documented in Chapter 2 Section 2.2.1) established the goals and objectives for natural hazard mitigation planning in Dunstable. This effort included a review and update of the goals listed in the 2015 Hazard Mitigation Plan. The goals were restructured to better represent Dunstable's local priorities (as the previous goals were from a regional HMP) and provide simplified messaging.

1. **Protect Health and Safety:** Ensure that people, structures, systems, natural/cultural/historic resources and the overall health and safety of Dunstable are protected from natural hazards.
2. **Increase Outreach and Education:** Increase awareness and support for natural hazard mitigation among private organizations, businesses, and area residents through outreach and education.
3. **Increase Response Capacity:** Increase Dunstable's community's capacity for responding to a natural hazard event.
4. **Protect Priority Populations:** Implement a broad range of mitigation measures that protect the Town's priority populations.
5. **Consider the Economy:** Develop a mitigation strategy that considers area businesses and protects the economic vitality of the Town.
6. **Integrate Climate Change:** Implement mitigation strategies to protect the community from the impacts of climate change.
7. **Encourage Smart Development:** Discourage future development in hazard prone areas, such as flood plains.
8. **Increase Coordination:** Increase coordination between the Federal, State, regional and local levels of government.
9. **Keep the Plan Relevant:** Update and maintain the Plan as resources permit.
10. **Be Sustainable:** Encourage sustainability of the Town.

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2. Planning Process

The Dunstable HMP-MVP was informed by data review and analysis, input received from the Core Team during and outside of the Core Team meetings, input from the CRB Workshop held with targeted stakeholders, and input from public engagement activities.

2.1. Overview of Plan Development

The HMP-MVP planning process proceeded according to the timeline shown in Table 2-1

Table 2.1: HMP Planning Timeline

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Kickoff	X											
Engagement		X	X	X	X	X	X	X	X	X	X	X
CRB Workshops				X								
Asset Inventory		X	X	X								
Hazard Profiles				X	X	X	X					
Vulnerability & Impact Assessment				X	X	X	X					
Goals & Capabilities		X				X						
Actions & Priorities				X	X	X	X	X	X			
Public Review										X	X	
Adoption												>>

2.2. Engagement and Outreach

Input and feedback from three groups was a core component of developing the plan. These three groups included:

- **Core Team:** A group of Town staff who met regularly to consult on the HMP-MVP planning process.
- **Stakeholders:** A team of representatives of a wide variety of groups and experiences to participate in Community Resilience Building Workshops and provide targeted review the draft HMP-MVP.
- **General Public:** Outreach, public surveys, and public meetings open to all community members and neighbors.

The subsequent pages describe the involvement of the Core Team, Stakeholders, and the public in the MVP-HMP planning process in more detail.

2.2.1. | Core Team

The Town of Dunstable convened a Core Team to act as a steering committee for the development of the HMP-MVP. The Core Team played an important role in identifying community assets, identifying and involving key stakeholders, supporting and attending the CRB workshops, capturing the Town's capacity to mitigate hazard alongside ongoing operations, and confirming mitigation actions to be completed in the future. Members of the Core Team are listed in Table 2-2.

Table 2.2: Core Team Members

Name	Title/Affiliation
Leah Basbanes	Vice Chair, Select Board & Conservation Commission Member
Jason Silva	Town Administrator
Erik Hoar	Chief, Dunstable Police Department
Bridget Baley	Health Agent
William Farrell	Chief, Dunstable Fire Department
Dave Tully	Highway Department
Mike Martin	Roadway Commissioner
John O'Brien	Commissioner, Water Commission
Mari Amodei	Chair, Board of Health
Jon Crandall	Emergency Management Director

The Core Team met regulatory during the HMP-MVP planning process. The Core Team also provided regular input through email and survey. More information on these meetings is included in Appendix A. Table 2-2 lists the meetings and topics of discussion.

Table 2.3: Core Team Meetings

Meeting	Date	Meeting Topics
Kick-Off Meeting	July 10, 2023	• Overview of project and process • Roles and responsibilities • Data source request • Discussion of hazards in Dunstable • Project schedule • Preview of next steps • Review logistics
Core Team Meeting #1	August 14, 2023	• Review and finalize list of HMP goals • Discuss assets and asset categories • Review and confirm list of Dunstable assets • Finalize logistics for Community Resilience Building Workshop • Discuss promotion of public survey
Core Team Meeting #2	March 31, 2024	• Review draft HMP-MVP: questions and comments from Core Team • Confirm mitigation actions including prioritization • Plan for public review process
Core Team Meeting #3	TBD	TBD

2.2.2. | Stakeholders

A variety of stakeholders were invited to participate in plan development and review. Appendix B lists workshop invitees and attendees.

- **Municipal staff beyond those involved in the Core Team** (e.g., Planning Board members, Highway, additional Conservation Commission members, Board of Selectmen, Council on Aging, Historical Commission, Master Planning Committee, Zoning Board of Appeals, Capital Planning Committee, Building Inspector, Parks Commission, Animal Control, School Committee, Senior Center, Veteran Services, Library, etc.)
- **Local survey respondents.** (See Section 2.2.3)
- **State and Regional entities** (e.g., State Senators and Representatives, NMCOG, MassDEP, DCR, MEMA, Merrimack River Watershed Council, Nashua River Watershed Council, MassDOT, Lowell General Hospital, National Grid, Verizon, Charter, etc.).
- **Adjacent communities** (representatives from Tyngsborough, Pepperell, and Groton, MA and Nashua and Hollis, NH).

Stakeholders and local survey respondents were engaged by being provided an invitation to the local workshops and an invitation to review the draft HMP-MVP.

The **Community Resilience Building (CRB) Workshops** were held at the Dunstable Town Hall on Friday, October 20 and Thursday, October 26, 2023, as two half-day, four-hour workshops. The workshops were organized around topic areas that included People, Structures, Systems, Historical/Cultural/Natural Resources, Economy, and Activities that have Value to the Community. 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 workshops, Weston & Sampson provided information about natural hazards and climate change, including the top hazards impacting Dunstable. Participants were invited to suggest People, Structures, Systems, Historical/ Cultural/ Natural Resources, Economy, and Activity features in town that are vulnerable to, or provide strength against, these challenges.

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 B, along with the materials from each workshop. There were 19 participants at Workshop #1 and 20 participants at Workshop #2. Key participants at the workshops included:

- Municipal staff members involved in emergency management and response;
- Members of boards and committees, including the Master Planning Committee and Conservation Commission;
- Representatives from State agencies and regional organizations, including Northern Middlesex Council of Governments and Merrimack River Watershed Council; and
- Several Dunstable Residents.

Stakeholders also provided feedback on the draft report. Feedback and responses are included in Appendix B.

2.2.3. | General Public

In order to gather information from the community and educate community members on hazard mitigation and climate change, the Town pursued the following approach:

Getting the word out (Survey): This first step involved posting an online survey to capture initial input. The online survey allowed residents to engage with the project on their own time, and as their schedule allowed. Materials were posted for four weeks in September on the Dunstable Town website and advertised through email blasts, a social media post on the Town Facebook page, and flyers were handed out at the summer concert, and distributed at the fire station, library, and town hall. The online survey received 80 responses. A copy of the survey questions and responses is included in Appendix C. Survey responses are incorporated into this HMP-MVP.

Public Meeting: Tuesday, November 7, 2023
The Town presented at the Board of Selectmen Public Meeting at the Dunstable Town Hall. The key topics presented were:

- Plan workshops and overall progress
- Plan schedule
- Hazard and vulnerabilities
- Asset categories
- Mitigation actions
- Next steps

No questions were asked at the Board of Selectmen Public Meeting. Appendix D includes a copy of the presentation.

Virtual Listening Session: Thursday April 11, 2024, 6 to 7 PM
This second step involved hosting a virtual Public Listening Session.

The webinar presented information related to the MVP program, climate change in Dunstable, local strengths and vulnerabilities, existing mitigation measures, and priority action items for future climate adaptation. Attendees were invited to submit comments on the draft plan during the listening session and in the following three weeks through an online comment form. More information about the virtual Public Listening Session and Comment Period is in Appendix D.

Survey to solicit input on Draft HMP-MVP: The Town posted an online survey to capture input on the draft HMP-MVP, in particular, the comprehensive list of mitigation actions. This approach allowed stakeholders and residents to provide input. Materials were posted for three weeks in April on the Dunstable Town website and advertised through email blasts, a social media post on the Town Facebook page. The online survey received XX responses. A copy of the survey questions and responses is included in Appendix C.

2.3. Review of Existing Plans/ Studies/ Reports/ Technical Information

The following plans, studies, reports, and technical information were reviewed and incorporated into the update of this HMP. Specifically, the information is used in developing portions of the risk assessment found in Chapters 3 and 4.

There are also a variety of bylaws and regulations, as well as committees, that further the Town's efforts to proactively address natural hazards and climate change, which are discussed in Chapter 5 in the Capabilities Assessment.

2.3.1. | Statewide Climate Adaptation Planning Efforts and the Latest Climate Data

The Commonwealth of Massachusetts released the 2023 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2023 ResilientMass Plan) in October 2023. This update includes the incorporation of new population growth and development data, findings from the 2022 Massachusetts Climate Assessment, additional and modifications to the hazards described in Chapter 4, new data and mapping regarding environmental justice and other priority populations, and inclusion of all of the latest available climate data. In developing its updated plan, Dunstable has included all of the updated data and findings from the ResilientMass Plan in order to provide the community with the best available data to prepare for climate mitigation and adaptation in the community.

2.3.2. | Local Plans Related to Hazard Mitigation and Climate Change

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

- Dunstable Master Plan (Committee, 2018)
- Open Space and Recreation Plan 2018-2025 (Commission, 2018)
- Hazard Mitigation Plan for the Northern Middlesex Region (Northern Middlesex Council of Governments, 2015)
- Decennial Census (Bureau, Decennial Census, 2020)

Information from the Master Plan and Open Space and Recreation Plan was used to describe the changes in development that have occurred in hazard-prone areas that have increased or decreased Dunstable's vulnerability since the 2015 HMP, as well as potential future development, as described in Section 3.2.2. Information from the 2015 HMP was used to support narrative of past occurrences of natural hazards throughout Section 4.2 and the Mitigation Actions described in Chapter 6. The Census Data were used to describe people assets, as documented in Section 3.2.1

2.3.3. | FEMA Guidance

All aspects of the planning process were created and implemented in accordance with the updated FEMA Local Mitigation Planning Policy Guide (FEMA, 2022) and FEMA Local Mitigation Planning Handbook (FEMA, May 2023).

3

3. Risk Assessment: Community Assets

Assets are defined broadly as anything that is important to the character and function of a community (FEMA, 2023). Assets can be built, natural, or non-physical elements. They range from emergency facilities and critical infrastructure to community events that help shape collective identity and social cohesion. Below are asset categories, community lifelines, and the list of assets in Dunstable. This analysis is the first step in the risk assessment to identify local vulnerabilities to natural hazards (Chapter 4) and develop a plan for future resilience (Chapter 6).

3.1. Asset Categories

The following sections discuss categories of community assets and how community assets are categorized into community lifelines.

3.1.1. | Overarching Categories

Assets are organized into the following five categories (FEMA, 2022). These categories represent the wide variety of perspectives, purposes, and goals that assets can include.

While assets may fall into multiple categories, they will be listed under just one. The categories are used for organizational purposes only and will not impact the mitigation actions or vulnerability assessments of any assets.

- **People (including underserved communities and socially vulnerable populations):** "Assets that serve populations that are more vulnerable to disaster (e.g., elderly, children, visiting populations) and/or serve densely populated areas."
- **Structures (including facilities, lifelines, and critical infrastructure):** "Built facilities that provide community lifeline services. A community lifeline enables the

continuation of critical government and business functions and is essential to human health and safety or economic security."

- **Systems (including networks and capabilities):** "A collection of components that perform a critical service for the community. Systems are linear type assets. Systems may include horizontal assets associated with linear type assets."

- **Natural resources:** "Natural Resources are
  - areas that provide protective function to reduce magnitude of hazard impact and increase resiliency.
  - areas of sensitive habitat that are vulnerable to hazard events,
  - protection of areas that are important to community objectives, such as the protection of sensitive habitat, provide socio-economic benefits, etc."

- **Historical and Cultural Resources:** "Assets that possess historical, cultural, archaeological or paleontological significance, including sites, contextual information, structures, districts, and objects significantly associated with or representative of earlier people, cultures, maritime heritage, and human activities and events."

- **Economic Assets:** Economic assets are defined as entities that produce a financial benefit for the owner or community.

- **Community Assets:** "Activities that benefit the community by increasing community morale and well-being. Activities may include education and knowledge transfer."

3.1.2. | Community Lifelines

"Community Lifelines" is FEMA's term for assets of a community that the community cannot survive without. "A lifeline enables the continuous operation of critical government and business functions and is essential to human health and safety or economic security" (FEMA, 2020).

For the purposes of hazard mitigation planning and the asset inventory, community lifelines are used to categorize all assets in terms of these critical functions. Not all assets are community lifelines.

A subset of the Town of Dunstable's assets falls into one of eight lifelines that have been classified and described as follows (FEMA, 2019).

Table 3.1: Community Lifelines

Safety and Security	Law enforcement and government services, as well as the associated assets that maintain communal security, provide search and rescue, evacuations, and firefighting capabilities, and promote responder safety.
Food, Hydration, Shelter	Support systems that enable the sustainment of life, such as water treatment, transmission, and distribution systems; food retail and distribution networks; and wastewater collection and treatment systems.
Energy (Power & Fuel)	Infrastructure and service providers for medical care, public health, patient movement, fatality management, behavioral health, veterinary support, and health or medical supply chains.
Health and Medical	Service providers for electric power infrastructure, composed of generation, transmission, and distribution systems, as well as gas and liquid fuel processing, transportation, and delivery systems. Disruptions can have a limiting effect on the functionality of other community lifelines.
Communications	Infrastructure owners and operators of broadband internet, cellular networks, landlines, cable services, satellite communications services, and broadcast networks (radio and television). Communications systems encompass a large set of diverse modes of delivery and technologies, often intertwined but largely operating independently. Services include elements such as alerts, warnings, and messages, as well as 911 and dispatch. Also includes accessibility of financial services.
Transportation	Multiple modes of transportation that often serve complementary functions and create redundancy, adding to the inherent resilience in overall transportation networks. Transportation infrastructure generally includes highways/roadways, mass transit, railway, aviation, maritime, pipeline, and intermodal systems.

Systems that mitigate threats to public health/welfare and the environment. This includes assessment of facilities that use, generate, and store hazardous substances, as well as specialized conveyance assets and efforts to identify, contain, and remove incident debris, pollution, contaminants, oil or other hazardous substances.

Systems for Potable Water and Wastewater Management. This includes potable water intake, treatment, storage, and distribution. It also includes Wastewater collection, storage, treatment, and discharge.

3.2. Town of Dunstable Assets

Assets in the Town of Dunstable have been identified utilizing the newest MassGIS data, the most up to date MassGIS L3 Parcel data, the asset inventory presented in the 2015 Hazard Mitigation Plan, and input collected at the Community Resilience Building Workshops. This section describes community assets and provides summary tables of assets by category including more detail on the general types of assets within that category, how many assets there are, and which assets are considered community lifelines. Maps of community assets are included in Appendix E.

Table 3.2: Summary of Community Assets

People	22
Structures	28
Natural Resources	32
Systems	22
Cultural + Historic Resources	16
Economic + Community Assets	10
% of Assets that are Community Lifelines	58

3.2.1. | People Assets

Populations

According to the latest U.S. Decennial Census, the Town of Dunstable has a:

- Population of approximately 3,400 people
- Median age of 42
- Race and ethnicity mix of 90% white, 5% Hispanic, 3% Asian, and 1% black

- Median household income of over $190,000
- 1% of persons living below the poverty line
- Primarily owner occupied, single unit housing
- Foreign-born population (just over 6%)
- Educated population (60% holds a bachelor's degree or higher)

There are not mapped Environmental Justice populations in the Town of Dunstable. These populations are defined by specific geographic areas that meet one or more criteria based on race, income, or languages spoken.

However, there are priority populations in Dunstable. According to EEA, "Priority populations are people or communities who are disproportionately impacted by climate change due to life circumstances that systematically increase their exposure to climate hazards or make it harder to respond. In addition to factors that contribute to Environmental Justice status (i.e., income, race, and language), other factors like physical ability, access to transportation, health, and age can indicate whether someone or their community will be disproportionately affected by climate change. This is driven by underlying contributors such as racial discrimination, economic disparities, or accessibility barriers that create vulnerability. The term priority populations acknowledges that the needs of people with these experiences and expertise must take precedence when developing resilience solutions to reduce vulnerability to climate change. All communities have priority populations even if they do not have a mapped Environmental Justice neighborhood." **According to input at the CRB workshops, priority populations in Dunstable include seniors, veterans, and those with special needs.**

Facilities that Serve these Populations

People Assets are defined as "assets that serve populations that are more vulnerable to disaster (e.g., elderly, children, visiting populations) and/or serve densely populated areas." (FEMA, 2022).

Table 3.3: People Assets

Asset Type	Name	Location	Community Lifeline
Schools/ Daycare	Swallow Union Elementary School	518 Main Street	Food, Hydration, Shelter
	Maple Village Preschool	518 Main Street	Food, Hydration, Shelter
	Little Red School House	64 Main Steet	Food, Hydration, Shelter
	Groton-Dunstable Regional High School	703 Chicopee Row, Groton MA	Food, Hydration, Shelter
	YMCA Camp	234 Hall St	Food, Hydration, Shelter

Asset Type	Name	Location	Community Lifeline
	Home Daycares	Multiple	Food, Hydration, Shelter
	Patricia Crandall	147 Hardy Street	Food, Hydration, Shelter
Religious Centers	Dunstable Congregational Church	516 Main Street	Food, Hydration, Shelter
Recreation	Larter Field + Tennis Courts	Groton Street	
	Unofficial Swimming Area (Private)	Massapoag Pond	
	Tully Wildlife Refuge (Dunstable Rural Land Trust)	Approx. West of Main Street, North of Fletcher Street, East of Hollis Street	
Priority Populations	Senior Center / Council on Aging at Dunstable Free Public Library	511 Main Street	Food, Hydration, Shelter
	Veteran Services	Townwide	Safety & Security
	Senior Population Office	Townwide	Food, Hydration, Shelter
	Special Needs Seniors	Townwide	Safety & Security
Library	Dunstable Free Public Library	588 Main Street	Food, Hydration, Shelter
Food / Agriculture	Dunstable Grange	Townwide	Food, Hydration, Shelter
	PACH Food Bank	Pepperell	Food, Hydration, Shelter
	Meals on Wheels	Townwide	Food, Hydration, Shelter
Public Safety	Townwide	Townwide	Safety & Security
Volunteer Force	Townwide	Townwide	Safety & Security

3.2.2. | Structures Assets

"Structure" assets are built facilities including residential, commercial, and industrial facilities that may be in harm's way during a hazard event. Many of these structures provide community lifeline services. Dunstable is a mix or suburban and rural where much of the land is open space and residential neighborhoods with a core commercial corridor. There is an extensive amount of conservation land and undevelopable wetlands.

Development Since Previous Hazard Mitigation Plan

The majority of Dunstable's land use by parcels is comprised of residential development (nearly 40% of the Town's land cover), agriculture (approximately 15% of the Town's land cover), and conservation land (just over 20% of the Town's land cover) (2018 Master Plan). The majority of residential areas in Dunstable consist of single-family homes. Residential parcels are dispersed throughout the Town, with the highest concentrations near the center of Town and along primary roads. Agricultural development is also dispersed throughout the Town, although the largest parcels are concentrated in the northwest corner of Town. Conservation land is dispersed throughout town and provides residents with easy access to natural space from any part of town.

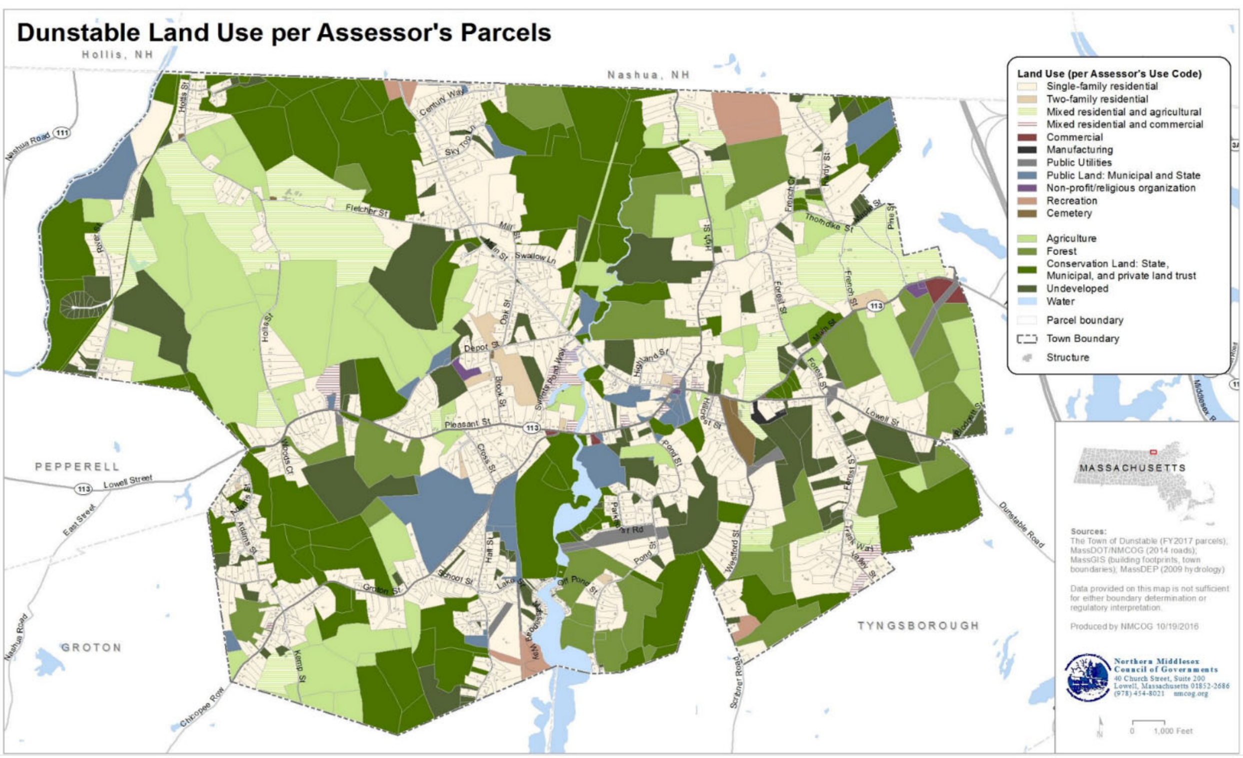


Figure 3.1: Dunstable Land Use (2018 Master Plan)

Dunstable's land use goals include:

- maintaining the Town's rural character and landscape by preserving trees, stone walls, agricultural fields and pastures, and historic architecture;

- Strengthening and maintaining the Town Center as the civic and cultural heart of the community; and
- Examining zoning options to allow for small business enterprises that are compatible with the character and needs of the community (since these goals were set, the Town has passed the Town Center District Overlay which facilitated this goal).

Dunstable regulates land use and development through zoning, which has the capacity to guide the development of vacant land. There are six conventional use districts in Dunstable and three overlay districts:

- Single-family residence (R-1)
- General Residence (R-2)
- Commercial Recreational (R1-a)
- Retail business District (B-1)
- Service Business District (B-2)
- Expanded Commercial District (B-3)
- Mixed Use Overlay District (MUD)
- Floodplain Overlay District
- Tower Overlay District

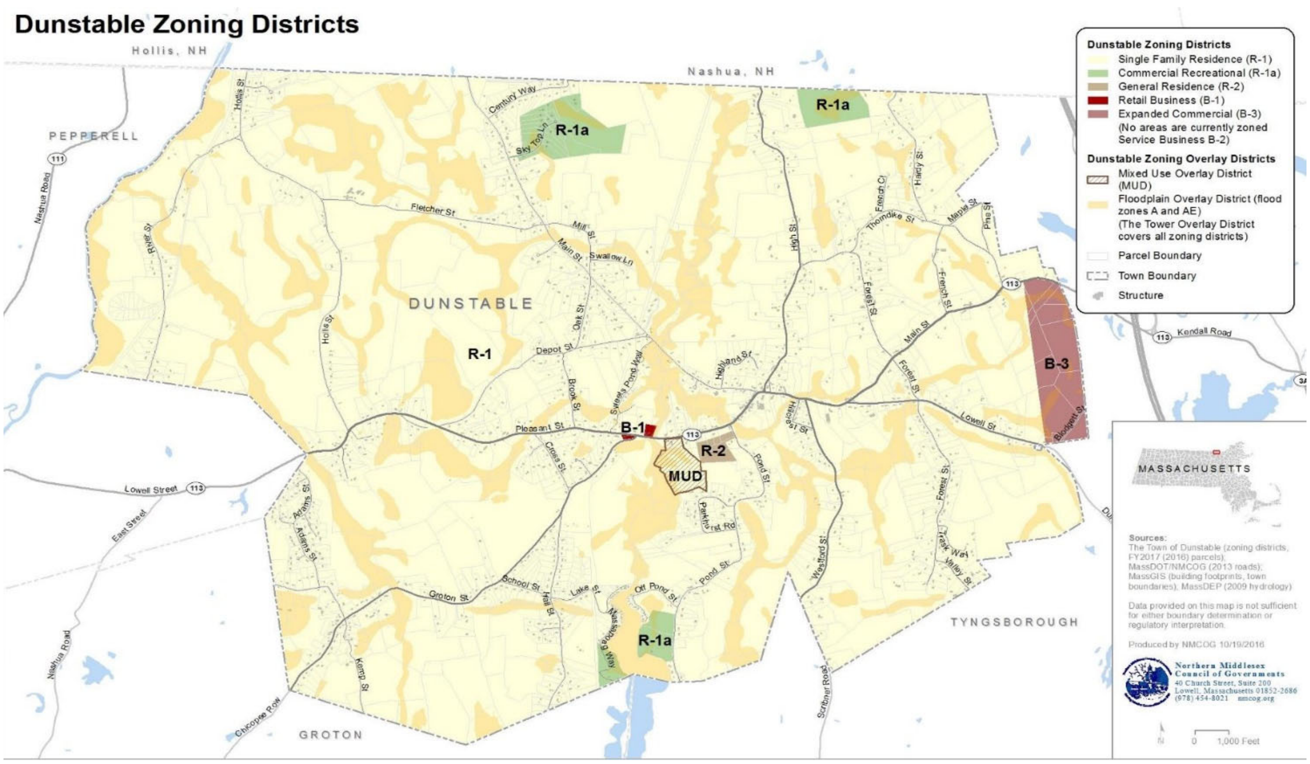


Figure 3.2: Dunstable Zoning Districts

There are also a variety of development standards incorporated in site plan review related to landscaping, parking and loading, signage, and outdoor lighting, all of which guide land use and development.

Since preparation of the last HMP in 2015, a number of new or redevelopment projects have occurred in the Town of Dunstable.

Table 3.4 shows the number of annual building permits in Dunstable. Generally, these have been for single family houses. They have been only three larger developments including Bear Hill, Chapman Street, and Alexander Way, all of which are less than 12 lots and are open space developments (i.e., an area of the development has to be open space protected in perpetuity.)

This level of development coupled with existing land use controls through zoning and wetlands result in an overall decrease to the community's vulnerability to natural hazards.

Table 3.4: Annual Building Permits in Dunstable since 2015 (Last HMP)

Year	Number of Building Permits
2015	12
2016	18
2017	11
2018	19
2019	6
2020	1
2021	2
2022	5

Existing Structure Assets

Table 3.5 shows current structural assets in Dunstable by type and number. In addition, the relevant community lifeline, previously described in Section 3.1.2, is noted. Appendix E includes maps showing town assets.

Table 3.5: Structure Assets

Asset Type	Name	Location	Community Lifeline
Emergency Response	Police Station	23 Pleasant Street	Safety & Security
	Fire Station	28 Pleasant Street	Safety & Security

Asset Type	Name	Location	Community Lifeline
Emergency Shelters	Swallow Union School	518 Main Street	Food, Hydration, Shelter
	Dunstable Congregational Church	516 Main Street	Food, Hydration, Shelter
	Shelters in other Communities	Tyngsborough, Groton	Food, Hydration, Shelter
	Town Hall	511 Main Street	Safety & Security
Town Facilities	Town Hall	511 Main Street	Safety & Security
	Dunstable Free Public Library	588 Main Street	
	DPW Garage	107 Pleasant Street	Transportation
	DPW Garage	589 Pleasant Street	Transportation
	Storage Barn for Highway and Police	91 River Street	Transportation
Post Office	Dunstable Post Office	170 Pleasant Street	Communications
Animal Clinics	Dunstable Animal Clinic	386 Main Street	
Food & Pharmacy	Dunstable General Store & Dunkin' / Gas Station	238 Pleasant Street	Food, Hydration, Shelter
	Tully Farms Dairy Store	446 Pleasant Street	Food, Hydration, Shelter
	The Farmhouse Café	17 Pleasant Street	Food, Hydration, Shelter
Dams	Massapoag Pond Dam (Private) Significant Hazard	Off Lower Dam Way	Water Systems
	Cow Pond Brook Dam (Salmon Brook) (Private) Significant Hazard	Tyngsborough, Groton	Water Systems
	Woodwards Mill Dam	Approximate Intersection of Pond	Water Systems

Asset Type	Name	Location	Community Lifeline
	(Town-owned) Low Hazard	Street and Pleasant Street	
	Joint Grass Brook Dam (Town- owned) Low Hazard	Mills Street just north of Swallow Lane	Water Systems

Critical infrastructure like dams and levees provide recreation, water supply, floodplain management, energy, and other essential functions. Dam owners and operators can be private, non-profit, or public. These structures and their owners are a vital component of local hazard mitigation.

The Hazard Potential Classification System for Dams provides an indication of the consequences of failure of a dam in the United States. This system contains three classes I – Low, II – Significant, and III – High, each representing the degree of potential damage to downstream life and property (FEMA, 2004).

The Town of Dunstable owns and operates three dams, as shown in Table 3.5, above. There is also one private dam in Town. None of these dams are assigned the assigned the high hazard potential classification, which means failure or mis-operation will cause loss of human life.

Potential Future Development

The Town's 2018 Master Plan projects a 14% growth in population from 2010 to 2040, which amounts to approximately 500 residents. The Master Plan also predicts housing will grow by just under 14% from 2020 to 2030 (adding approximately 175 housing units), and then another 10% from 2030 to 2040 (adding approximately 100 housing units.)

The Core Team described two potential affordable housing developments planned in Dunstable under Chapter 40B. One potential affordable housing development may be located "behind" 396 Main Street, or south of this parcel and to the west of Canyons Lake. A second potential affordable housing development may be located at 164 Pleasant Street. A portion of both of these parcels is within the mapped FEMA 100-year flood zone, which must be considered as part of development.

3.2.3. | Systems Assets

Systems are defined as "a collection of components that perform a critical service for the community. Systems are linear type assets. Systems may include horizontal assets associated with linear type assets." (FEMA, 2022).

Table 3.6: Systems Assets

Asset Type	Name	Location	Community Lifeline
Primary Evacuation Routes	Pleasant Street (Route 113) Groton Street High Street Lowell Street Westford Street Main Street	Targeted corridors in Town	Transportation
Culvert & Bridges	All across town	Town-wide	Transportation
Roads	Private roads / direct roads	Townwide	Transportation
Pump Stations	Drinking Water	One at each well	Water Systems
Water Tower	Water Tower	108 Pleasant Street (Simmons Way)	Water Systems
Drinking Water Supply Wells	Salmon Brook Well #1	711 Main Street (and associated Zone I and Zone II)	Water Systems
	Salmon Brook Well #2	711 Main Street (and associated Zone I and Zone II)	Water Systems
Natural Gas	National Grid	Townwide	Energy
Electricity	National Grid	Townwide	Energy
Cable	Charter	Townwide	Communications
	Verizon	Townwide	Communications
Communications	Cell Tower	583 Pleasant Street	Communications
	Reverse 911	Townwide	Communications
	Internet	Townwide	Communications

Asset Type	Name	Location	Community Lifeline
	Cell Tower at Dunstable Congregational Church	516 Main Street	Communications
	Repeater on Water Tower for Fire Department	108 Pleasant Street (Simmons Way)	Communications
Gas Stations	Irving Oil	238 Pleasant Street	Energy
Closed Landfill	Dunstable Transfer Station & Landfill	Depot Street	Hazardous Materials
Hazardous Materials Site	Charles George Landfill Superfund Site	Cummings Road	Hazardous Materials
Solar	Solar installation (private)	Back of 11 Cummings Road, Tyngsborough (0 Blodgett Street, 0 Lowell Street)	Energy
	Solar installation (private)	Back of 377 Groton Street	Energy
	Solar installation (private)	11 Blodgett Street	Energy

3.2.4. | Natural Resources Assets

Natural Resources are defined as "areas that provide protective function to reduce magnitude of hazard impact and increase resiliency, areas of sensitive habitat that are vulnerable to hazard events, and protection of areas that are important to community objectives, such as the protection of sensitive habitat, provide socio-economic benefits, etc." (FEMA, 2022).

Table 3.7: Natural Resources Assets

Asset Type	Name	Location	Community Lifeline
	Petapawag Area of Critical Environmental Concern (ACEC)	Western half of Dunstable	

Asset Type	Name	Location	Community Lifeline
Natural Resources	Black Brook	Southeastern portion of Dunstable, parallel to Westford Street	
	Hauk Brook	Central Dunstable, crosses into Brook Street, Sweets Pond Way, Parallel to Pleasant Street.	
	Lower Massapoag Pond	South-central Dunstable, crosses Pleasant Street, parallel to Gorton Street and Parkhurst Road	
	Upper Massapoag Pond	South-central Dunstable, crosses into Groton and Tyngsborough	
	Nashua River	Northwest Dunstable, parallel to River Street	
	Bass Pond	Northwest Dunstable, between Fletcher and Main Streets	
	Joint Grass Brook	Northwest Dunstable, parallel to Hollis Street	
	Morgan's Pond	Mill Street	
	Unkety Brook + Meadow (Cold Water Fishery)	Northwest Dunstable, crosses into River street and Gorton Street, east and parallel to Adam Street	
	Nissitissit River (Scenic & Protected River)	Parallel and to the north of Brookline Street	
	Kennedy Conservation Area	Main Street, Northeast Dunstable, next to Nashua Acton & Boston Railroad and west of Salmon Brook	

Asset Type	Name	Location	Community Lifeline
	Proctor Conservation Area	Swallow Ln, Dunstable, Northeast of Dunstable, east of Nashua Acton & Boston Railroad	
	Dunstable Brook Wildlife Management Area	Southeast Dunstable, intersection of Lowell Steet and Dunstable Road, east of Forest Street	
	English Wildlife Refuge	Southeast Dunstable, Westford Street	
	Spaulding-Proctor Reservation	Groton Street, west of Lower Massapoag Pond, and to the east of Hall Street	
	Larter Field	80 Groton Street	
	Pierce Town Forest	Groton Street	
	Hauk Swamp Wildlife Management Area	South-central Dunstable, at intersection of Pleasant Depot Streets	
	Horse Hill Quarry	Hall Street Dunstable	
	Dunstable Rural Land Trust Wildlife Preserve	1076 Main Street	
	Flat Rock Hill	High Street abutting Stone Arch Bridge	
	Priority Habitat of Rare Species	Townwide	
	Estimated Habitats of Rare Wildlife	Townwide	
	Certified Vernal Pools	Townwide	
	Potential Vernal Pools	Townwide	
Trees	Trees	Townwide	
Farms + Barns	Farms	Townwide	Food, Hydration, Shelter

Asset Type	Name	Location	Community Lifeline
	McLoon Barn (Dunstable Rural Land Trust)	370 Thorndike	Food, Hydration, Shelter
Open Space + Parks	Article 97 Land	Townwide	
	Town Common	510 Main Street	

3.2.5. | Cultural and Historic Resources Assets

Cultural and Historic Resources are defined as “assets that possess historical, cultural, archaeological or paleontological significance, including sites, contextual information, structures, districts, and objects significantly associated with or representative of earlier people, cultures, maritime heritage, and human activities and events." (FEMA, 2022).

Table 3.8: Cultural and Historic Resources Assets

Asset Type	Name	Location	Community Lifeline
Cultural Resources	Little Red Schoolhouse	64 Main Street	Food, Hydration, Shelter
	Stone Arch Bridge	Salmon Brook, north end of Town	
Historic Resources	West Dunstable - River Road Area	Northwest Dunstable, north of intersection of Hollis and Fletcher Streets	
	Meetinghouse Hill	Main Street	
	East Main Street Area	Main Street	Transportation
	YMCA Camp Massapoag Family Outdoor Center	234 Hall Street	Food, Hydration, Shelter
	Dunstable Center Historic District	Pleasant Street	
	Pond and Pleasant Street Area	Near intersection of Pond and Pleasant Streets	Transportation
	Historical Society	Townwide	

Asset Type	Name	Location	Community Lifeline
	Massachusetts Historic Commission Inventory Properties	Townwide	
	National Register of Historic Places	Townwide	
Cemeteries	Blood Cemetery	580 Hollis Street	
	1754 Meetinghouse Hill Cemetery	200 - 296 Main Street	
	Rideout Cemetery	Fletcher Street	
	Swallow Cemetery	Brook Street	
	Central Cemetery	Westford Street & Route 113	

3.2.6. | Economic and Community Assets

Economic assets are defined as entities that produce a financial benefit for the owner or community, while community assets are defined as "Activities that benefit the community by increasing community morale and well-being. Activities may include education and knowledge transfer." (FEMA, 2022).

Table 3.9: Economic and Community Assets

Asset Type	Name	Location	Community Lifeline
Rail Trail	Nashua River Rail Trail	Northwest Dunstable, crosses Unkety Brook, parallel to River Street	Transportation
Cultural Events	Summer Concert Series	Dunstable Town Common 510 Main Street	
	Fall Fest	McLoon Barn	
	Winter Fest	Fletcher Conservation Land, Main Street	

	Memorial Day Parade	Dunstable Town Center	
	Jingle Fest	Dunstable Town Common	
	Tully Farm Open House	446 Pleasant Street	
	Strawberry Fest	188-198 Kendall Road	
Top Employers	Town of Dunstable	511 Main Street	
	School Department		

4

4. Risk Assessment: Natural Hazards, Asset Vulnerabilities, and Community Impacts

Natural hazards have the potential to induce damage or loss to physical assets, including the structures, infrastructure, and natural, historic, and cultural resources within the Town. Natural hazards also have the potential to affect people, including priority populations, municipal processes and operations, and activities that have value to the community.

As explained by FEMA, "in hazard mitigation planning, risk is the potential for damage or loss when natural hazards interact with people or assets. These assets may be buildings, infrastructure or natural and cultural resources. The way natural hazards interact with a community's people, property and assets can result in a disaster. A risk assessment is a robust, data-driven analysis. It explains what might happen. It also finds where the local jurisdiction is vulnerable to hazards."

4.1. Key Terms & Methods

As previously stated in Section 1.1, **Natural Hazards** are a source of harm or difficulty created by a meteorological, environmental, or geological event (such as extreme wind events, tornadoes, winter weather as well as earthquakes, flooding, and fires) (FEMA). The natural hazards presented herein are those from the 2023 ResilientMass Plan that apply to Dunstable. Because Dunstable is not a coastal community, no information is provided related to Coastal Erosion, Coastal Flooding, or Tsunami.

Table 4.1: Natural Hazards that Apply to Dunstable

Average / Extreme Temperatures
Changes in Groundwater
Drought
Earthquakes
Flooding from Precipitation
Hurricanes / Tropical Cyclones
Invasive Species
Landslides/Mudflows
Other Severe Weather
Severe Winter Storms
Tornadoes
Wildfire

For each natural hazard, the following is discussed in accordance with FEMA guidance:

- How is the hazard described (description)?
- Where might it happen in Dunstable (location)?
- How severe or intense may it be (extent)?
- Where has it happened in the past (previous occurrences) and how likely it is to occur (frequency)?
- How may it change in the future (probability)?
- Which assets are at risk from it (vulnerability)?
- What effects will it have on the community assets including populations (impacts)?

Throughout Section 4.2, information provided in "quotes" is directly from the ResilientMass Plan unless otherwise noted. Sources cited within the quotes are from the ResilientMass Plan and are cited within that plan. Any other source specific to this report for Dunstable is cited. Hazards are presented alphabetically, not in a prioritized order.

The following methods were used to complete each section of the risk assessment:

- **Description:** A description for each natural hazard from the Massachusetts 2023 State Hazard Mitigation and Climate Adaptation Plan (ResilientMass Plan) is provided.

- **Location:** Location is the geographic boundary in which a hazard occurs or the type of environment that is conducive to the hazard. This may include areas larger or smaller than the Town of Dunstable's jurisdiction. It may also include a specific land cover or topographic environment. This information is from the ResilientMass Plan and local knowledge provided at the CRB workshops discussed in Chapter 2.

- **Previous Occurrence(s) and Frequency:** A list or summary of historical occurrences of the natural hazard event within or near Dunstable. Frequency refers to how often the hazard has occurred in the past within the geographical area, based on historic records publicly available.

- **Severity/Intensity:** The likely magnitude of the hazard, using industry standard scales where applicable. For example, the National Hurricane Center's categorizations of tropical storms and hurricanes was used to define the range of hurricanes that may affect areas of Massachusetts. When no standard scale is available, a qualitative description is provided.

- **Probability of Future Hazard Events, including due to Climate Change:** Probability is the likelihood of a hazard occurring or reoccurring. This includes the effects of future conditions, including long term weather patterns, temperatures, and sea levels, on the type, location, and range of anticipated intensities of the hazard. Climate projections indicate a change in long-term weather patterns. Each section identifies how climate change may affect the probability of the natural hazard occurring, and to what degree it may change. In 2018, MA EOEEA created ResilientMass, an online clearinghouse for local governments and the public to explore climate change science and data, information on community resilience, and decision support tools. The climate change planning efforts that ResilientMass has undertaken have focused on the 2030, 2050, 2070, and 2090 planning horizons, which are defined by the bounding years 2020-2039, 2040-2059, 2060-2079, and 2080-2090, respectively. Future climate data in each section was obtained from the ResilientMass clearinghouse and the ResilientMass Plan.

- **Vulnerability:** A description of which assets within locations identified to be hazard prone are at risk from the effects of the identified hazard(s) (FEMA, 2022). To determine which assets identified in Chapter 3 are located within an area identified to be hazard prone, presently or in the future, the natural hazard profiles presented in this chapter were utilized. For inland flooding, GIS mapping of assets and areas of flooding were utilized to describe vulnerability, as further described in Section 4.7. For all other hazards, the identified hazard is not mapped or cannot be mapped and therefore a qualitative analysis that relies on local knowledge and rational decision making was used to identify vulnerability. Vulnerability discussions focus on specific assets that are most important and most susceptible to damage or loss from hazards.

- **Impacts:** Consequences or effects of each hazard on the town's assets identified in the vulnerability assessment. (FEMA, 2022). There are three ways to analyze impacts:

  - Historical Analysis: Historical analysis uses data on the impacts and losses of previous hazard events, which can be used to predict the anticipated impacts and losses for a similar future event. **For Dunstable, a formal historical analysis was not utilized; however, information from those in attendance at the CRB workshops was included in the narrative in this Chapter.**

  - Exposure Analysis: An exposure analysis identifies the existing and future assets in known hazard areas. GIS is often used for this analysis and to make maps to visualize the risk. An exposure analysis can quantify the number, type and value of structures, community lifelines and other assets in areas of identified hazards. It can identify any assets exposed to multiple hazards. Exposure analysis can also help a community understand areas that may be vulnerable if and when buildings, infrastructure and community lifelines are built in hazard-prone areas.

  - Scenario analysis: A scenario analysis asks "what if" a certain event occurs. This kind of analysis uses a hypothetical situation to think through potential impacts and losses. A scenario analysis can be completed narratively by walking through a scenario with the planning team and documenting what could happen. It can also be completed using modeling. FEMA's Hazus program is one of the most common scenario analysis tools for hazard mitigation. **For Dunstable, FEMA's Hazus-MH Version 2.2 SP1 was used to estimate potential losses from earthquakes, flooding, and hurricanes.**

The categories below discuss general impacts that can be the result of natural hazards affecting Dunstable's assets. The impacts are discussed throughout this chapter.

Table 4.2: Types of Impacts due to Occurrence of Natural Hazards

Impact	Examples
Loss of Life	Death
Physical Injuries	Cuts, bruises, broken bones, or amputations.
Public Health	Spread of disease, bacterial infections, and vector-borne illnesses Elevated rates of emergency room visits Respiratory problems arising from air pollution, allergens, and mold
Displacement	Forced abandonment of the home due to unsafe living conditions, either permanently or temporarily
Psychological Impacts	Trauma Anxiety Stress PTSD
Impacts to Daily Life	Cancellation or postponement of sporting or other events that are important to the community Damage to parks, community centers, or public pools inhibits recreation Destruction of historic or cultural landmarks
Property Damage	Damage to physical structures Damage to contents within homes and buildings Damage to vehicles
Building Damage	Structural damage to roofs, walls, or foundations Collapse or destruction
Utility Infrastructure Damage	Damage to power lines, communications towers, and water, wastewater, and gas mains resulting in power outages, loss of water, wastewater, or gas services, and loss of communication, radio signal, or internet
Transportation Infrastructure Damage	Damage to or debris build-up on roads, bridges, railways, or airports that render them impassable or unsafe to use
Disruption to Lifelines	Medical facilities, emergency services, or transportation networks are unable to provide essential services due to damage or debris
Water Resources	Disruption to agriculture practices Yield reduction or damage to drinking water wells

Impact	Examples
Business Impacts	Lost wages Closure of or interruption to businesses Increased insurance premiums Increased costs for repairs/rebuilding Decreased property values Disruption of industry and the transport of goods and services Decreased tourism revenues
Utilities	Increased cost of utilities Disruption of utilities creating travel delays or lack or services
Building Damage	Structural damage to roofs, walls, or foundations Collapse or destruction
Economic	Lost wages Closure of or interruption to businesses Increased insurance premiums Increased costs for repairs/rebuilding Decreased property values Disruption of industry and the transport of goods and services Decreased tourism revenues
Government Services	Increased demand for state and municipal government services Cost to repair services
Municipal Resources	Increased need for municipal resources Disruption of resources
Contamination	Air pollution from dust and debris Transport of toxic chemicals by floodwaters Release of hazardous materials into soil and water Decreased water quality Sewage release into waterways
Ecological	Loss of wildlife Loss or destruction of habitat Disruption to migratory patterns Loss of biodiversity Loss of or damage to natural resources Changes in groundwater temperature
Geological	Landslides Erosion Removal of topsoil Debris deposit Altered nutrient balance

4.2. Previous Federal/State Disaster Declarations

To understand the importance of hazard mitigation, it is useful to know the types and frequencies of disasters that occur in Massachusetts. Since 1991, there have been 16 storms in Massachusetts that resulted in Federal or State Disaster Declarations in Middlesex County, which includes the Town of Dunstable. These disasters and the related assistance from FEMA are described in Table 4.3.

Table 4.3: Federal/State Disaster Declarations for Middlesex County since 1985

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Hurricane Gloria Sep 27, 1985	DR-751	FEMA Public Assistance	Counties of Barnstable, Berkshire, Bristol, Dukes, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester
Severe Storms, Flooding Mar 30, 1987 - Apr 13, 1987	DR-790	FEMA Public Assistance; FEMA Individual & Households Program	Counties of Berkshire, Essex, Franklin, Hampshire, Middlesex, Norfolk, Worcester
Hurricane Bob August 19, 1991	DR-914	FEMA Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
Winter Coastal Storm Dec 11, 1992 - Dec 13, 1992	DR-975	FEMA Public Assistance	Counties of Barnstable, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Blizzards, High Winds and Record Snowfall Mar 13, 1993 - Mar 17, 1993	EM-3103	FEMA Public Assistance	All 14 Massachusetts Counties
Blizzard January 7-13, 1996	DR-1090	No funding reported	All 14 Massachusetts Counties
Blizzards, High Winds and Record Snowfall	EM-3119	FEMA Public Assistance; FEMA Individual & Households Program	Counties of Essex, Middlesex, Norfolk, Suffolk, Plymouth

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Oct 20, 1996 - Oct 25, 1996			
Severe Storms/Flooding October 20-25, 1996	DR-1142	FEMA Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain and Flooding June 13-July 6, 1998	DR-1224	FEMA Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Snowstorm Mar 5, 2001 - Mar 7, 2001	EM-3165	FEMA Public Assistance	Counties of Bristol, Essex, Franklin, Hampshire, Middlesex, Norfolk, Worcester
Severe Storms & Flooding March 5-April 16, 2001	DR-1364	FEMA Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Snowstorm Feb 17, 2003 - Feb 18, 2003	EM-3175	FEMA Public Assistance	All 14 Massachusetts Counties
Snow Dec 6, 2003 - Dec 7, 2003	EM-3191	FEMA Public Assistance	Counties of Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester
Flooding April 1-30, 2004	DR-1512	FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester
Snow Jan 22, 2005 - Jan 23, 2005	EM-3201	FEMA Public Assistance	All 14 Massachusetts Counties
Hurricane Katrina Evacuation Aug 29, 2005 - Oct 1, 2005	EM-3252	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Storms and Flooding	DR-1614	FEMA Public Assistance;	All 14 Massachusetts Counties

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
October 7-16, 2005		FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	
Severe Storms and Flooding May 12-23, 2006	DR-1642	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Middlesex, Essex, Suffolk
Severe Winter Storm Dec 11, 2008 - Dec 18, 2008	EM-3296	FEMA Public Assistance	Counties of Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Suffolk, Worcester
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storm and Flooding March 12-April 26, 2010	DR-1895	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Water Main Break May 1, 2010 - May 5, 2010	EM-3312	FEMA Public Assistance	Essex, Middlesex, Suffolk, Norfolk
Hurricane Earl Sep 1, 2010 - Sep 4, 2010	EM-3315	FEMA Public Assistance	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Snowstorm January 11-12, 2011	DR-1959	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, Suffolk

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Hurricane Irene Aug 26, 2011 - Sep 5, 2011	EM-3330	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Storm Oct 29, 2011 - Oct 30, 2011	EM-3343	FEMA Public Assistance	Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Worcester
Severe Storm and Snowstorm October 29-30, 2011	DR-4051	FEMA Public Assistance; FEMA Public Assistance Snow Removal; FEMA Hazard Mitigation Grant Program	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Worcester
Hurricane Sandy Oct 27, 2012 - Nov 8, 2012	EM-3350	FEMA Public Assistance	All 14 Massachusetts Counties
Explosions Apr 15, 2013 - Apr 22, 2013	EM-3362	FEMA Public Assistance	Bristol, Middlesex, Norfolk, Suffolk
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Snowstorm March 13-14, 2018	DR-4379	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester
Covid-19 Jan 20, 2020 - May 11, 2023	EM-3438	FEMA Public Assistance	All 14 Massachusetts Counties
Covid-19 Pandemic	DR-4496	FEMA Public Assistance: Emergency protective measures -	All 14 Massachusetts counties

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Jan 20, 2020 - May 11, 2023		direct federal assistance FEMA Individual Assistance: Crisis Counseling Program	
Hurricane Lee September 15-17, 2023	EM-3599-MA	FEMA Public Assistance; FEMA Individual Assistance	All 14 Massachusetts counties

Source: Information in the table above is available online at: https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

4.3. Average/Extreme Temperatures

4.3.1. | Description

"Average/Extreme Temperatures includes extreme cold, extreme heat, and the change over time of average temperatures experienced throughout the year in Massachusetts" (ResilientMass, 2023). Although there is no universal definition, temperatures are considered extreme when they extend outside of the typical range of average conditions for acute or prolonged periods of time. Extremes can vary seasonally and occur in the form of either extreme cold or extreme heat. The 2023 ResilientMass Plan defines extreme temperatures as "those that are far outside the normal seasonal ranges for Massachusetts" (ResilientMass, 2023). In addition, the ResilientMass Plan states:

- "Extreme heat can be defined as a period of excessively hot weather—usually defined as a daily high temperature above 90 degrees Fahrenheit (°F) in Massachusetts—which may be accompanied by high humidity." (ResilientMass, 2023)
- "Extreme cold is defined as a period of excessively low temperatures, especially with additional wind chill. In Boston, the National Weather Service (NWS) issues a wind chill advisory when the Wind Chill Temperature index drops below −15°F." (ResilientMass, 2023)

4.3.2. | Location

Extreme Heat

Extreme heat is often more extreme in concentrated parts of Dunstable that have less tree canopy, more pavement, and dark surfaces such a roofs and parking areas that absorb more heat.

Extreme Cold

Extreme cold can occur throughout Dunstable. Extreme cold can disproportionately affect priority community members through the town, especially for people without shelter, those who are stranded, and those who live in home that are poorly insulated or without heat.

4.3.3. | Severity/Intensity

Extreme Heat

Heat wave is an extreme heat phenomenon that affects the town. Heat waves are identifiable as 3 or more consecutive days when maximum temperatures greater than 90°F occur. This implies that there is an extended period of unusually high temperatures, causing stress on everyday operations and physical health (EEA & EOPSS, 2018).

Relative humidity can worsen human health effects as temperatures increase. The extent of extreme heat temperatures is generally measured through the NWS Heat Index, which is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. Figure 4.1 presents the heat index chart as published by the National Weather Service and NOAA.

NWS Heat Index

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

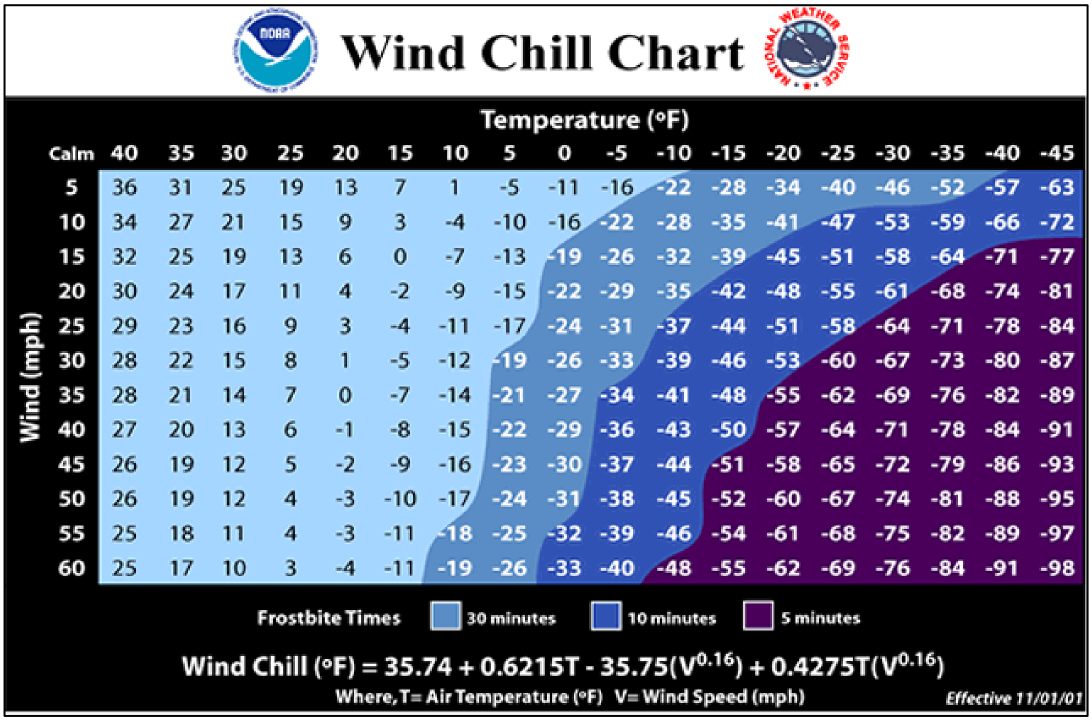
Caution | Extreme Caution | Danger | Extreme Danger

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Figure 4.1: National Weather Service Heat Index (NWS NOAA)

Extreme Cold

Extreme cold temperatures can be exacerbated by factors such as wind and relative humidity. The extent of extreme cold temperatures is generally measured through the Wind Chill Temperature Index, and Figure 4.2 shows the Wind Chill Temperature Index. As evident from the figure, temperatures can feel colder and cause more damage to human health as wind speeds increase. The NWS issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to – 24°F for at least 3 hours, based on sustained winds (not gusts). For example, frostbite can occur in 30 minutes at warmer than usual temperatures if wind speeds are greater.


Wind Chill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 4.2: National Weather Service Wind Chill Chart (NWS NOAA, 2001)

4.3.4. | Previous Occurrences and Frequency

Extreme Heat

"Between 2018 and 2022, the National Oceanographic and Atmospheric Administration listed 10 heat warning events in Massachusetts (ResilientMass, 2023)."

The 2023 MA State Hazard Mitigation and Climate Adaptation Plan listed notable high temperature events between 1994 and March 2023 (ResilientMass, 2023). Dunstable, like all communities in the commonwealth, experienced these notable heat events.

Table 4.4: High Temperatures

High Temperatures	
01/13/1995	Record Warmth

High Temperatures	
07/13/1995	Record Heat
02/22/1997	Record Warmth
01/03/1998	Record Warmth
03/27/1998	Record Warmth
03/28/1998	Record Warmth
03/31/1998	Record Warmth
09/27/1998	Record Heat
12/02/1998	Record Warmth
12/07/1998	Record Warmth
01/24/1999	Record Warmth
02/12/1999	Record Warmth
03/18/1999	Record Warmth
06/07/1999	Excessive Heat
06/07/1999	Record Heat
07/04/1999	Excessive Heat
07/05/1999	Record Heat
07/16/1999	Record Warmth
07/17/1999	Record Warmth
07/18/1999	Record Warmth
09/07/1999	Record Warmth
03/08/2000	Record Warmth
05/08/2000	Record Heat
05/09/2000	Record Heat
10/14/2000	Record Warmth
12/17/2000	Record Warmth
04/24/2001	Record Heat
05/02/2001	Record Heat

High Temperatures	
05/03/2001	Record Heat
05/04/2001	Record Heat
05/12/2001	Record Heat
07/06/2010	Excessive Heat
07/21/2011	Excessive Heat
07/05- 02/06/2013	Heat
07/19/2013	Heat
07/01/2018	Excessive Heat
07/03/2018	Excessive Heat
08/28/2018	Excessive Heat
08/29/2018	Heat
09/03/2018	Heat
07/19/2020	Heat
07/27/2020	Heat
06/28/2021	Heat
08/11/2021	Heat
08/26/2021	Heat
08/04/2022	Heat
08/08/2022	Heat

Extreme Cold

The 2023 MA State Hazard Mitigation and Climate Adaptation Plan listed notable low temperature events between 1994 and March 2023 (ResilientMass, 2023). Dunstable, like all communities in the Commonwealth during these times, experienced these extreme cold events.

"Between 2018 and 2022, the National Oceanographic and Atmospheric Administration listed 17 cold warning events in Massachusetts. In February 2023, an arctic front moved through the region with a dangerously cold airmass that stayed in place on February 3–4. The cold temperatures broke the records for the lowest recorded minimum temperature and resulted in several deaths (ResilientMass, 2023)."

Table 4.5: Low Temperatures

Low Temperatures	
01/15/1994	Cold
01/18/1994	Cold
01/19/1994	Cold
01/27/1994	Cold
01/17/2000	Extreme Cold
05/20/2002	Freeze
05/22/2002	Freeze
10/15/2002	Freeze
01/15/2004	Extreme Cold/Wind Chill
01/25/2007	Cold/Wind Chill
02/03/2007	Extreme Cold/Wind Chill
01/01/2009	Cold/Wind Chill
01/16/2009	Cold/Wind Chill
04/29/2009	Frost/Freeze
05/19/2009	Frost/Freeze
06/01/2009	Frost/Freeze
05/09/2010	Frost/Freeze
05/13/2010	Frost/Freeze
01/23/2011	Extreme Cold/Wind Chill
01/22-01/24/2013	Cold/Wind Chill
01/02/2014	Cold/Wind Chill
01/07/20144	Cold/Wind Chill
01/21/2014	Cold/Wind Chill
01/26-01/28/2014	Cold/Wind Chill
01/07/2015	Extreme Cold/Wind Chill
01/30-02/02/2015	Cold/Wind Chill

Low Temperatures	
02/05/2015	Cold/Wind Chill
02/13/2015	Cold/Wind Chill
02/15-02/16/2015	Extreme Cold/Wind Chill
02/19-02/20/2015	Extreme Cold/Wind Chill
02/23/2015	Cold/Wind Chill
02/13-02/14/2016	Extreme Cold/Wind Chill
12/15/2016	Cold/Wind Chill
03/11/2017	Cold/Wind Chill
01/01/2018	Extreme Cold/Wind Chill
01/05-01/06/2018	Extreme Cold/Wind Chill
01/06/2018	Cold/Wind Chill
01/13/2018	Cold/Wind Chill
11/22/2018	Cold/Wind Chill
01/20-01/21/2019	Extreme Cold/Wind Chill
01/30/2019	Extreme Cold/Wind Chill
02/021/2019	Cold/Wind Chill
12/18/2019	Cold/Wind Chill
01/28-01/29/2021	Extreme Cold/Wind Chill
03/02/2021	Cold/Wind Chill
01/11/2022	Cold/Wind Chill
01/14/2022	Extreme Cold/Wind Chill
01/20/2022	Cold/Wind Chill
01/29/2022	Cold/Wind Chill
12/23/2022	Cold/Wind Chill
02/03-02/04/2023	Extreme Cold/Wind Chill

4.3.5. | Probability of Future Hazard Events, including Due to Climate Change

"Climate change has already changed average and extreme temperatures in Massachusetts. Climate change is projected to reduce the number of extreme cold events, increase the number of extreme heat events, and shift the average temperature in the Commonwealth higher and shift the seasons the warm seasons forward and lengthen their duration. The effects of these changes will include changes in growing seasons and crops, shifts in habitat and vegetation, warming surface waters, degradation of air quality, impacts on public health, and increased demand for energy and water resources." (ResilientMass, 2023)

Attendees of the CRB workshop shared that the farming community notices the "kill frost." It used to occur by mid-September and now it is late October or early November.

Extreme Heat

Based on all the recently published reports (IPCC, MA Climate Assessment, GBRAG) temperatures will continue to increase through the 21st century. Summers are expected to get hotter with a greater number of days with maximum temperature above 90°F and above 100°F.

The average summer across the Commonwealth during the years between 1971 and 2000 included 4 days over 90 degrees. "The MA Climate Assessment (Commonwealth of Massachusetts, 2022) predicts that by 2050 the average summer temperature will feel like that of Maryland (average high of 94°F with about 90% humidity), and by 2090 average summer temperatures will feel like that of Georgia (average high of 95°F with 90% humidity)." (ResilientMass, 2023)

The ResilientMass Climate Change Projections Dashboard shows hot days for the years 2030, 2050, 2070, and 2090 on an annual basis for the Town of Dunstable. Figures 4.3 and 4.4 show the contrast between 2030 and 2090 for Hot Days.

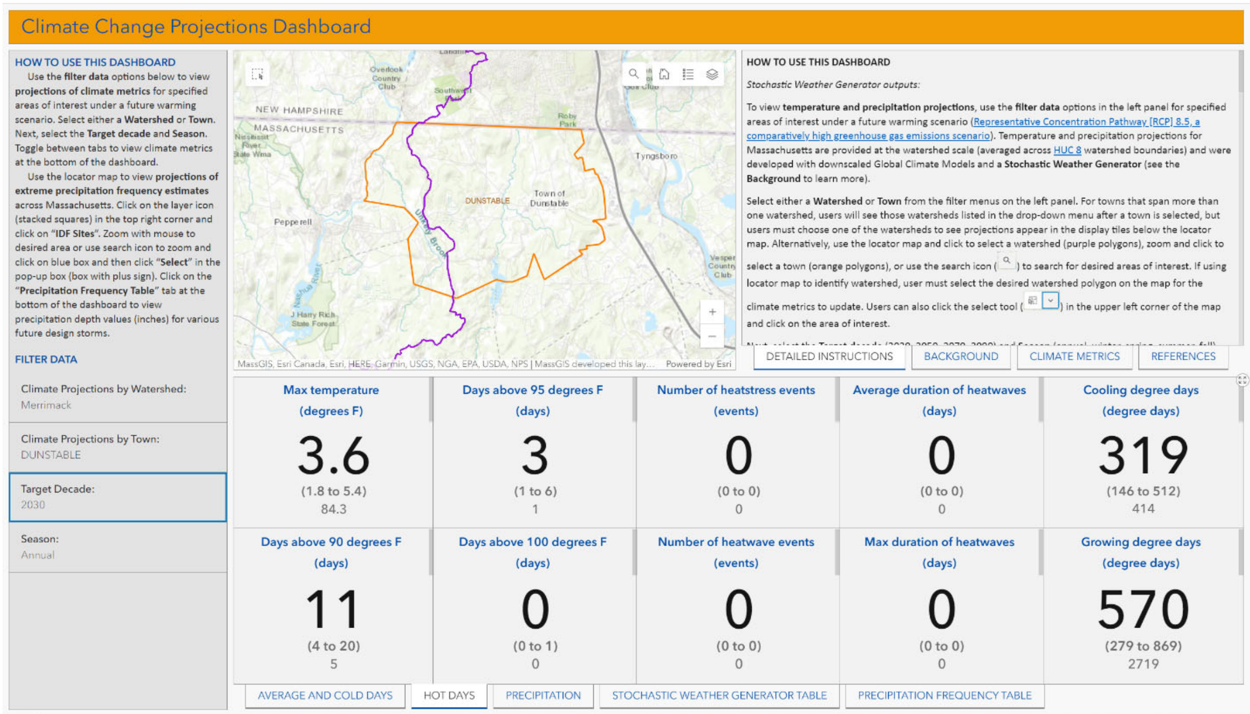


Figure 4.3: Annual Hot Days Projections for 2030

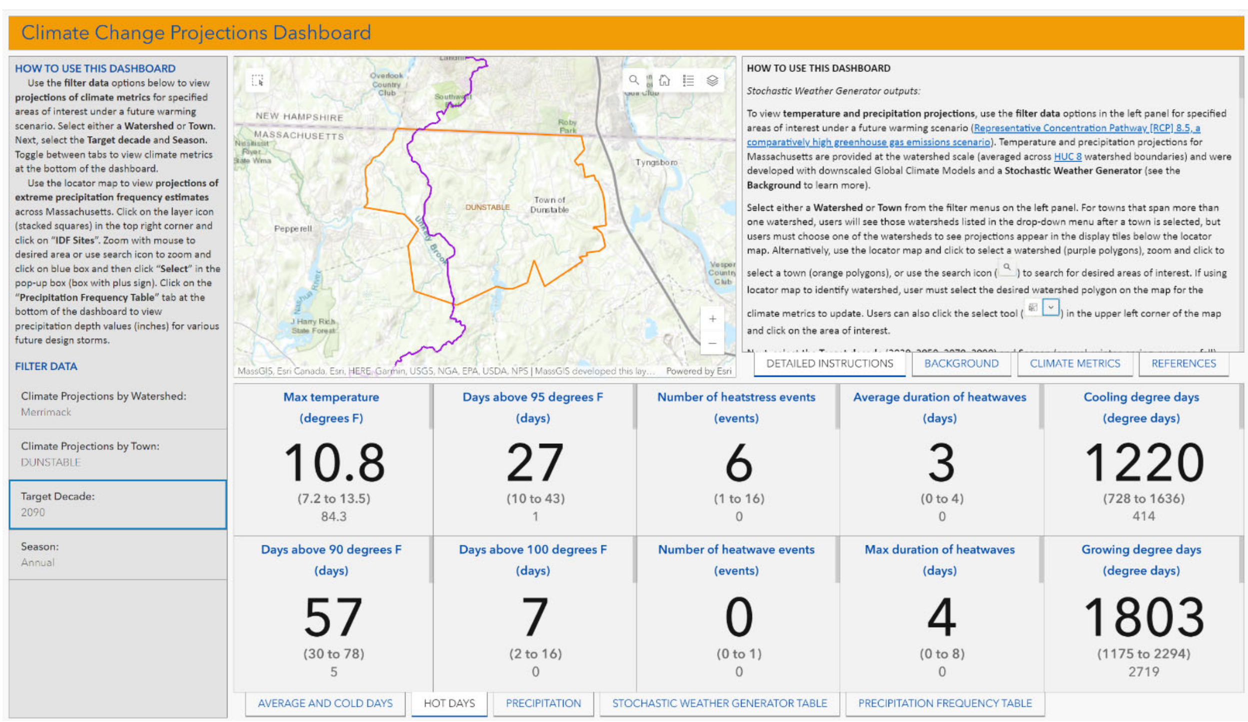


Figure 4.4: Annual Hot Days Projections for 2090

Extreme Cold

The number of days in Massachusetts that experience extreme cold are expected to decrease due to climate change. "Winter temperatures have been rising at a faster rate of 1.3°F (0.7°C) per decade on average. Even what seems like a very small rise in temperatures can cause major changes in climate patterns such as rain or snowfall. In Massachusetts, temperatures are projected to increase significantly over the next century. Winter average temperatures are likely to increase more than those in summer, with major impacts (ResilientMass, 2023)."

The ResilientMass Climate Change Projections Dashboard shows average and cold days for the years 2030, 2050, 2070, and 2090 on an annual basis for the Town of Dunstable. Figures 4.5 and 4.6 show the contrast between 2030 and 2090 for Average and Cold Days.

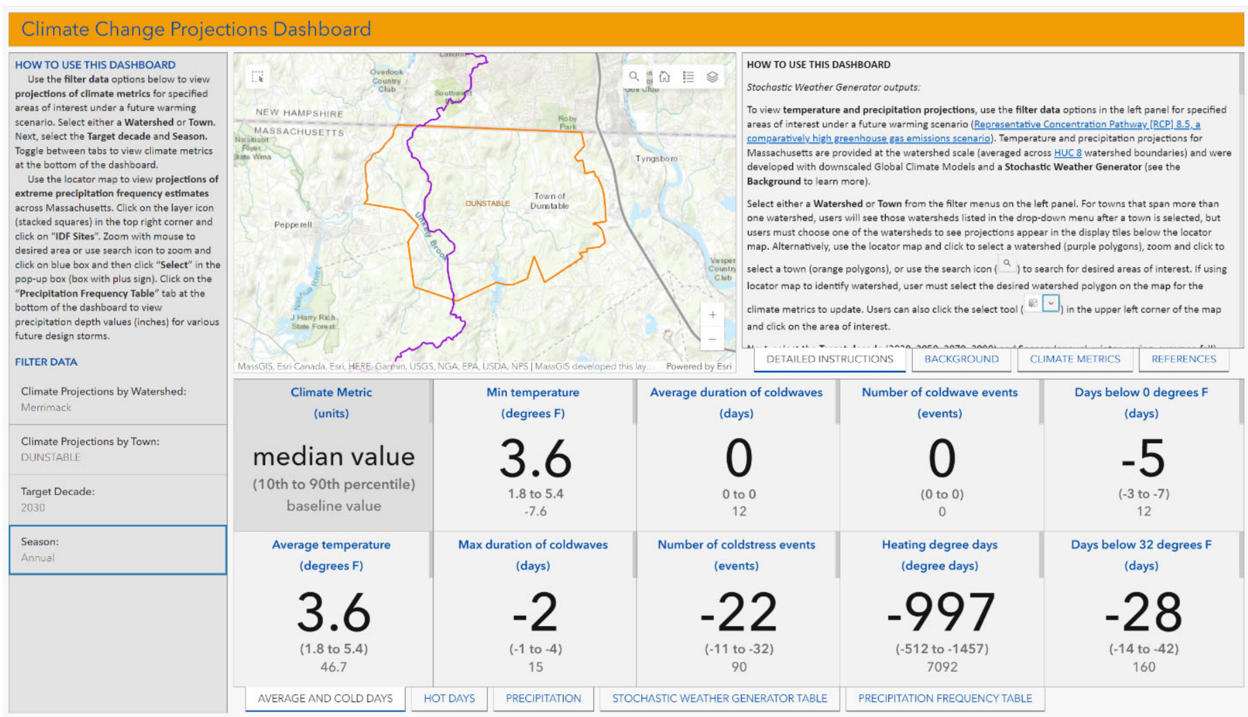


Figure 4.5: Annual Average and Cold Days Projections for 2030

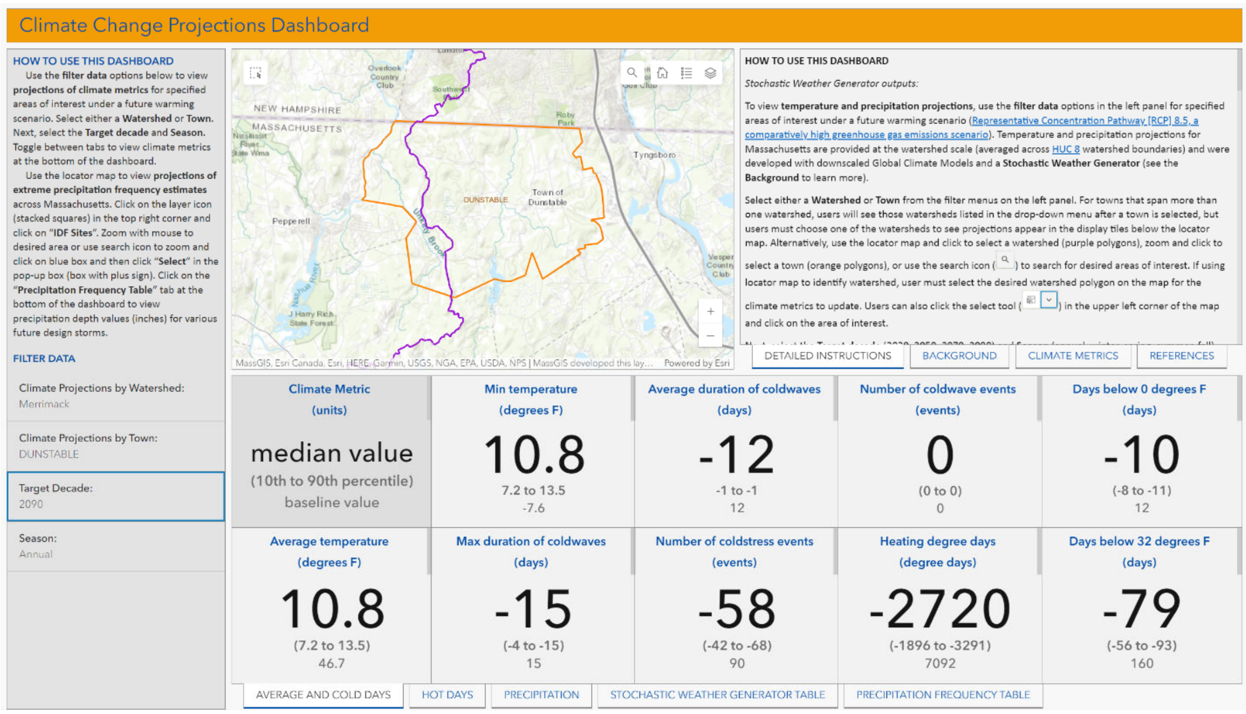


Figure 4.6: Annual Average and Cold Days Projections for 2090

4.3.6. | Vulnerability and Impacts

Extreme temperatures can have severe impacts on the Town of Dunstable. During instances of extreme heat, the frequency of heat stroke, heat stress, or heat related illness is higher. High temperatures can cause people to lose fluids more quickly than usual, leading to dehydration. Dehydration can cause headaches, dizziness, and fatigue. This is especially true for individuals who work physically demanding jobs outside, such as landscapers or construction workers. These individuals should be considered vulnerable during episodes of extreme heat. Extreme heat can cause materials such as concrete, asphalt, and steel to expand and contract, leading to cracking, warping, and other forms of structural damage. High temperatures also increase the demand on the water supply, which can potentially lead to shortages. High temperatures also increase the risk of wildfires, which can cause significant damage to structures and infrastructure. **At the CRB workshop, Dunstable residents expressed concerns regarding a lack of air conditioning in the schools. Residents were highly concerned about power outages during days of extreme heat that could become dangerous to students in the schools. A respondent to the public survey noted that Extreme heat affects everyone at this point and AC is becoming as much a necessity as heat.**

Extreme cold scenarios are equally impactful and more common in the state of Massachusetts. Extremely cold temperatures can impact public health, transportation, agriculture, energy, water resources, and infrastructure. The homeless, the elderly, and people with disabilities are especially vulnerable during instances of extreme cold. Cold weather can cause frostbite or hypothermia. Power outages during cold weather events may cause pipes to freeze and burst. Even underground pipes are subject to freezing and bursting, potentially leading to water main breaks. Power outages may also result in the inappropriate use of space heaters or generators in poorly ventilated areas, potentially leading to carbon monoxide poisoning. If extreme cold is accompanied by snow or ice, travel conditions can become extremely dangerous, and public transportation may shut down. **Dunstable residents noted the increase in the elderly population that would be particularly vulnerable to both extreme cold and extreme heat. However, residents also noted that the community is quick to assist the elderly and infirmed with snow removal during instances of severe cold or winter weather.**

Table 4.6: Impacts of Average/Extreme Temperatures on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Increased risk of cold-related or heat-related death or illness (hypothermia, frostbite, heat stroke, heat exhaustion, etc.) • Most at-risk populations include children, the elderly, the homeless, and those that work outside
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Extreme heat can lead to structural damage such as cracking or warping • Extreme cold can freeze and damage pipes leading to water leaks and flooding when temperatures rise
Systems	Impacts to transportation systems, and electricity and water systems: • Power grid strain from increased heating or air conditioning use, potentially resulting in power outages • Extreme heat can cause pavement to soften and buckle leading to road closures and transportation disruptions • Extreme cold can result in icy road conditions and reduced visibility, making travel hazardous
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Potential increase of wildfires during extreme heat • Extreme temperatures may alter migrations, allow for invasive species, decrease crop yields, and adversely affect livestock
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being:

Asset Category	Likely Impacts
	• Cancellation of community or sports events due to extreme temperatures

4.4. Changes in Groundwater

4.4.1. | Description

According to the ResilientMass Plan, "groundwater is a renewable, long-term resource that depends on an adequate quantity and quality of water to replenish it. The quantity and quality of groundwater reflects the cumulative effects of extraction, recharge, and contamination.

Groundwater challenges are caused or amplified by other hazards such as sea level rise, extreme temperatures and rising temperatures, drought, extreme precipitation, and other meteorological events.

There are three primary categories of risk associated with groundwater in Massachusetts:

- Rise in groundwater levels
- Groundwater depletion
- Changes in groundwater quality and characteristics

When variation of groundwater surpasses an elevation threshold or duration, changes in groundwater can affect human and natural systems. The disruption can generate long- term risk to human life and property. Changes in groundwater can result in interruption, loss, and risk due to human demands and impacts on the resource. Infrastructure is built using historical water conditions and parameters. When groundwater levels change outside historical ranges, this can affect critical infrastructure including drainage systems, septic systems, and building foundations" (ResilientMass, 2023).

4.4.2. | Location

Dunstable is located atop a New York and New England group of crystalline-rock aquifers. The town also lies across the Coastal Plain physiographic province. This physiographic region is composed of plains, hills, and coastline with unconsolidated sediments. The water table in Massachusetts is relatively close to the ground surface. Figure 4.7 shows the aquifers in Dunstable.

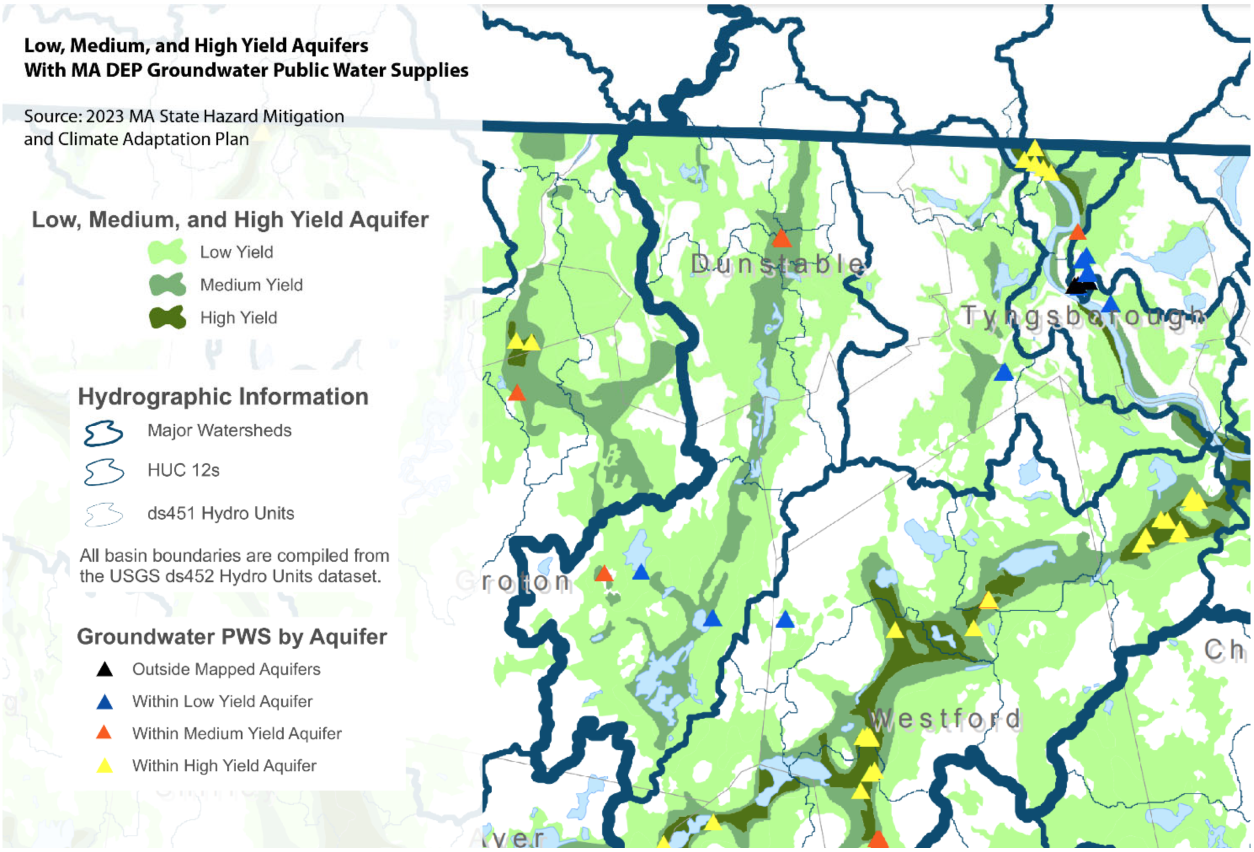


Figure 4.7: MassDEP Groundwater Public Water Supply Aquifers

4.4.3. | Severity/Intensity

"The severity of groundwater rise, depletion, and contamination depends heavily on the ability of the groundwater system to recharge (i.e., the balance between extraction and recharge), the timing of the recharge, and the quality of the water. Extraction can take place through human activity and natural discharge, which can increase when surface water levels drop—particularly during droughts. Water levels can increase during periods of high precipitation, snowmelt, and coastal and inland flood events. In coastal areas, groundwater levels will be affected by coastal conditions including meteorological events, coastal storms, tides, and sea level rise. Local characteristics including topography, hydrology, vegetation, soil conditions, and human activity also have significant impacts on the severity and intensity of groundwater changes. The following environmental factors can affect the severity and intensity of changes in groundwater and have been associated with hazardous conditions and disruption to human and environmental systems.

Groundwater rise is driven by precipitation intensity, coastal and inland storms, sea level rise, and snow melt. Groundwater rise can result in flooding, salinity intrusion, contamination and pollution of groundwater and aquifers, and increased inundation of ecosystems, below ground and at grade assets and infrastructure.

Groundwater depletion, which results in lower a water table and strained water resources, will be more intense when conditions for groundwater recharge are low. These conditions include increasing frequency of drought, a reduced snowpack, higher rates of evapotranspiration, reduced precipitation, diversion of precipitation away from groundwater recharge areas, and pressure from human consumption and natural discharge into surface water. Development patterns and river and stream flood management infrastructure also reduce opportunities for groundwater recharge. Recharge rates can vary significantly between regions: for example, the recharge rate near the South Coastal watershed is 57 percent of total precipitation while annual recharge rates range from 37 to 44 percent of annual precipitation around the Concord watershed (Knott et al., 2022)." (ResilientMass, 2023)

4.4.4. | Previous Occurrences and Frequency

"Changes in groundwater levels can be influenced by several factors associated with human actions, climate change, and natural variations. Groundwater levels fluctuate daily, weekly, and seasonally. Recent analysis has detected long-term variation in groundwater levels over the last 50 years, but the direction of change depends on complex interactions. While there are several studies that evaluate the changes in groundwater levels in specific locations and at the regional level, there is need for a statewide understanding of factors affecting groundwater. One study estimated that annual groundwater recharge could decrease by 3 to 28 percent statewide by the year 2100 (Knott et al., 2022)."

4.4.5. | Probability of Future Hazard Events, including Due to Climate Change

"Climate change can affect the severity of groundwater rise, depletion, and contamination due to the following factors: changes in precipitation, groundwater recharge, impacts from sea level rise, and changing temperatures. These factors' net impact on groundwater can be inferred and is being studied but has not been quantified." (ResilientMass, 2023). The following descriptions from the ResilientMass Plan explain how these factors can impact groundwater.

- **Precipitation:** Increased quantities of precipitation can elevate groundwater levels and increase recharge. However, slow steady snowmelt and rain are more likely to lead to recharge than extreme precipitation events. The timing of precipitation affects groundwater recharge depending on antecedent soil moisture. Rising temperatures are likely to lead to fewer days where the ground is frozen and increase the number of days when recharge is possible. However, recharge from snowmelt will be shifted to the winter rather than the usual springtime.

- **Temperature:** Rising temperatures will also increase the number of days when evapotranspiration is higher. Evapotranspiration is associated with lower rates of groundwater recharge. Increased temperatures are also likely to extend the growing season, placing more demands on aquifer reserves via additional water use and evapotranspiration. Shallow, unconfined aquifers are also likely to experience higher temperatures.

- **Intensity of precipitation:** Climate change is expected to change the intensity of precipitation events. High levels of precipitation over short periods affect the ability of the soil and groundwater system to absorb the water, which can lead to reduced recharge and increased runoff resulting in flooding.

- **Drought:** Climate change is projected to affect the severity and duration of drought. Aquifers experience reduced recharge and increased demand for water reserves during drought periods. Research on the relationship between suburban drought and residential development found that increased developments raised sensitivity to suburban droughts and long-term planning between land use and water management was critical in reducing drought vulnerability and risks to groundwater systems that are needed for multiple ecosystem services (Hill & Polsky, 2007).

- **Contamination:** Higher precipitation over shorter periods can mobilize surface contaminants that can seep into the groundwater (Amanambu, 2015). This is particularly a concern in shallow aquifers like those in Massachusetts. The Plymouth 2021 Hazard Mitigation plan mentioned above addresses the groundwater protection concerns identified in reports conducted by the State Source Water Assessment Protection program[1] by reducing contaminants through zoning enforcement and restrictions on certain development (Horsley Witten Group, 2021). Contamination may also occur from road salting (Heath & Morse, 2013). More frequent road salting necessitated by more rain on snow "mixed precipitation" events can exacerbate salt contamination. (ResilientMass, 2023).

4.4.6. | Vulnerability and Impacts

Groundwater rise can lead to the flooding of below-grade and at-grade utilities, infrastructure, natural environments, living spaces, and workspaces. Rising groundwater levels can also mobilize contaminants in soil and destabilize ground and soil. Groundwater rise can lead to saltwater intrusion to salt-sensitive habitats, vegetation, land uses, and infrastructure. Saltwater intrusion corrodes infrastructure and alters natural habitats.

Decreases in the water table can also have an impact on ecosystems and human health by reducing the availability of freshwater sources. Long-term changes in groundwater levels can also affect structure stability, especially for buildings built on wood pilings.

Groundwater changes in salinity and height driven by sea level rise can affect drinking water supplies and have significant impacts on the natural environment. Groundwater rise can interact with precipitation, drainage, and sea level rise in complex ways that can contribute to flooding.

Attendees of the CRB workshop noted that availability of drinking water is a big concern in Town, as many residents have private wells. Access to drinking water is critical for the health and safety of residents.

Table 4.7: Impacts of Changes in Groundwater on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Flooding and damage to basements or below grade living areas creating risk of mold and contamination • Septic system failure leading to water quality degradation in nearby waterways and increased bacterial exposure
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Damage or loss to below-grade buildings and foundations of buildings due to flooding or unstable soils • Damage to building foundations from salinity intrusion
Systems	Impacts to transportation systems, and electricity and water systems: • Damage or loss to below-grade or at-grade utilities, infrastructure, roads, and transit including power, heat, water, sewer, and stormwater services due to flooding or unstable soils
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Damage to habitats, natural areas, and wetlands due to reduced freshwater supplies • Saltwater intrusion and inundation of aquifers, wetlands, and ecosystems that cannot adapt to new conditions due to sea level rise • Changes to groundwater temperature in urban environments which can amplify heat island effects and stress vegetation and urban trees
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Increased costs for alternative sources of water such as desalination • Cost of damage from flooding, especially in areas of repetitive loss • Disruption of utility and infrastructure creating travel delays or lack of water, power, or sewer service

4.5. Drought

4.5.1. | Description

Drought is an extended duration of time characterized by below normal levels of precipitation. The duration of drought can vary widely and can occur in virtually all climatic zones, with different conditions based on the region-specific precipitation normals. Drought differs from aridity, in which a region experiences low precipitation as a typical or permanent characteristic of the climate (i.e., a desert).

The ResilientMass Plan states that "drought is a natural phenomenon that serves a purpose in ecological processes. However, when drought limits the capacity of natural and human systems to sustain themselves, particularly in heavily urbanized or otherwise altered lands, drought can result in hazardous impacts and negative economic outcomes when drought limits the capacity of systems to sustain themselves, particularly in heavily urbanized or otherwise altered lands. The National Drought Mitigation Center (n.d.-b) references five common, conceptual definitions of drought as categorized in the seminal work of Wilhite and Glantz (1985):

- Meteorological drought is when the amount and duration of rainfall in a region is less than normal. It is defined solely by the degree of dryness. Due to climatic differences, what might be considered a drought in one part of the country may not be a drought in another location.
- Hydrological drought results when the lack of precipitation affects streamflow, surface water bodies and groundwater such that they are below normal levels. The frequency and severity of hydrological drought is often defined on a watershed or river basin scale.
- Agricultural drought occurs when there is not enough water available for a particular crop to grow at a particular time. Agricultural drought is defined in terms of soil moisture deficiencies relative to the water demands of plant life, primarily crops. This type of drought can occur when there are precipitation shortages, soil water deficits, and reduced ground water reservoir levels.
- Socioeconomic drought occurs when the demand for an economic good such as water exceeds the supply because of precipitation-related shortfall. This differs from the other types of droughts because its occurrence depends on the processes of supply and demand.
- Ecological drought is a deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedback in natural and/or human systems (Crausbay et al., 2017)" (ResilientMass, 2023).

4.5.2. | Location

"Regions of Massachusetts can experience significantly different weather patterns due to topography; distance from the coast; and a combination of regional, national, and global weather patterns. As a result, the Massachusetts Drought Management Plan (DMP, 2019) organized Massachusetts into seven drought regions" (ResilientMass, 2023). Dunstable is part of the Northeast drought region. This regional approach allows customization of drought actions and conservation measures to address the drought conditions specific to the region. "Dependent on the drought conditions, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) may adjust the geographic scale of analysis to county or watershed scale to facilitate location-specific response actions and communications" (ResilientMass, 2023).

4.5.3. | Severity/Intensity

"In Massachusetts, drought is defined by a combination of several indices, as detailed in the Massachusetts DMP (Massachusetts Executive Office of Energy and Environmental Affairs & Massachusetts Emergency Management Agency, 2019). The indices are:

1. Precipitation. The Standardized Precipitation Index is based on monthly precipitation totals compiled from DCR's Precipitation Program and the National Weather Service network. The Standardized Precipitation Index is widely used and can be calculated for a range of lookback periods.
2. Streamflow. This index provides an early indication of impacts to rivers, streams, wetlands, and other riparian habitats due to precipitation deficits.
3. Groundwater. Due to the length of time required for groundwater recharge, this index provides information on drought impacts over a longer period.
4. Lakes and impoundments. This index captures the effect of droughts on surface- water storage, including lakes, ponds, and water supply and flood control reservoirs.
5. Fire danger. The Keetch-Byram Drought Index indicates the fire potential and flammability of organic material in the ground by assessing the amount of precipitation required for the top eight inches of soil to be saturated.
6. Evapotranspiration. This index is based on the Crop Moisture Index, which assesses the short-term or current conditions of dryness or wetness relative to the water needs of specific crops and can be used to understand potential impacts to agricultural crops.

These indices are monitored on a weekly basis and used to generate a monthly hydrological conditions report. multiple state and federal agencies monitor these indices, including DAR, DCR, NWS, and USGS. However, the DCR Office of Water Resources is responsible for delivering monthly reports on the six drought indices for MA (Massachusetts Executive Office of Energy and Environmental Affairs & Massachusetts Emergency Management Agency, 2019). The state uses the indices described above to determine the onset, end, and severity of droughts. Refer to Section 3.4.1 of the DMP for more details on the methodology and use of the indices. The DMP defines five levels of increasing drought severity:

- Normal, Level 0
- Mild Drought (formerly Advisory), Level 1
- Significant Drought (formerly Watch), Level 2
- Critical Drought (formerly Warning), Level 3

- Emergency Drought (formerly Emergency), Level 4

The drought levels are associated with state actions outlined in the DMP. In Massachusetts, the DMTF recommends drought levels for each region to the Secretary of EEA, who declares the drought level for each region of the state. Refer to Table 3 of the DMP for a comparison of these indices." (ResilientMass, 2023)

4.5.4. | Previous Occurrences and Frequency

Middlesex County, which includes the Town of Dunstable, most recently experienced a period of Severe Drought (D2) from July 2016 through April 2017 (NOAA Storm Events Database, 2023). According to NOAA, during this period precipitation levels and soil moisture were abnormally low and groundwater conditions were found to be below normal. River and streamflow conditions were also well below normal.

4.5.5. | Probability of Future Hazard Events, including Due to Climate Change

"Rising temperatures and changes in precipitation patterns are expected to increase the length, frequency, and intensity of droughts. Reduced snowpack will affect the ability of groundwater supplies to recharge and the availability of water for the growing period.

The likely range of consecutive dry days per year is projected to increase by up to 33 days per year in 2090, compared to the annual, statewide-average baseline of 31 days from 1986 to 2005. Table 4.8 indicates the projected number of consecutive dry days based on the Stochastic Weather Generator data developed for the 2022 Massachusetts Climate Change Assessment (MA Climate Assessment). Projections from the MA Climate Assessment suggest that the average days of zero precipitation per year is likely to increase across most of the Commonwealth. Individual drought events are likely to increase in frequency and severity. In addition, drought may persist with extremely low precipitation days; therefore, consecutive dry days and average dry days per year likely underestimate the potential increase in dry or drought conditions. (ResilientMass, 2023)."

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Table 4.8: Indicators of Drought—Consecutive Dry Day Events and Total Annual Days Without Rain

Number of Consecutive Dry Day Events per Year					
Region	Baseline	2030	2050	2070	2090
Eastern Inland (including Dunstable)	32	32	32	33	33

Source: Steinschneider & Najibi (2022).

Number of Days without Rain per Year [a]					
Region	Baseline	2030	2050	2070	2090
Eastern Inland (including Dunstable)	186	181	185	188	193

Source: MA Climate Assessment (Commonwealth of Massachusetts, 2022).

[a] Future projections presented for four time periods are identified in the table by their central year: 2030 (near-term, 2020–2039); 2050 (mid-century, 2040–2059); 2070 (mid-late century, 2060–2079); and 2090 (end of century, 2080–2099). Values may not sum due to rounding.

4.5.6. | Vulnerability and Impacts

Droughts can lead to water scarcity, which can affect drinking water supplies, sanitation, and hygiene. Lack of access to safe drinking water can lead to dehydration, malnutrition, and waterborne illnesses, which can be especially harmful to children and vulnerable populations. Droughts can cause the soil to dry out, shrink, and crack, which can lead to settlement and subsidence of buildings. This can result in damage to foundations, walls, and other structural elements. Droughts can impact water infrastructure, including reservoirs, wells, and pipelines. Lower water levels can impact water quality and availability, leading to water rationing and potentially causing damage to infrastructure due to exposure. Finally, droughts can impact soil quality by reducing moisture levels, leading to soil erosion, degradation, and reduced fertility. This can impact agriculture, food production, and ecosystem health.

Attendees of the CRB workshop shared that drought is a concern for drinking water both at the public water supply and private wells.

Table 4.9: Impacts of Drought on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Increased risk of dehydration, death, heat-related illness, and heat stroke (if the drought coincides with warmer months)

Asset Category	Likely Impacts
	• Dry soils and wildfires can increase the number of airborne particles such as pollen and smoke with can worsen chronic respiratory illness. For example, in Dunstable, drought may impact the unofficial Massapoag Pond Swimming Area (Private) or the swimming area at Tully Wildlife Refuge (Dunstable Rural Land Trust), which will reduce access to areas used for cooling and other co-benefits.
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Can cause power outages, especially in areas powered by hydroelectric power plants • Drying or cracking of sediments can cause foundation damage to structures or the settlement/ subsidence of buildings
Systems	Impacts to transportation systems, and electricity and water systems: • Reduced water availability can complicate firefighting efforts • Decrease in groundwater supplies may cause shortages or rationing of water • Waterways can recede which can limit the size of ship that can navigate shallower waters, potentially impacting the delivery of goods and services
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Damage to wildlife habitat, degradation of air and water quality, wildfires, degradation of landscape quality, loss of biodiversity, soil erosion • Loss of wetlands, lakes, and vegetation • Impact on crop production and supplies of animal feed • Increased potential for fires
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Waterways can recede which can limit the size of ship that can navigate shallower waters, potentially impacting the delivery of goods and services • Potential to drain state and local resources, which can have a significant fiscal impact on local government

4.6. Earthquakes

4.6.1. | Description

"An earthquake is experienced as the vibration of the Earth's surface that follows the release of seismic energy in the Earth's crust. Seismic energy is released when cracks in the crust (called faults) suddenly slip. Earthquakes happen at the edges of the world's tectonic plates, which rub against each other as they move across the surface of the Earth. The stresses of tectonic plate motions also build up within the interiors of the tectonic plates, causing some faults to slip there and cause intraplate earthquakes—though these are much rarer than the plate boundary earthquakes that are common in places such as California (Richardson, n.d.). Scientists are still exploring the cause of intraplate earthquakes; many believe they occur along geologic features that were created millions of years ago and are now weaker than the surrounding areas (Kafka, 2020). New England experiences intraplate earthquakes when stress is released within the interior of the North American plate. Ground shaking and the liquefaction resulting from it are the primary causes of earthquake damage. This damage can vary locally due to soil types that can amplify shaking or are susceptible to liquefaction. A contributor to this amplification is the velocity at which rock or soil transmits shear waves (S waves). Accordingly, the National Earthquake Hazards Reduction Program classifies soil according to S-wave velocity in the top 30 meters (100 feet) below the Earth's surface. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building, infrastructure, and utility damage and losses. A seismic site classification map for Massachusetts using these soil types is shown Figure 4.8 Areas along the shoreline that have previously been filled are particularly at risk from liquefaction and increased damage from earthquakes" (ResilientMass, 2023).

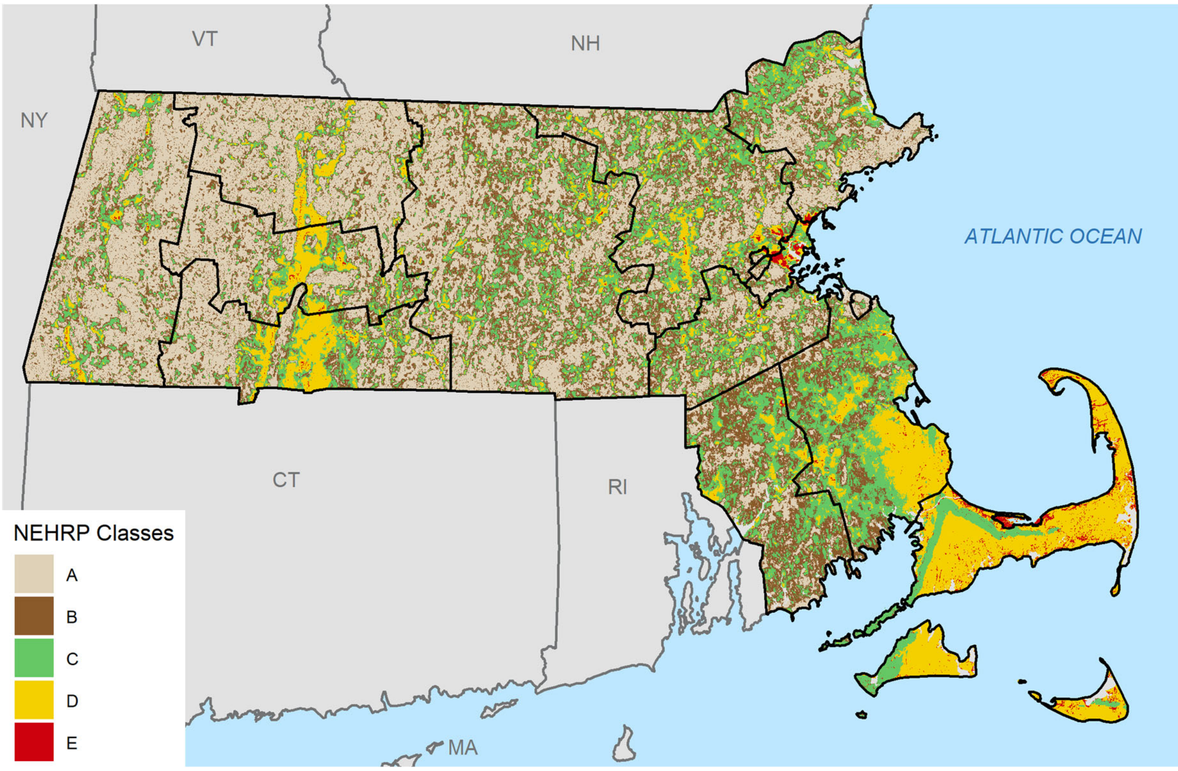

Figure 4.8: Massachusetts Soil Types

4.6.2. | Location

"New England earthquake epicenters may not follow the major mapped geologic faults of the region, nor are they confined to any geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region, although it is possible that earthquakes tend to re-occur along pre-existing planes of weakness (Kafka, 2020). Generally, USGS seismic hazard maps show that Massachusetts has a low to moderate level of seismic hazard compared to other areas of the country (USGS, 2018a). Peak ground accelerations (PGA) with a 2 percent probability of being exceeded in 50 years are predicted to be higher in Dunstable and the northeast part of the Commonwealth, around 20– 30 percent the force of gravity (Figure 4.9). Shaking at this level is known to cause some property damage, such as broken chimneys. However, as discussed above and shown in Figure 4.4, softer soil types can amplify local ground shaking and thus the impacts from an earthquake.

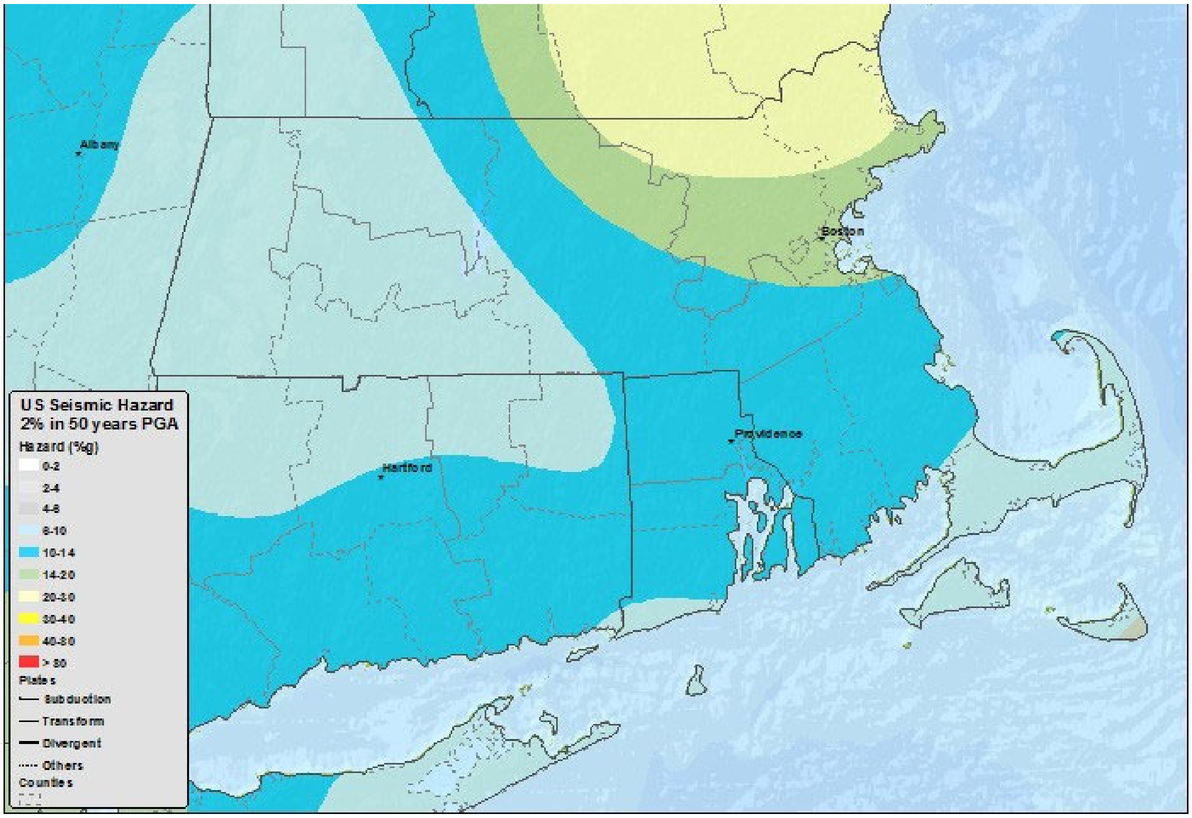

Figure 4.9: Seismic Hazard

4.6.3. | Severity/Intensity

"The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). Globally, earthquakes with focal depths up to about 43.5 miles are classified as shallow.

Earthquakes with focal depths of 43.5 to 186 miles are classified as intermediate. The focus of deep earthquakes may reach depths of more than 435 miles. Most earthquakes have focal depths of 20 miles or less. The depth to the Earth's core is about 3,960 miles, so even the deepest earthquakes originate in relatively shallow parts of the Earth's interior. The epicenter of an earthquake is the point on the Earth's surface directly above the focus.

Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude of an earthquake is a seismograph-measured value of the amplitude of the seismic waves. The most widely known scale for earthquake magnitude is the Richter scale, developed in 1935 as a mathematical device to compare earthquakes. The Richter scale has no upper limit.

Importantly, it does not express 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. It is the presence of vulnerable assets and populations near an earthquake epicenter, combined with the earthquake magnitude, that determines the amount of damage and where that damage takes place.

The severity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features. Intensity is expressed by the Modified Mercalli Intensity (MMI) scale, which describes how strongly an earthquake was felt at a particular location using values ranging from I to XII. Seismic hazards are also expressed in terms of PGA, which USGS defines as the greatest acceleration that "is experienced by a particle on the ground." More precisely, seismic hazards are described in terms of spectral acceleration, defined by USGS as "approximately what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building" in terms of percent of acceleration force of gravity (percent g).

Table 4.10 summarizes the MMI scale, associated damage, and corresponding PGAs and Richter scale magnitudes. Note that the typical comparisons between Mercalli intensity and Richter magnitudes are biased toward the type of earthquakes that happen in California. Smaller magnitude earthquakes can be felt over larger regions in New England, so the Mercalli descriptions for "equivalent"-magnitude earthquakes are not always accurate in this region. For example, a 4.2 magnitude is typically considered to be equivalent to MMI II ("felt only by a few persons"); this may be true on the West Coast, but an earthquake of that magnitude in New England can be felt my many more people over a wide area, sometimes so strongly that people get scared and run out of their buildings (as is typically described for an MMI IV or V earthquake)." (ResilientMass, 2023)

Table 4.10: MMI and Equivalent PGA and Richter Scale Magnitude

\Mercalli Intensity	Equivalent Richter Scale Magnitude	Description	Abbreviated MMI Scale Descriptions	Acceleration (Percent g) (PGA)
I		Detected only on seismographs.	Not felt except by a very few under especially favorable conditions.	< .17
II		Some people feel it.	Felt only by a few people at rest, especially on upper floors of buildings.	.17–1.4

\Mercalli Intensity	Equivalent Richter Scale Magnitude	Description	Abbreviated MMI Scale Descriptions	Acceleration (Percent g) (PGA)
III		Felt by people resting; like a truck rumbling by.	Felt quite noticeably by people indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.	.17–1.4
IV		Felt by people walking.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	1.4–3.9
V	< 4.8	Sleeping people awake; church bells ring.	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.	3.9–9.2
VI	< 5.4	Trees sway; suspended objects swing; objects fall off shelves.	Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.	9.2–18
VII	< 6.1	Mild alarm; walls crack; plaster falls.	Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken.	18–34
VIII		Moving cars are uncontrollable; masonry fractures; poorly constructed buildings damaged.	Slight damage in specially designed structures; considerable damage in ordinary substantial buildings, with partial collapse. Great damage in poorly built structures. Chimneys, factory stacks, columns,	34–65

\Mercalli Intensity	Equivalent Richter Scale Magnitude	Description	Abbreviated MMI Scale Descriptions	Acceleration (Percent g) (PGA)
			monuments, and walls fall. Heavy furniture overturned.	
IX	< 6.9	Some houses collapse; ground cracks; pipes break open.	Considerable damage in specially designed structures; well-designed frame structures thrown out of plumb. Great damage in substantial buildings, with partial collapse. Buildings shifted off foundations.	65–124
X	< 7.3	Ground cracks profusely; many buildings destroyed; liquefaction and landslides are widespread.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.	>124
XI	< 8.1	Most buildings and bridges collapse; roads, railways, pipes, and cables are destroyed; general triggering of other hazards occurs.	Few, if any (masonry structures remain standing. Bridges destroyed. Rails bent greatly.	>124
XII	> 8.1	Total destruction; trees fall; ground rises and falls in waves.	Total damage. Lines of sight and level are distorted. Objects thrown into the air.	>124

Source: Swiss Seismological Service (n.d.).

Dunstable can be expected to have a low to moderate risk of earthquake damage compared to other areas of the country. However, the damage incurred by even a moderate earthquake would still be relatively high. Therefore, Dunstable can be characterized as a “high impact, low probability” earthquake region (Ebel, 2019).

Impacts in Dunstable can vary based on types of construction, building density, and soil type, among other factors. This is demonstrated in the Hazus analysis summarized in Section 4.4.6.

4.6.4. | Previous Occurrences and Frequency

Earthquakes cannot be predicted and may occur at any time. USGS seismic hazard maps are used to determine the likelihood that a given earthquake severity will be exceeded over a defined period (as shown in Figure 4.5) which maps the PGA with a 2 percent chance of being exceeded in 50 years). However, these maps are not useful for predicting the timing of individual events.

A 1994 report by USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an estimated probability of occurrence for earthquakes above magnitude 5.0 (earthquakes of this size can cause damage near their epicenters, and in general larger-magnitude earthquakes can cause damage over larger areas). This report found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10 to 15 percent, which the Intergovernmental Panel on Climate Change classifies as "unlikely." This probability rises to about 41 to 56 percent for a 50-year period. Larger earthquakes have lower probabilities of occurrence.

Meanwhile, small earthquakes (magnitude 1 to 1.5) like those experienced in Peabody in 2021, typically occur once or twice a month throughout New England (McCarthy, 2021). The rate of earthquake occurrence in New England appears to be fairly constant over time (Northeast States Emergency Consortium, n.d.). There is no research indicating any effects of climate change on the frequency or severity of the earthquakes in the Commonwealth.

Since 1963, there have been 151 earthquake events in Massachusetts (USGS 2023), the highest having a magnitude of 3.7 on the Richter scale. There have been no epicenters located in Dunstable.

4.6.5. | Probability of Future Hazard Events, including Due to Climate Change

"There is no consensus on the effects of climate change on the frequency and severity of earthquakes across the United States or within Massachusetts. Some scientists and researchers have speculated that the effects that sea level rise will have on groundwater levels near the coast may increase the areas exposed to liquefaction risk. Other and research have considered the impacts of extreme precipitation events on increased frequency and intensity of earthquakes. While these questions have been raised and some studies are pursuing further information, there is no current consensus on any links between earthquakes and climate change in the Commonwealth or the United States." (ResilientMass, 2023).

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4.6.6. | Vulnerability and Impacts

In addition to building collapse, earthquakes can cause structural damage to roadways, breakage of water and gas lines, and flooding and fires. Furthermore, landslides can be triggered by earthquakes.

"The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. Dunstable is a rural community with a low population density, however, there are a significant number of older buildings that can be found throughout the town (2015 Hazard Mitigation Plan for the Northern Middlesex Region)."

A particularly strong earthquake could be potentially devastating for the town, causing disruptions to daily life and severe structural damage. Using FEMA's Hazus software, potential losses for various earthquake scenarios were estimated. Both a magnitude 5 and a magnitude 7 earthquake would be disastrous for the town. Both scenarios result in severe property damage, large amounts of debris generation, displaced households, people seeking public shelter, and losses due to business interruption. Obviously, a magnitude 7 earthquake would be more detrimental to the Town and have greater, more severe impacts.

Table 4.11: Hazus Earthquake Impacts

Type of Damage or Displacement	Magnitude 5.0	Magnitude 7.0
Building Damages		
Number of buildings sustaining slight damage	375	135
Number of buildings sustaining moderate damage	196	428
Number of buildings sustaining extensive damage	50	341
Number of buildings completely damaged	12	337
Number of households displaced	5	222
Number of people seeking public shelter	2	98
Building debris generated (millions of tons)	0.01	0.08
Number of truckloads to clear building debris	360	3,040
Total property damage (millions of dollars)	86.48	531.53

Type of Damage or Displacement	Magnitude 5.0	Magnitude 7.0
Total losses due to business interruption (millions of dollars)	8.76	51.35

Table 4.12: Impacts of Earthquakes on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Loss of life or severe injury • Vehicle accidents • Injury from debris or falling objects • First responders are particularly at-risk
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Significant structural damage, especially if buildings are not constructed to withstand seismic forces or if there are insufficient evacuation plans • Critical facilities can be impacted or damaged from ground shaking and falling debris • Collapse of buildings or bridges
Systems	Impacts to transportation systems, and electricity and water systems: • Disruption of government operations • Seismic activity can damage communication infrastructure such as phone lines, cell networks, and data networks • Power outages from damaged electrical infrastructure • Disruption of gas lines, electric lines, or phone service
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Potential to trigger secondary hazards such as fires, flash flooding, hazardous materials release, slope failure, dam failure, and tsunamis • Contamination of the environment from hazardous materials • Significant injury to animals or livestock • Historic buildings may not be able to withstand ground shaking due to outdated construction standards
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being:

Asset Category	Likely Impacts
	• Expensive response and recovery efforts can drain local resources • Closure of businesses due to damage • Disruption of delivery services due to dangerous transportation conditions

4.7. Flooding from Precipitation

4.7.1. | Description

Extreme precipitation events can result in flooding, often characterized and "inland flooding" to distinguish it from coastal flooding. This section addresses the risks associated with flooding from high precipitation events, which include convective storms (thunderstorms or other typically sudden and extreme precipitation events), nor'easters, and hurricanes. Also included are inland flood events caused by extreme rainfall events, riverine overtopping, overwhelmed stormwater systems, ice jams blocking drainage, and dam failure or overtopping, described in greater detail below.

"Riverine Flooding: Riverine flooding occurs when excessive rainfall over an extended period collects across a watershed and causes a river to exceed its natural drainage capacity.

Stormwater Drainage Flooding: Stormwater drainage flooding is caused by high-intensity rainfall in combination with high amounts of impervious surface area that prevents infiltration. This causes stormwater drainage systems to reach a state of over-capacity, rather than rain causing a river system to exceed its capacity. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of conveyance systems that channel water away from developed areas to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration (plant water uptake and respiration). Since drainage systems reduce the amount of time that rainfall takes to reach surrounding streams, riverine flooding in developed areas can be exacerbated and may occur more quickly and reach greater depths than less densely developed areas. In addition, undersized, poorly maintained, or clogged drainage system increase the frequency and/or severity of this type of flooding.

Ice Jams: An ice jam is an accumulation of ice that acts as a natural dam and restricts the flow of a body of water. There are two types of ice jams: a freeze-up jam and a breakup jam. A freeze-up jam usually occurs in early to mid-winter during extremely cold weather when super-cooled water and ice formations extend to nearly the entire depth of the river channel. This type of jam can act as a dam and begin to back up the flowing water behind it. The second type, a breakup jam, forms because of the breakup of the ice cover at ice- out: large pieces of ice move downstream, potentially piling up at culverts, around bridge abutments, and at curves in river channels. Breakup ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding upstream of the obstruction.

Dam Failure: As dams are used to impound water by controlling water flow, changes in precipitation intensity and duration can affect dam performance and safety. When reservoir inflows exceed the capacity of a dam's spillway, rising reservoir water levels can result in increased rates of seepage outflow, destabilization of embankment slopes, and/or dam failure due to overtopping." (ResilientMass, 2023).

4.7.2. | Location

Floods can impact a small portion of the Town or the entire Town of Dunstable. Areas of lower elevation are more likely to experience impacts from flooding.

The Federal Emergency Management Agency (FEMA) characterizes the current hazard using floodplain boundaries. These data include the locations of FEMA flood zones:

- The 1 percent annual chance event (also sometimes referred to as 100-year flood) zones, including both A Zones and V Zones
- The 0.2 percent change event (or 500-year flood) zones

While A and V Zones are more likely to experience flooding than X zones, it is still possible to experience flooding in X zones.

Figure 4.10 shows FEMA Flood Zones in Dunstable.

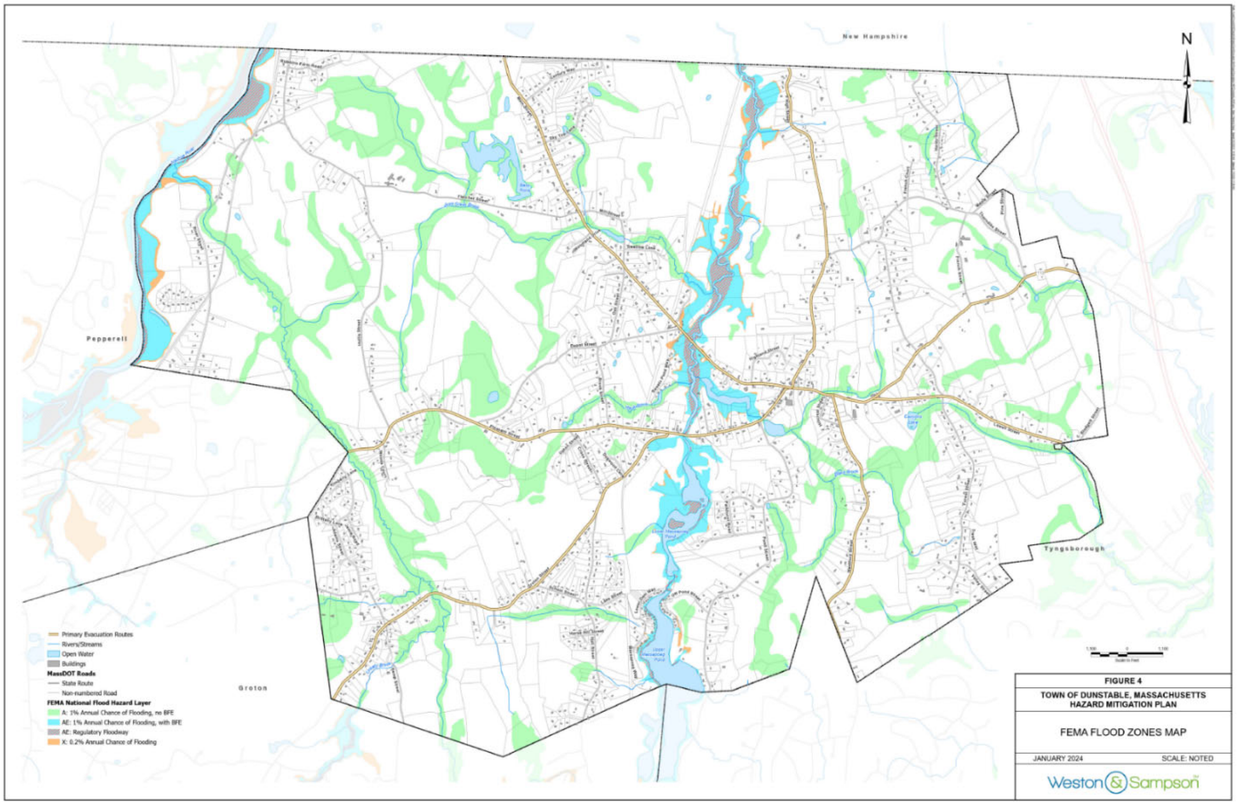

Figure 4.10: FEMA Flood Zones in Dunstable

4.7.3. | Severity/Intensity

As discussed in the previous section, return periods are used to represent the average interval between occurrences of particular rainfall events. Rainfall events with greater return periods will have much more rain than a smaller return period, and thus will cause more flooding and greater damage. Table 4.13 outlines the amount of precipitation that would fall during various return periods in Dunstable.

Table 4.13: 2030, 24-hour rainfall depth

Return Interval:	1 year	2 years	5 years	10 years	25 years	50 years	100 years	200 years	500 years	1000 years
Depth (inches)	2.9	3.6	4.6	5.5	6.7	7.6	8.5	9.7	11.5	13.1

Flooding from precipitation can vary in severity and intensity depending on several factors, including the amount and duration of rainfall, topography, soil conditions, land use patterns, and the capacity of drainage infrastructure. Increases in intensity and duration of precipitation on rainy days can lead to flooding, stress on built infrastructure and ecosystems, and consequent impacts on human health.

4.7.4. | Previous Occurrences and Frequency

Since the previous hazard mitigation plan update in 2015, there have been 38 days of flooding in Middlesex County (NOAA Storm Events Database). There were 13 days where this flooding resulted in property damage (NOAA Storm Events Database). Property damage in Middlesex County since 2015 totaled 1.639 million dollars.

Return periods, also known as recurrence intervals, are statistical measures used to estimate the likelihood of a specific event, such as a rain event of a certain magnitude, occurring within a given timeframe. In the context of rainfall events and flooding, return periods help assess the probability of different levels of rainfall intensity over a specified duration.

For example, a 100-year return period for a rainfall event means that, on average, such an event is expected to occur once every 100 years. It does not mean that the event will occur exactly once every 100 years, but rather that there is a 1% chance of it occurring in any given year. Similarly, a 10-year return period indicates that there is a 10% chance of that rainfall event occurring in any given year. The 2030, 24-hour 100-year rainfall event sees 8.5 inches of rain.

Return periods are typically calculated using historical rainfall data and statistical methods. By analyzing rainfall data from past years, statisticians can estimate the probability of rainfall events of different magnitudes occurring in the future. However, as rainfall has increased over the year years, the historically-calculated 100-year storm event has been occurring more frequently. This is expected to continue into the future, and is covered in Section 4.7.5.

A respondent to the public survey shared the torrential rains during summer 2023 caused significant erosion across town and locations of periodic flooding on side streets.

4.7.5. | Probability of Future Hazard Events, including Due to Climate Change

"Forecasting precipitation under climate change is complex, but scientists expect that there will be more precipitation overall in Massachusetts, on an annual basis and in most years: higher temperatures will mean the moisture-holding capacity of the atmosphere increases, but also that evaporation rates are higher. Patterns to date suggest that annual precipitation is likely to be more variable, and fall over few days, but that precipitation will be more intense on days when it does rain or snow. According to climate projections for Massachusetts, annual precipitation will increase and will fall more intensely at the daily to weekly scale. Climate change is also projected to bring longer and deeper periods of drought and/or reduced precipitation." (ResilientMass, 2023).

Figure 4.11 below shows projected precipitation intensity and frequency over time in the central region of Massachusetts, where Dunstable is located. The graph shows changes in the expected size of a 10-year return period rainstorm (i.e., a storm, defined in terms of equal or greater precipitation within 24 hours, that has 10 percent chance of occurring in a given year) and the expected frequency of rainstorms that would meet the current 10-year return period size (ResilientMass, 2023).

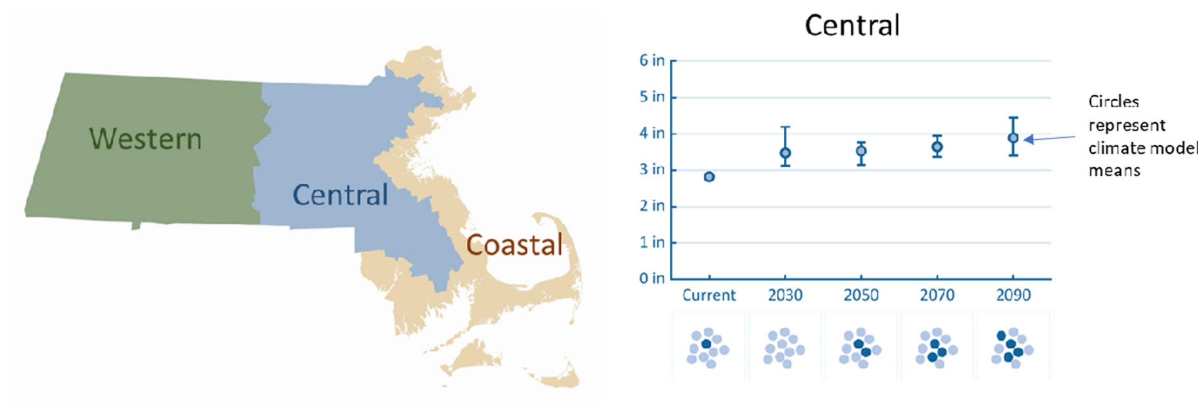

Figure 4.11: Changes in Intensity and Frequency of 10-year return period precipitation events

Source: MA Climate Assessment (Commonwealth of Massachusetts, 2022).

Figure 4.11 Note: A 10-year size indicates a 10 percent chance of equal or greater precipitation within 24 hours in a given year. Bar charts show the projected size of 10-year return period events, and filled dots show the anticipated frequency of storms that would exceed current 10-year return period events.

Under the current climate, the 10-year return period event is roughly 3 inches. By the end of the century, the intensity of the 10-year return period event is expected to increase by one third, to 4 inches in a day. The frequency of the current 10-year return period event is expected to increase by the end of the century by a factor of four in the Central region.

The ResilientMA Climate Change Projections Dashboard shows precipitation for the years 2030, 2050, 2070, and 2090 on an annual basis for the Town of Dunstable. Figures 4.12 and 4.13 show the contrast between 2030 and 2090 for precipitation.

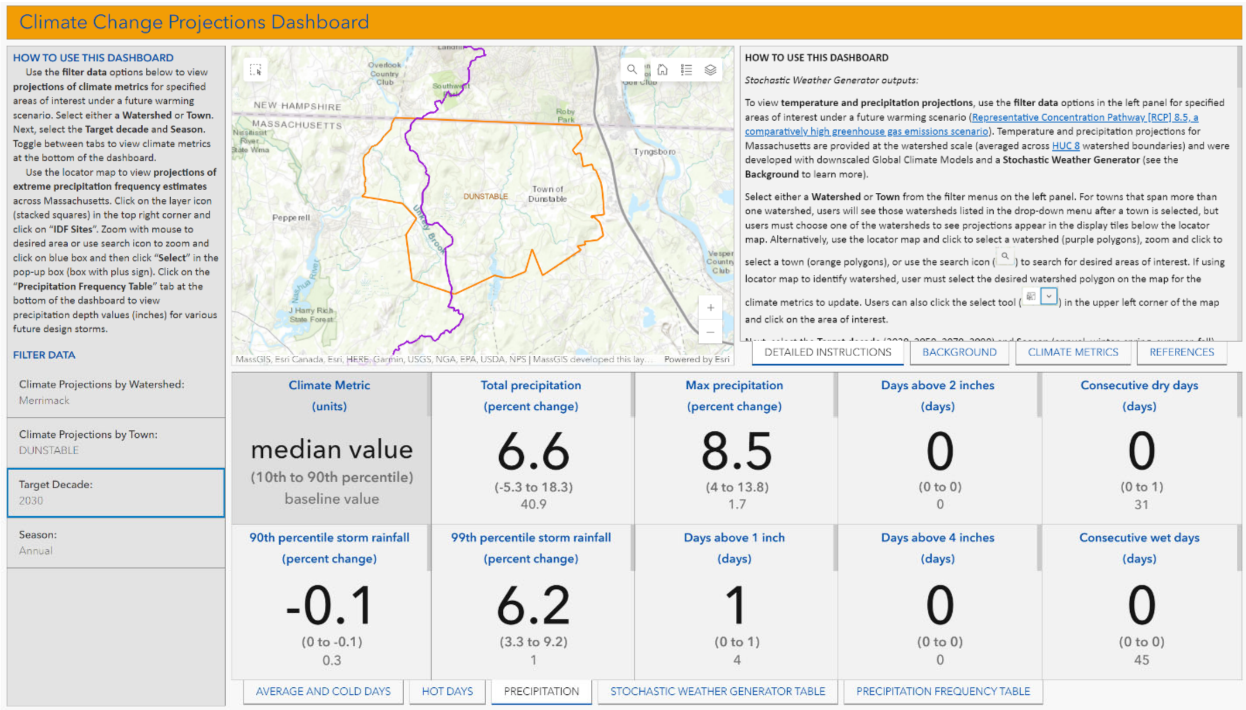

Figure 4.12: Annual Precipitation Projections for 2030

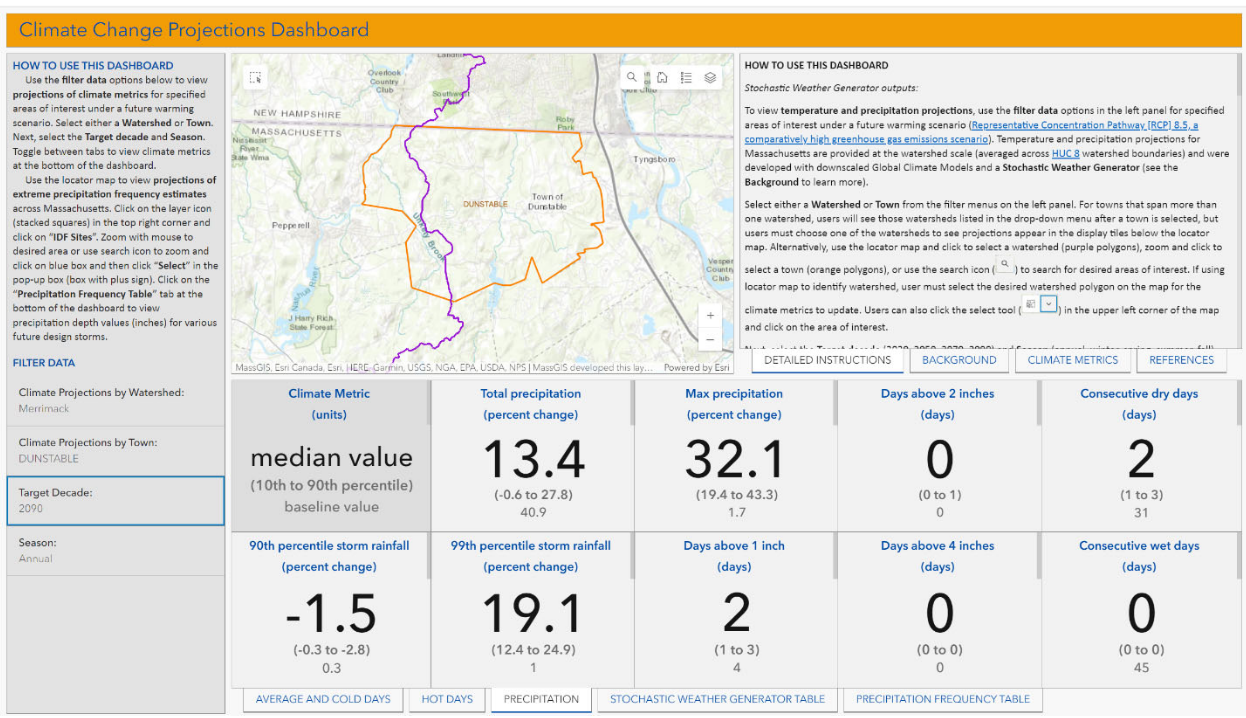

Figure 4.13: Annual Precipitation Projections for 2090

4.7.6. | Vulnerability and Impacts

Precipitation flooding includes stormwater flooding, riverine flooding, and flooding from dam overtopping. Riverine flooding is most likely to impact areas closest to bodies of water, while stormwater flooding can occur anywhere in the Town. Stormwater flooding is often concentrated to smaller areas including parking lots and roadways. Dam overtopping can impact areas adjacent to and downstream of the dam. Dams are categorized by DCR as "high hazard", "significant hazard" and "low hazard". Higher hazard dams post a greater risk to downstream populations. Dunstable has four low hazard and two significant hazard dams.

Much of the infrastructure in Dunstable, including bridges, stormwater systems, and roadways were designed based on historical rain events. With increased frequency and severity of storm events, inland flooding could become an increased vulnerability for the Town to manage. Recently, more frequent occurrences of flood events larger than the historic have occurred and put vital infrastructure at risk. Much of the population of Dunstable lives on dirt roads in isolated areas, and damage to the road network could impact a large percentage of the population and result in inability for them to get to work, appointments, and other essential locations.

Attendees of the CRB workshop expressed concerns regarding precipitation flooding. Dunstable residents noted the commonality of basement flooding, and their concerns regarding flooding from snow melt and rain. In addition, heavy rains have caused "gullies" alongside roadways, due to country drainage. This has created concerning infrastructure conditions and heavy maintenance and repair needs. Additionally, residents have noticed the impact that beaver dams have on increasing water levels and flooding in town and expressed interest in better monitoring of this impact. The Fire Department faces basement flooding due to water levels in nearby Salmon Brook.

A resident who took the public survey shared that the increase and rapid rainfall quickly causes flash flooding on our town streets and can result in flooded basements.

Using FEMA's Hazus software, potential losses during the 100-year and 500-year flood events were estimated. As seen in Table 4.14, both the 100- and 500-year flood event have the potential to displace many people from their homes, generate a few tons of debris, and cause losses due to business interruption.

Table 4.14: Hazus Flooding Impacts

Type of Damage or Displacement	100-Year	500-Year
Building Damages		
Number of buildings sustaining slight damage	3	10

Type of Damage or Displacement	100-Year	500-Year
Number of buildings sustaining moderate damage	0	0
Number of buildings sustaining extensive damage	0	0
Number of buildings completely damaged	0	0
Number of households displaced	52	84
Number of people seeking public shelter	8	8
Building debris generated (tons)	5	8
Number of truckloads to clear building debris	1	1
Total property damage (millions of dollars)	0.62	1.32
Total losses due to business interruption (millions of dollars)	6.07	8.80

The following community assets are at risk of flooding due to their proximity to mapped flood zones:

- The Dunstable Post Office
- The Dunstable Police Station
- The Dunstable Fire Station
- The Public Library
- The Massapoag Pond Dam
- The Woodwards Mill Dam
- The YMCA
- Salmon Brook Well #1 and #2

There are some community assets of historical significance in Dunstable that are vulnerable to flooding due to their proximity to flood zones, as well:

- Camp Massapoag Cabins
- Ebenezer Kendall House
- 466 Main Street
- 458 Main Street

- Lowell Street Property
- East Main Street Gates
- Captain Josiah Cummings House
- W. Gillson House
- Locust Avenue Bridge over Route 3
- Dea. Zebedee Kendall House
- 726 Main Street
- R. Robbins House
- Blood Cemetery
- Eber Blood House

Table 4.15: Impacts due to Flooding from Precipitation

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Physical injury or death • Increase in physiological stressors • Displacement due to building damage • Isolation due to road closures • Mold and allergens from water damage creates an increased risk to people with existing respiratory damage • Increase in vector-borne diseases and bacterial infections • Increased rate of emergency room visits
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Water damage to internal and external of buildings, including houses, governmental buildings, community lifelines, and critical infrastructure • Damage to facilities
Systems	Impacts to transportation systems, and electricity and water systems: • Disruption to roadways because of water and debris blocking routes and road washouts, making transportation networks impassible or unsafe • Damage to utility infrastructure • Bridge support scour • Dams are at higher risk of overtopping or experiencing damage from flooding
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Damage or destruction of the natural environment

Asset Category	Likely Impacts
	• Ecosystem degradation and reduced water quality due to increased sedimentation, nutrients, and contaminants from agriculture practices, stormwater runoff, and septic overflow. • Loss of habitat • Erosion • Changes in river and stream ecology • Forest health degradation • Damage to cultural resources and sites • Damage to historic buildings and sites • Parks and public spaces could experience damage or disruptions
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Business interruption • Limited patrons resulting in reduced revenue • Increased costs of maintenance • Increase in demand for municipal services • Increased cost for response and repairs • Temporary loss of community activities

4.8. Hurricanes / Tropical Cyclones

4.8.1. | Description

Hurricanes originate from tropical storms, which form rotating cloud systems, developing over tropical or subtropical waters. There are four classifications of these types of storms (tropical cyclones):

- "Tropical Depression: A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- Tropical Storm: A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- Hurricane: A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- Major Hurricane: A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale." (NOAA, n.d.)

"The term "tropical" refers both to the origin of these systems, which usually form in tropical regions of the globe, and their formation in maritime tropical air masses. The term "cyclone" refers to such storms' cyclonic nature, with counterclockwise wind flow in the Northern Hemisphere and clockwise wind flow in the Southern Hemisphere.

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical storms strengthen when water evaporates from the ocean and is released as the saturated air rises, resulting in condensation of the water vapor contained in the moist air. These storms are fueled by a different heat mechanism than other cyclonic windstorms, such as nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings—a phenomenon called "warm core" storm systems" (ResilientMass, 2023).

4.8.2. | Location

Despite being located inland, Dunstable is still vulnerable to the impacts of hurricanes and tropical cyclones. While coastal areas are typically more directly affected by hurricanes, Dunstable's vulnerability lies in the potential for severe weather conditions and flooding that can accompany tropical storms as they move inland. Heavy rainfall associated with hurricanes can lead to flash flooding, especially in low-lying areas or regions with poor drainage systems. Strong winds from hurricane remnants can also cause town-wide damage to structures, uproot trees, and disrupt power lines, impacting the local community.

4.8.3. | Severity/Intensity

"Hurricanes are measured according to the Saffir-Simpson scale, described in Table 4.16 below, which categorizes hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to estimate the property damage and flooding expected from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline in the landfall region. All winds are assessed using the U.S. one-minute average, meaning the highest wind that is sustained for one minute (ResilientMass, 2023)."

Table 4.16: Hurricane Categories

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	111–129	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	130–156	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	>157	Catastrophic: Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.

Source: NOAA (n.d.-d).

"Tropical storms (39–73 mph) and tropical depressions (38 mph or less), while generally less dangerous than hurricanes, often cause widespread damage, disruption, and injury and loss of life. Tropical storms can produce extremely powerful wind gusts and torrential rain, high waves, damaging storm surge, and tornadoes. These storms develop over large bodies of warm water but can lose their strength as they move over land due to increased surface friction and loss of the warm ocean as an energy source. The heavy rains that are often associated with a tropical storm can produce significant inland flooding, and storm surges can produce extensive coastal and inland flooding up to 25 miles from the coastline. Widespread and lengthy power outages are often a result of these events. For example, after Hurricane Irene passed through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for more than five days (ResilientMass, 2023)."

4.8.4. | Previous Occurrences and Frequency

Dunstable has been impacted by two tropical storms since the previous hazard mitigation plan update. Tropical storms occurred on September 20, 2017, and August 4, 2020. Together these storms caused $20,500 worth of damage in Middlesex County (NOAA Storm Events Database, 2023). Tropical storms and hurricanes have occurred in the proximity of the Commonwealth about once every two years on average. NOAA's National Hurricane Center estimates that a Category 3 hurricane could occur once every 50–60 years (NOAA, n.d.-e).

A respondent to the public survey shared that a hurricane back in late 80's/east 90's did quite a bit of damage in Dunstable.

4.8.5. | Probability of Future Hazard Events, including Due to Climate Change

"Both historic events and models of future conditions suggest that climate change will cause the intensity of tropical storms and hurricanes to increase, though uncertainty remains over the relationship between the frequency of tropical cyclones and climate change. The IPCC reports low confidence in observations of long-term changes to tropical cyclone frequency, partly due to inadequate historical data (IPCC, 2021). There is some evidence of a relative increase in the frequency of tropical cyclones in the Atlantic, resulting from a poleward shift in hurricane activity due to warmer temperatures (Shelton, 2022). Together with the increasing intensity and duration of tropical cyclones, these changes are likely to lead to significant changes in this hazard for the Atlantic coast (Dinan, 2017; Marsooli et al., 2019). A recent study of Atlantic tropical cyclones downscaled from climate reanalysis indicates increasing activity over the past 150 years, with a significant uptick since 1990 (Emanuel, 2021). The MA Climate Assessment identifies a possible increase in tropical cyclone frequency of nearly 50 percent by the end of the century (Commonwealth of Massachusetts, 2022)." (ResilientMass, 2023)

4.8.6. | Vulnerability and Impacts

Hurricane force winds can destroy buildings and mobile homes. Items that are not secured can quickly become airborne debris that can cause severe injury. Hurricanes can also spawn tornadoes. Heavy rain associated with hurricanes can cause extreme flooding. Historically, flooding has occurred on River Street, Main Street (near Sweets Pond), Lowell Street, and Forest Street (2015 Hazard Mitigation Plan for the Northern Middlesex Region). Hurricane rain and winds can result in downed trees and tree limbs, blocked roads, and downed telephone and power lines. This can severely disrupt transportation routes and communication channels. The elderly and those with mobility issues are of particular concern during hurricane or tropical storm events.

Using FEMA's Hazus software, potential losses for a Category 2 and Category 4 storm were estimated. Both storms have the potential to greatly impact the Town of Dunstable by causing property damage, debris generation, and business interruptions, as seen in Table 4.17.

Table 4.17: Hazus Earthquake Impacts

Type of Damage or Displacement	Category 2	Category 4
Building Damages		
Number of buildings sustaining minor damage	29.06	147.98
Number of buildings sustaining moderate damage	1.02	13.78
Number of buildings sustaining severe damage	.02	0.39
Household Displacement and Needs		
Number of households displaced	0	0
Number of people seeking public shelter	0	0
Debris		
Building debris generated (tons)	621	1,444
Tree debris generated	516	982
Number of 25-ton truckloads to clear building debris	4	18

Type of Damage or Displacement	Category 2	Category 4
Value of Damages		
Total property damages	$6,812.77	$17,297.44
Total losses due to business interruption	$95.37	$438.85

Dunstable residents at the CRB workshop discussed how the Hurricane of 1938 caused significant rain, wet conditions, and took down many trees, and how Hurricane Carol in the 1950s had an impact on Dunstable: it also took down a lot of trees, significantly changing the landscape of the town.

Table 4.18: Impacts of Hurricanes and Tropical Cyclones on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death and Injury • Mental health impacts such as anxiety or PTSD • Displacement • Loss of property
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Damage to buildings from high winds, flying debris, or flooding • Power outages • Damage to critical facilities is possible
Systems	Impacts to transportation systems, and electricity and water systems: • Damage to transportation infrastructure such as roads or bridges can impact emergency responses and daily travel • Damage to telecommunications infrastructure can disrupt communications • Widespread power outages can disrupt critical facilities, emergency response centers, water treatment plants, and hospitals • Water supply interruptions from flooding or damage to water treatment plants and pipelines • Flooding can overwhelm wastewater systems causing contamination and health risks • Utility services such as gas may be disrupted

Asset Category	Likely Impacts
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Historic buildings may not be able to withstand high winds • Increased coastal erosion • Potential for flash flooding and storm surge
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Decreased economic activity • Expensive response and recovery costs • Damage to businesses or business closures • School closures

4.9. Invasive Species

4.9.1. | Description

The term invasive species can apply to both flora and fauna. This section will focus on plants and insects (referred to as pests) specifically. The Massachusetts Invasive Plant Advisory Group (MIPAG) was founded in 1995 by the Executive Office of Energy and Environmental Affairs to inform the Commonwealth about the presence and management of invasive species. MIPAG defines invasive species as meeting the following four base criteria (MIPAG, 2022):

- non-indigenous to Massachusetts,
- demonstrates the potential for rapid and widespread dispersion and establishment,
- has the potential to disperse over spatial gaps,
- exists in high numbers in natural habitats.

"Invasive species have biological traits that give them competitive advantages over native species, particularly because they are not restricted by the biological controls of their native habitat. As a result, invasive species can outcompete natural communities, displacing many natives and causing widespread economic and environmental damage" (ResilientMass, 2023).

Pests exacerbate the problems that invasive plant species pose. Pests often prey on native plant species, causing pre-mature death and creating gaps in the eco-system for invasive species to fill. Certain pests, while not necessarily detrimental to the environment, can pose a threat to public health.

4.9.2. | Location

Invasive species are a widespread problem that have that potential to impact the entirety of Dunstable, although the impacts of these species vary by location, elevation, ecosystem, and habitat type, as well as land and water uses. Locations with the greatest susceptibility include natural areas, waterways and wetlands, roadsides and disturbed areas, agriculture areas, and areas that are landscaped with non-native species.

The ability of invasive species to travel far distances (via either natural mechanisms once established or accidental human transport) allows them to propagate rapidly over a large area. Similarly, in open freshwater and marine ecosystems, invasive species can spread quickly, as there are generally no physical barriers (other than physiological tolerances) to prevent establishment, and commercial and recreational water activities provide ample opportunities for transport to new locations.

A respondent to the public survey noted that Garlic Mustard, Bittersweet, Japanese Knotweed, Milfoil and Curly Leaf Pondweed in the Lake Massapoag area are problematic. Another resident to the public survey clarified that bittersweet is pervasive in the town's conservation areas, which has a significant negative impact on native species. It was noted at the CRB Workshop that the invasive species Wintercreeper (Euonymus fortunei) evergreen vine and Japanese Knotweed are becoming quite prevalent along roadsides.

4.9.3. | Severity/Intensity

"The geographic extent, severity, and intensity of invasive species varies greatly depending on the species in question and other factors, including the availability of hospitable natural or artificial habitats, as well as availability of disturbed habitats and ecosystems, and the range that the invasive species can inhabit. Invasive species are measured through monitoring and recording observations into existing databases. However, monitoring and reporting activities are time-consuming and costly and must be factored into the costs of this hazard.

Quantifying the extent of, and resultant damage from, invasive species can be challenging due to several factors. For one, accurately mapping their distribution and abundance is difficult due to their uneven distribution, dispersal mechanisms and speed, and impact from human activities. Invasive species may establish and spread in areas where they have not been previous documented and are not noticed until they reach high population densities. "Additionally, there is no way to directly evaluate or quantify impacts from invasive species on aesthetics or the perceived value of natural areas (Marsh et al., 2021)."

4.9.4. | Previous Occurrences and Frequency

Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences. However, increased rates of global trade and travel have created many new pathways for the dispersion of species outside their natural ranges. As a result, the frequency with which these threats have been introduced has increased significantly with globalization. Increased international trade in ornamental plants is particularly concerning because many of the invasive plant species in the U.S. were originally imported as ornamentals or for medicinal purposes. **Dunstable residents at the CRB workshop expressed concern about both Japanese knotweed and bittersweet. They also noted that the new jumping worm is having severe impacts on soil quality. Residents stated that recently they were seeing an impact to wooded areas in Dunstable due to non-native species.**

4.9.5. | Probability of Future Hazard Events, including Due to Climate Change

There are a multitude of factors that can determine the ability of invasive species to survive and propagate. These factors include "temperature, concentration of carbon dioxide in the atmosphere and oceans, frequency and intensity of coastal storm events, habitat disturbances (from storms, flooding, and other weather-related events), changes in seasons due to climate change (e.g., shorter winters, drier summers) and available nutrients. Climate change is already altering these variables, increasing the temperature of the oceans, the frequency and intensity of storms, and the concentration of carbon dioxide in the atmosphere and the oceans." (ResilientMass, 2023).

"Additionally, increased risks to ecosystems from flooding, fire, drought, and heat, are already creating stress to native flora and fauna, making it easier for invasive species to outcompete them. Some research suggests that extreme weather events, which are increasing due to climate change, may lead to increased establishment of invasive species. Extreme events, such as hurricanes, high wind events, and others, can cause damage or mortality for native species and allow invasive species to take over as they are often able to establish more rapidly following a disturbance (North American Invasive Species Management Association, 2022). Other climate change impacts that could increase the severity of the invasive species hazard include the following (Casey, 2021; Finch et al., 2021; North American Invasive Species Management Association, 2022; Sorte, 2014):

- Elevated atmospheric carbon dioxide levels could increase some organisms' photosynthetic rates, improving the competitive advantage of those species.
- Changes in atmospheric conditions, such as changes in temperature and humidity, could decrease the transpiration rates of some plants, increasing the amount of moisture in the underlying soil. Species that could most effectively capitalize on this increase in available water would become more competitive.

- Fossil fuel combustion can result in widespread nitrogen deposition, which tends to favor fast-growing plant species. In some regions, these species are primarily invasive, so continued use of fossil fuels could make conditions more favorable for these species.
- As the growing season shifts to earlier in the year, several invasive species (including garlic mustard, Japanese barberry, glossy and common buckthorn, and Asian bush honeysuckle) have proven more able to capitalize on this by beginning to flower earlier, which allows them to outcompete later-blooming plants for available resources. Species whose flowering times do not respond to elevated temperatures have decreased in abundance.
- Some research has found that forest pests (which tend to be ectotherms, drawing their body heat from environmental sources) will flourish under warming temperatures. As a result, the populations of defoliating insects and bark beetles are likely to increase.
- Warmer winter temperatures also mean that fewer pests will be killed over the winter season, not only allowing populations to grow beyond previous limits, but also allowing southern pests previously limited by winter temperatures to spread north into Massachusetts." (ResilientMass, 2023)

4.9.6. | Vulnerability and Impacts

Invasive species can have far reaching impacts on the town of Dunstable and its surrounding areas. Invasive species can sometimes outcompete native species, resulting in the extinction of local flora or fauna. Invasive species can be direct predators for local flora and fauna. This can disrupt or upset ecosystems. Additionally, invasive species have the potential to spread disease.

Table 4.19: Impacts of Invasive Species on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Increased potential for vector-borne diseases • Invasive species can bring new diseases or aggravate existing health problems
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Japanese knotweed is known to decrease streambank stability and contribute to topsoil erosion which can contribute to flood damage
Systems	Impacts to transportation systems, and electricity and water systems: • Facilities that rely on biodiversity or the health of the surrounding ecosystems such as outdoor recreation areas or agricultural/forestry operations could be vulnerable

Asset Category	Likely Impacts
	• Japanese knotweed is known to decrease streambank stability and contribute to topsoil erosion which can contribute to flood damage
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Die-off of native species that are unable to complete with invasive species • Loss of biodiversity • Loss of ecosystem function • Potential loss of species that were culturally important • Japanese knotweed can contribute to streambank destabilization and erosion
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Increased cost of ongoing control efforts • Economic impact from loss of crops, aquaculture, and public goods such as water quality

4.10. Landslides / Mudflows

4.10.1. | Description

"A landslide or mudflow is the movement of rocks, earth, or debris down a slope (USGS, n.d.-b). The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows (Mabee & Duncan, 2013). Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive water or saturated soils leading to excess pore pressures in the subsurface. In 2013, the Massachusetts Geological Survey and the University of Massachusetts Amherst published a Slope Stability Map of Massachusetts. This project, which was funded by the Federal Emergency Management Agency's Hazard Mitigation Grant Program, was designed to provide statewide mapping and identification of landslide hazards that can provide the public, local governments, and emergency management agencies with the locations of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall. Historical landslide data for the Commonwealth suggest that most landslides are preceded by two or more months of higher-than-normal precipitation, followed by a single, high-intensity rainfall of several inches or more that can cause slopes to become saturated and fail (Mabee & Duncan, 2013).

Landslides associated with slope saturation occur in areas with steep slopes underlain by glacial till or bedrock. Bedrock is impermeable relative to the unconsolidated material that overlies it.

Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, less permeable, un-weathered till and/or bedrock. Water accumulates on this less permeable layer and cannot filter through it, resulting in pore pressure at the interface of the hard and impermeable layer and the soils and unconsolidated material that forms the surface. This interface becomes a plane of weakness and materials above it are at high risk for landslides.

Geologic conditions also contribute to landslide risk. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. These lakes include Bascom, Hitchcock, Nashua, Sudbury, Concord, and Merrimack, among many other smaller glacial lakes in more remote areas of the Commonwealth. The greater Boston area is underlain by the Boston Blue Clay, a glaciomarine clay. The northeastern coast of Massachusetts is underlain by marine clays. When over steepened or exposed in excavations, these vulnerable areas often produce classic rotational landslides.

External forces such as undercutting due to flooding or wave action can initiate landslides. Undercutting of slopes during flooding or coastal storm events is a major cause of property damage. Streams and waves erode the base of the slopes, causing them to over- steepen and eventually collapse. This is particularly problematic in unconsolidated glacial deposits, which cover most of the Commonwealth. This type of failure occurs often along the coasts and rivers in the Commonwealth, for example in Cape Cod, Nantucket, Martha's Vineyard, Scituate, Newbury, the Connecticut River Valley, the Cold River in Savoy, and the Deerfield River.

Another external force can be construction. Construction-related failures occur predominantly in road cuts through glacial till where topsoil has been placed on top of the till. Examples of these failures can be found along the Massachusetts Turnpike. Other construction-related failures occur in utility trenches constructed in areas with very low cohesive strength and an associated a high water table (usually within a few feet of the surface). This situation occurs in sandy deposits with very few fine sediments and can occur in any part of the Commonwealth.

In Massachusetts, landslides tend to be more isolated in size and pose threats to linear systems and networks such as highways, roadways, rail, and utilities. Additionally, due to their location in more remote and less populated areas, structures that support fisheries, tourism, outdoor recreation, rural communities, and interstate transportation infrastructure are often exposed to landslides." (ResilientMass, 2023).

4.10.2. | Location

Landslides and mudflows are most likely to occur in areas of elevation changes or higher slopes. The 2013 slope stability map (see Figure 4.14) categorizes areas of Massachusetts into stability zones, and the categorization is correlated to the probability of instability in each zone. The probability of instability metric indicates how likely each area is to be unstable, based on the parameters used in the analysis (e.g., slope angle, angle of internal friction and cohesion, flow direction, transmissivity/recharge) (Mabee & Duncan, 2013).

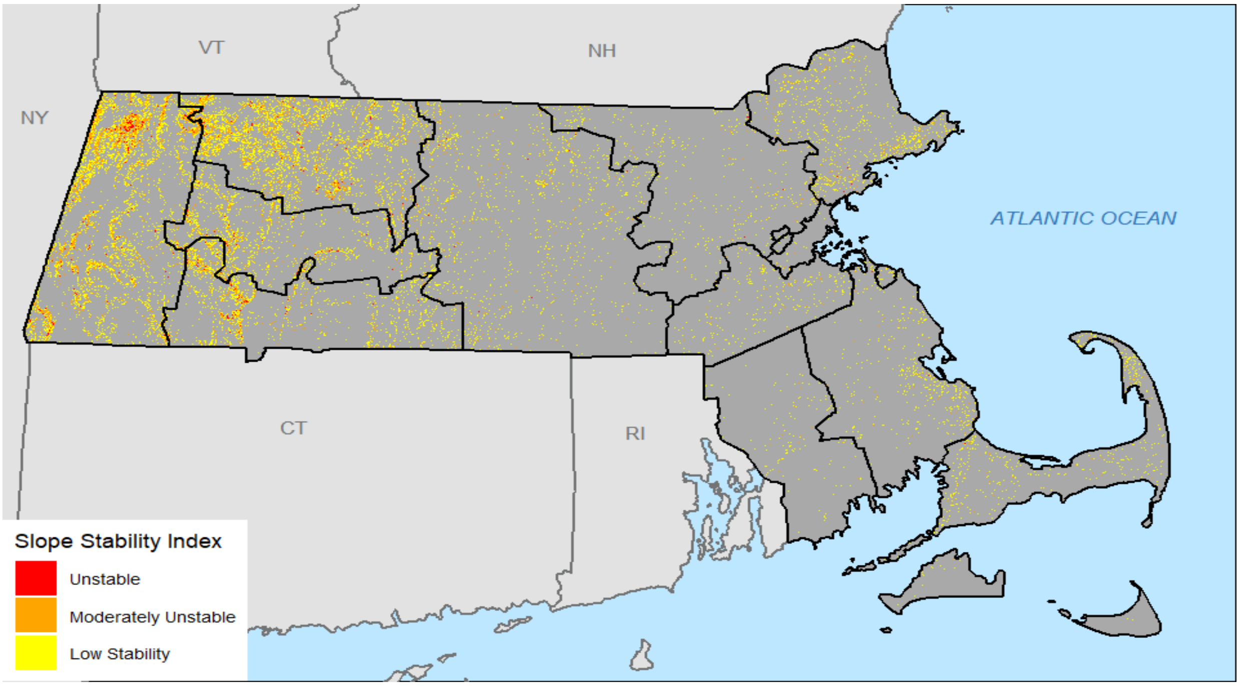

Figure 4.14: Slope Stability Map of Massachusetts

While Dunstable is located in an area not typically associated with high landslide or mudflow risk compared to regions with steeper terrain or more frequent heavy rainfall, there are still factors that could contribute to localized risks. These include areas of town with slopes that are prone to instability, especially those that have been altered by human activities such as construction or landscaping. Soil characteristics such as loose or poorly compacted soils, particularly if they are situated on slopes, can increase vulnerability. Saturated soils have lower stability, and limited vegetation cover can cause erosion and reduce water absorption from the soil.

4.10.3. | Severity/Intensity

"Variables that contribute to the extent of potential landslide activity include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult and data are limited and hard to collect due to limited monitoring instruments and lack of eyewitness accounts. As a result, estimations of the severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides can provide insight on where landslides may occur and what types of damage may result. It is important to note, however, that susceptibility only identifies areas potentially affected and does not imply a timeframe when a landslide might occur. Nor does this process account for how climate change is altering the intensity and frequency of the hazards that increase the risks of landslides. Therefore, it is important not to rely solely on past events, but to also consider the variables and conditions that increase landslide risk and evaluate areas for those factors (ResilientMass, 2023)."

4.10.4. | Previous Occurrences and Frequency

Landslides commonly occur shortly after other major natural disasters, such as extreme precipitation events, wildfire, earthquakes, and floods, which can slow response and recovery efforts, including emergency response, evacuations, debris removal, restoration of services, and stabilization efforts. Many landslide events occur in remote areas and are unobserved or reported, making it difficult to account for the frequency of landslides, the scale of such events, and the geographic range. In general, landslides are most likely during periods of higher-than-average rainfall, with the intensity of the rainfall being an important factor, as well as the health of the soil. Areas that have experienced disturbance due to wildfire, drought, invasive species, recent development, or vegetation or tree removal are more likely to experience landslides.

There are no records of significant landslides or mudflows in Dunstable.

4.10.5. | Probability of Future Hazard Events, including Due to Climate Change

"It is difficult to determine the probability of future occurrences due to a lack of recent data on landslides in the Commonwealth (The 2013 data for landslides in Massachusetts—the most data recent available—are a decade old). Impacts of climate change on the duration and intensity of rainfall events, wildfire, drought, and invasive species will result in an increase in the frequency of landslides and may result in an increase in the areas at risk from landslides. Another factor is the changes in the intensity and type of land uses in areas with high risk for landslides (ResilientMass, 2023)."

4.10.6. | Vulnerability and Impacts

Landslides or mudflows can cause significant damage to trees, structures, roadways, cars, and other built infrastructure. This damage can result in blocked transportation routes, road closures, general disruption to daily life, and costly repairs.

Table 4.20: Impacts of Landslides/Mudflows on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death or Injury • Loss of property
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Collapse of buildings or other damage • Damage to critical infrastructure
Systems	Impacts to transportation systems, and electricity and water systems: • Blocked or damaged roadways or bridges

	• Potential to impact utility services such as power, water, or gas lines • Road closures
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Increased erosion
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Cancellation of community events • Possible business or school closures

4.11. Other Severe Weather

4.11.1. | Description

Other severe weather refers to conditions such as high winds, thunderstorms, lightning, thunder, hail, tropical storms, and extreme precipitation events. The ResilientMass Plan defines these conditions below:

High Winds

"Wind advisory events are defined by the National Weather Service (NWS) as sustained winds of 31 to 39 miles per hour for at least one hour or any gusts of 46 to 57 miles per hour over land. Wind advisories pose a moderate threat to life and property and the NWS recommends securing objects that are outdoors and taking caution when driving in wind advisories. High winds are sustained winds of over 40 miles per hour or any gusts of over 58 miles per hour and pose a high threat to life and property. The NWS recommends reducing driving speeds and seeking shelter during high winds. Over water, the NWS issues a small craft advisory for sustained winds of 25 to 33 knots, a gale warning for sustained winds of 34 to 47 knots, a storm warning for sustained winds of 48 to 63 knots, or a hurricane-force wind warning for sustained winds of 64 knots or more.

For tropical systems, the NWS issues a tropical storm warning for any inland or coastal areas expecting sustained winds of 39 to 73 miles per hour. NWS issues a hurricane warning for any coastal or inland areas expecting sustained winds of 74 miles per hour. High winds can cause downed trees and/or power lines; damage to communication infrastructure; and damage or loss to buildings, particularly roofs, windows, outbuildings, and structures and utilities on roofs or outside of buildings. High winds can also damage unanchored structures such as mobile homes, carports, awnings, trampolines, and debris that is not properly stored, including hazardous waste and toxic materials. High wind events can disrupt transportation services, resulting in air travel delays, cancellation of ferry service, closed roadways due to debris and downed power lines, and transit service delays. High winds also pose unique risks to outdoor workers and often result in power outages, transportation delays, and communication disruptions due to downed trees and power lines. High winds are also a hazard for the maritime, shipping, and aviation industry sectors." (ResilientMass, 2023)

Thunderstorms

"Thunderstorms include heavy rains, strong winds, lightning, thunder, and sometimes hail and tornadoes. A thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 miles per hour (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, n.d.). Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. As warm surface air rises, it transfers heat from the surface of the Earth to the upper levels of the atmosphere (i.e., the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets; both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder. An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms.

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage similar to that of a tornado. A small (less than 2.5-mile path) downburst is known as a "microburst" and a larger downburst is called a "macroburst." An organized, fast-moving line of microbursts traveling across large areas is known as a "derecho;" these occasionally occur in Massachusetts. Winds exceeding 100 miles per hour have been measured from downbursts in Massachusetts." (ResilientMass, 2023)

Extreme Precipitation

"Extreme precipitation generally refers to events of rainfall or snowfall that substantially exceeds what is normal in an area. In Massachusetts, extreme precipitation is often defined or measured as an accumulation of rain or snow of 2 or more inches within 24 hours (Commonwealth of Massachusetts, 2018; Runkle et al., 2022). Heavy precipitation events occur when an air mass holding significant amounts of moisture moves over land or converges into a storm system. Extreme precipitation events do not mean that total precipitation in an area has increased—it only refers to more intense events occurring over a shorter duration. Climate change is expected to increase the intensity and frequency of extreme precipitation. The impacts of these events include crop damage, soil erosion, and increased flood risk." (ResilientMass, 2023)

4.11.2. | Location

Severe weather can impact all of Dunstable, but there are factors that create increased vulnerability. Areas of Dunstable that are more exposed or have fewer natural windbreaks, such as hills, ridges, or open fields, may experience stronger winds. Additionally, areas with sparse vegetation or where trees have been removed posed an increased risk of impacts from high winds.

Locations near large bodies of water, such as rivers or lakes, can experience increased wind speeds due to unobstructed airflow across the water surface. Bodies of water can also increase the risk of thunderstorms, as the water bodies contribute moisture to the atmosphere, enhancing instability and providing a source of energy for thunderstorms to develop.

Extreme precipitation events can occur in the entirety of Dunstable, but there are various conditions that can increase the likeliness of their occurrence. These include topography, where areas with steeper slopes or valleys may experience more localized heavy rainfall. Low lying areas and locations with inadequate drainage are at a higher risk of flooding from extreme precipitation.

The types of severe weather outlined in this section oftentimes occur simultaneously, with one bringing on the other. Certain weather conditions, such as thunderstorms, nor'easters, or tropical cyclones, can bring strong winds and precipitation to the region.

4.11.3. | Severity/Intensity

High Winds

"Massachusetts is susceptible to high winds from several types of weather events: straight- line winds, before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Straight-line winds are often the result of a thunderstorm downdraft but can be caused by several other meteorological processes. Straight-line winds are defined as winds exceeding 50 to 60 miles per hour and can reach up to 100 miles per hour and cover hundreds of miles (FEMA, 2021). Sometimes, wind gusts of only 40 to 45 miles per hour can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall since both can weaken root systems and make trees more susceptible to the wind's effects. Winds measuring less than 30 miles per hour are not considered to be hazardous under most circumstances (ResilientMass, 2023)."

Figure 4.15 presents a map of wind speeds in the United States. Dunstable is in tornado Zone II, which corresponds with a moderate risk of high winds but low risk of tornadoes. It is also located in a hurricane-prone region, which represents high risk for hurricanes and other high wind events. High wind events not associated with hurricanes or nor'easters often have localized impacts.

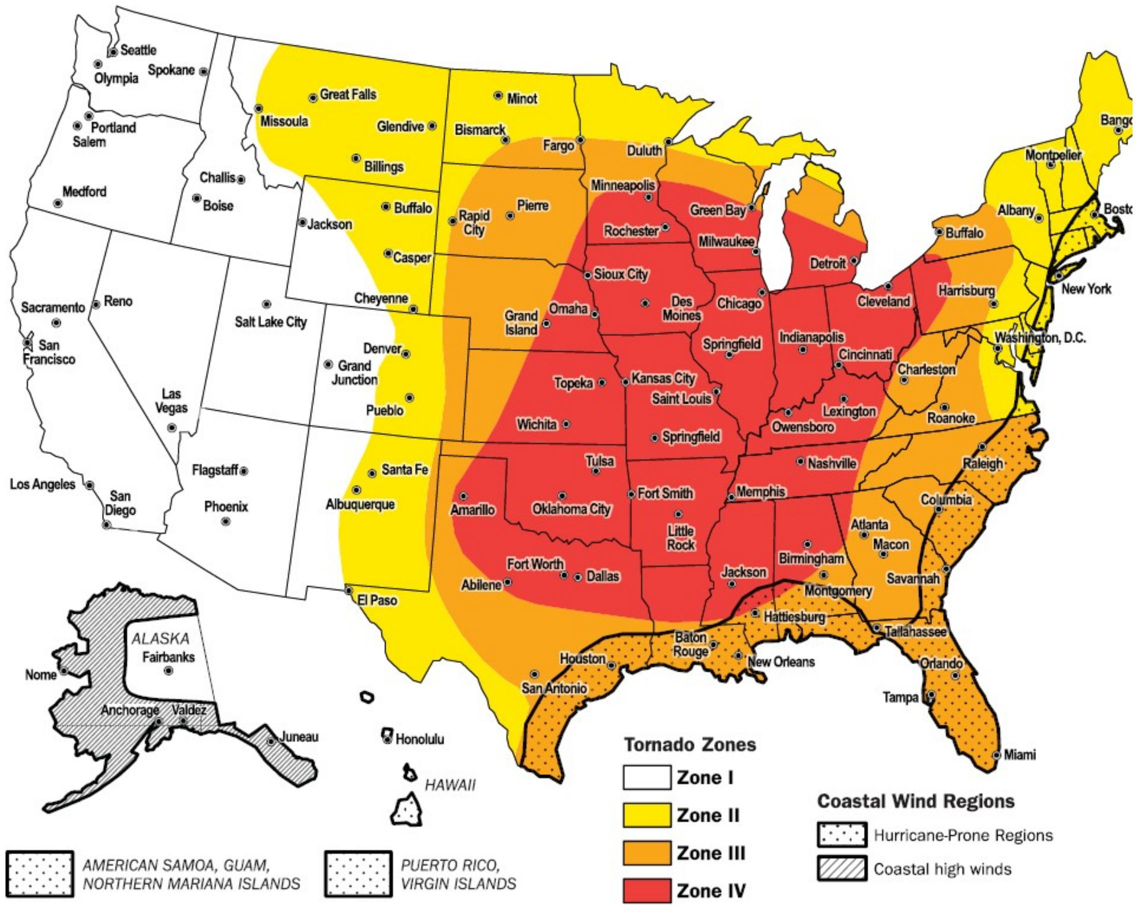

Figure 4.15: Wind Hazards in the United States

Thunderstorms

"The severity of thunderstorms can vary widely, from short-term, localized events to large- scale storms that result in major consequences, including flooding and direct damage to people, buildings, and ecosystems throughout a region. Widespread flooding is the most common characteristic that leads to a storm being declared a disaster in Massachusetts. The severity of flooding varies widely based on characteristics of the storm and the region in which it occurs. Lightning can also present a high magnitude of consequence to humans (ResilientMass, 2023)."

Extreme Precipitation

Extreme precipitation events in Dunstable, Massachusetts, can occur under various weather conditions and can have significant impacts on the town and its residents. These events are characterized by unusually high rainfall amounts over short durations, leading to localized flooding, property damage, and disruption of infrastructure.

Extreme precipitation events in Dunstable typically occur during periods of intense weather systems, such as severe thunderstorms, tropical storms, or nor'easters. These events can happen throughout the year but are more common during the warmer months, particularly in the spring and summer when atmospheric instability is higher. These events can produce heavy rainfall rates, often exceeding the capacity of natural drainage systems and stormwater infrastructure to handle runoff. Rainfall amounts during these events can vary widely but may reach several includes within a short period, leading to flash flooding and rapid rises in water levels.

4.11.4. | Previous Occurrences and Frequency

Since the previous Hazard Mitigation Plan in 2015, there have been 149 days where Middlesex County has experienced either strong wind, high wind, or thunderstorm wind (NOAA StormEvents Database, 2024). In total, these 149 events caused 3.071 million dollars in damage in Middlesex County (NOAA StormEvents Database, 2024). In 2021, there was one fatality in the Northwest part of the County due to a falling tree during one of these storm events (NOAA StormEvents Database, 2024). Since 2015, there have been 11 injuries caused by severe weather in Middlesex County (NOAA StormEvents Database, 2024). Severe weather occurs fairly frequently in Dunstable.

4.11.5. | Probability of Future Hazard Events, including Due to Climate Change

High Winds

"Climate models and projections do not always model changes in winds, and some climate scientists have found uncertainties in long-term wind trends (Schauffler, 2021). However, global wind speeds on average have increased since 2010 and buoy data off the Gulf of Maine has tracked an increase in monthly average wind speeds (Zeng et al., 2019).

Massachusetts is highly likely to continue experiencing high wind events based on previous occurrences. Though the effect of climate change on high winds is not certain, based on recent data, it appears likely that high wind events will increase because of more frequent severe weather events in the future." (ResilientMass, 2023)

Thunderstorms

"Massachusetts experiences between nine and 27 thunderstorm days each year. Based on previous occurrences, Massachusetts is highly likely to continue experiencing thunderstorms. Data for Massachusetts from the Localized Constructed Analogs' downscaled global climate models supports the trend of slightly increased frequency. Based on these projections the probability of future thunderstorm events is anticipated to increase. Two key factors lead to the formation of thunderstorms: convective available potential energy (CAPE) and strong wind shear. Climate change is expected to increase CAPE while decreasing wind shear in mid-latitudes. Modeling suggests that CAPE will increase enough to overwhelm the small decrease in wind shear, leading to more favorable conditions for thunderstorms in the eastern United States (NASA Earth Observatory, 2013).

CAPE and thunderstorm precipitation rates can be used to predict lightning strikes. Climate change is very likely to increase lightning strikes over the contiguous United states by about 50 percent over the next century. Modeling using a 1990–2020 baseline predicts lightning strikes to increase in every Massachusetts county by at least 40 percent by 2030 and by over 100 percent in 2070 (Romps et al., 2014)." (ResilientMass, 2023)

Extreme Precipitation

"Scientists expect that there will be more rain overall in Massachusetts. The amount of annual precipitation and intensity of precipitation is likely to increase, and this increase is expected to occur in most years. The patterns emerge as higher temperatures are anticipated to increase the moisture-holding capacity of the atmosphere. The days of rainfall, however, are likely to be more variable and reduce overall, implying that on days when it does rain, there will be more moisture. The Massachusetts Climate and Hydrologic Risk Project supports the trend of a slightly increased frequency of high-intensity rainfall events, defined here as a day with more than 2 inches of precipitation. Table 4.21 shows modeling results for the planning horizons identified in this plan (2030, 2050, 2070, and 2090) for the increase in days with more than 1 inch of rain and more than 2 inches of rain. Extreme precipitation projections by U.S. Geological Survey subbasins indicate that the coast will experience the greatest number of high-intensity rainfall days, but increased precipitation will occur in every region of the Commonwealth." (ResilientMass, 2023)

Table 4.21: Projected Frequency of Future Annual Extreme Precipitation Events in Massachusetts

	2030	2050	2070	2090
Number of days >1" precipitation	2.7–7.3	3.1–8.0	3.7–8.7	4.0–9.2
Number of days >2" precipitation	0.2–1.0	0.2–1.2	0.3–1.4	0.4–1.5

Note: This table was developed with information in the Massachusetts Climate and Hydrologic Risk Project (Phase 1) Stochastic Weather Generator Climate Projections

Source: Massachusetts Executive Office of Energy and Environmental Affairs (2023).

4.11.6. | Vulnerability and Impacts

Severe storms, high winds, and heavy precipitation can have a wide range of effects on people, structures, systems, and resources. First and foremost, in the absence of proper shelter, people are subject to serious injury or even death from hail, lightning, and high winds. Thunderstorms can cause power outages, which can disrupt daily life and impact essential services. They can also cause damage to electrical infrastructure, such as power lines, transformers, and substations. Severe thunderstorms can also strain public safety resources, including emergency services, law enforcement, and medical facilities. They can also cause wildfires from lightning strikes. High winds have the capability of blowing down tree limbs and creating flying debris that can injure people or block roads.

CRB attendees clarified that a big concern locally is trees coming down and power lines being destroyed.

A resident who provided input via the public survey reminded that no power often means no water.

Table 4.22: Impacts of Severe Weather on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death and injury • Mental health impacts such as anxiety and PTSD • Displacement
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Falling objects, trees, or debris can damage buildings or critical infrastructure • Fallen power lines • High winds and hail can damage buildings or infrastructure
Systems	Impacts to transportation systems, and electricity and water systems: • Airport closures • Electrical infrastructure damage • Communications disruptions from damage to telecommunications infrastructure • Power outages • Transportation disruptions from heavy rain, strong winds, or flooding • Severe storms can overwhelm water treatment plants and wastewater facilities leading to contamination and water supply disruptions
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Flash floods or riverine flooding • Potential for wildfire due to lightning strikes • Potential for tornadoes to form
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Severe storms may cause business closures • Cancellations of community or sporting events

4.12. Severe Winter Storms

4.12.1. | Description

"Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation. Severe winter storms are a type of extratropical cyclone, which are formed when a cold mass of air meets with a warm mass of air and creates a front. Extratropical cyclones have cold air at their core and can be accompanied by either weak or strong winds.

Blizzards: A blizzard is a winter snowstorm with sustained or frequent wind gusts of up to 35 miles per hour or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile (NWS, n.d.-a). These conditions must be the predominant characteristics over a three-hour period to classify as a blizzard. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of the definition. Although extremely cold temperatures are not necessary, the likelihood of a blizzard occurring increases significantly with temperatures below 20ºF. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 miles per hour, and visibility reduced by snow to near zero.

Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions due to the blowing snow. Blowing snow is wind-driven snow that reduces visibility to 6 miles or less, causing significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground picked up by the wind.

Ice Storms: Freezing rain is defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups. While even a trace of ice can cause significant impacts, an ice storm, by the National Weather Service's definition, is a half inch of ice accretion across any location. Lesser icing events can be incorporated into either Winter Storm Warnings or Winter Weather Advisories, whenever icy conditions may lead to dangerous walking or driving conditions or can result in damage to power lines and trees.

Ice pellets are another form of freezing precipitation, formed when snowflakes fall through a shallow warmer layer of air above the surface. As they fall through the warm layer, they melt. Sleet is the result of those raindrops refreezing back into snow before they reach the surface. As a result, the observed precipitation mimics a pellet of ice. The difference between sleet and hail is that sleet is a wintertime phenomenon, whereas hail falls from convective clouds (usually thunderstorms), and often occurs during the warmer spring and summer months.

Nor'easters: A nor'easter is a storm that occurs along the East Coast of North America with winds from the northeast (NWS, n.d.-b). A nor'easter is characterized by a large counterclockwise wind circulation around a low-pressure center that often results in heavy snow or rain and high winds. A nor'easter gets its name from its continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas.

Nor'easters can occur at any time of year, though they most often occur between September and April (NWS, n.d.-b). These weather events produce heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and damage to coastal infrastructure, buildings, and habitats. More detail on the risks associated with Coastal Erosion (Section 5.4) and Coastal Flooding (Section 5.5) is available. These storms occur most often in late fall and early winter. The storm radius of a nor'easter is often as much as 100 miles across, and nor'easters can last between 12 hours and 3 days, affecting multiple tide cycles and causing extended heavy precipitation in an area. Sustained wind speeds of 20 to 40 miles per hour are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 miles per hour. Nor'easters are commonly accompanied by a storm surge equal to or greater than 2 feet.

Nor'easters begin as strong areas of low pressure either in the Gulf of Mexico or off the East Coast in the Atlantic Ocean. The low-pressure system will move either up the East Coast, into New England and the Atlantic provinces of Canada, or out to sea. A strong hurricane often causes more severe damage than a nor'easter, but historically Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (one to two per year, on average). Nor'easters can directly affect Massachusetts for a longer period than tropical storms and hurricanes—the duration of high storm surge and winds in a hurricane range from six to 12 hours, while a nor'easter can last much longer." (ResilientMass, 2023).

4.12.2. | Location

The entire town of Dunstable is at risk from the hazard of severe winter storms. "Nor'easters can bring heavy snow, which can paralyze inland cities or regions, limiting or eliminating access to some areas and disrupting power and communications. Inland areas, especially those in floodplains, low-lying areas, or development areas on historic wetlands, are at risk for flooding. Wind damage can occur throughout the Commonwealth." (ResilientMass, 2023) Factors such as elevation, vegetation cover, and proximity to infrastructure and transportation networks can influence the severity of impacts in Dunstable.

4.12.3. | Severity/Intensity

"Snowfall is a component of multiple hazards, including nor'easters and other severe winter storms. Since 2005, the Regional Snowfall Index (RSI) has become the descriptor of choice for measuring winter events that affect the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale from 1 to 5, as shown in Table 4.23. It is like the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and the population affected (NOAA NCEI, n.d.).

The RSI is a regional index. Each of the six climate regions in the eastern two-thirds of the nation (as identified by the NOAA National Centers for Environmental Information) has a separate index, calculated according to region-specific parameters and thresholds. The RSI is important because, with it, a storm event and its societal impacts can be assessed in the context of a region's historical events. Snowfall thresholds in Massachusetts (in the Northeast region) are 4, 10, 20, and 30 inches of snowfall, while thresholds in the Southeast U.S. are 2, 5, 10, and 15 inches. Based on the RSI, the number of high-impact snowstorms (categorized as "notable" or higher) occurred at a rate of almost three per year over the last 50 years, although there is significant interannual variability in the frequency and severity of winter storms (ResilientMass, 2023)."

Table 4.23: Regional Snowfall Index Categories, Corresponding RSI Values, and Description

Category	RSI Value	Northeast Threshold	Description	Number of Events in New England (1973–2022)
1	1–3	Less than 4 inches	Notable	75
2	3–6	4–10 inches	Significant	23
3	6–10	10–20 inches	Major	7
4	10–18	20–30 inches	Crippling	4
5	18.0+	30+ inches	Extreme	3

Source: National Centers for Environmental Information (n.d.).

4.12.4. | Previous Occurrences and Frequency

Middlesex County, which includes Dunstable, experienced 35 days of severe winter weather since the previous hazard mitigation plan update. A complete list of winter weather events is presented in Table 4.24 below. The combined property damage from these winter events totaled $464,900.

Attendees of the CRB workshop noted that the largest two storms in memory were the Storm in 2008 and the Halloween Storm in 2009. The power was out for almost a week for many residents in town.

A respondent to the public survey noted another severe winter storm in early 2013, where 3 feet of snow fell.

A respondent to the public survey shared that there were big ice storms around 2010 / 2011 and that was when the electricity was out the longest this resident had ever experienced.

Table 4.24: Winter Weather Events in Dunstable

Date of Occurrence	Type of Hazard
1/18/2015	Winter Weather
2/5/2015	Winter Weather
2/21/2015	Winter Weather
3/1/2015	Winter Weather
12/29/2015	Winter Weather
1/23/2016	Winter Weather
2/8/2016	Winter Weather
3/21/2016	Winter Weather
4/3/2016	Winter Weather
4/4/2016	Winter Weather
12/17/2016	Winter Storm
1/7/2017	Winter Storm
2/8/2017	Winter Weather
2/9/2017	Winter Storm
2/12/2017	Winter Storm
12/9/2017	Winter Storm
12/22/2017	Winter Weather
12/23/2017	Winter Weather
12/25/2017	Winter Weather
1/4/2018	Winter Storm
1/23/2018	Winter Weather
2/7/2018	Winter Weather
2/17/2018	Winter Storm
3/7/2018	Winter Storm
3/13/2018	Winter Storm
12/28/2018	Winter Weather

Date of Occurrence	Type of Hazard
1/19/2019	Winter Storm
2/13/2019	Winter Weather
3/3/2019	Winter Storm
12/30/2019	Winter Weather
4/18/2020	Winter Weather
10/30/2020	Winter Weather
2/1/2021	Winter Storm
1/28/2022	Winter Storm
12/16/2022	Winter Weather

4.12.5. | Probability of Future Hazard Events, including Due to Climate Change

"Massachusetts already experiences notable winter weather events and nor'easters every year. Therefore, it is virtually certain Massachusetts will continue to experience severe winter storms at least annually. However, it is unclear how much the frequency of these storms will change in Massachusetts over the next few decades due to climate change. Extreme weather events—including extreme precipitation events—are anticipated to occur more often as climate change occurs. Rising temperatures mean that more of this precipitation is likely to fall as rain rather than snow, However, there has been little information on the climate trends of extratropical cyclones such as nor'easters. The Greater Boston Research Advisory Group found little evidence to indicate that nor'easters and other extratropical storms will change in frequency in the region (Douglas & Kirshen, 2022).

However, historical data show that the frequency of extreme snowstorms in the U.S. doubled between the first half of the 20th century and the second. As temperatures throughout the year increase, it is possible that nor'easter events may become more concentrated in the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain. Whether events are classified as nor'easters or not, storm surge impacts from all winter storms are likely to increase significantly because of sea level rise and coastal erosion.

While evidence for the frequency is not clear, climate change is likely to increase the intensity of winter storms. Increased sea surface temperature in the Atlantic Ocean due to climate change will cause air moving north over the ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of precipitation than normal can be anticipated to fall on Massachusetts. Although no one storm can be linked directly to climate change, the severity of rain and snow events has increased dramatically in recent years. As shown in Figure 4.16, the amount of precipitation released by the heaviest storms in the Northeast has increased by 55 percent since 1958 (U.S. Global Change Research Program, 2018). Other research has found that increasing water temperatures and reduced sea ice extent in the Arctic are changing atmospheric circulation patterns that favor the development of winter storms in the eastern U.S. by sending more cold air to the Eastern Seaboard (Rawlins, 2022) (ResilientMass, 2023)."

Attendees of the CRB workshop noted ice storms are becoming a bigger concern – there are more freezing rains than there used to be.

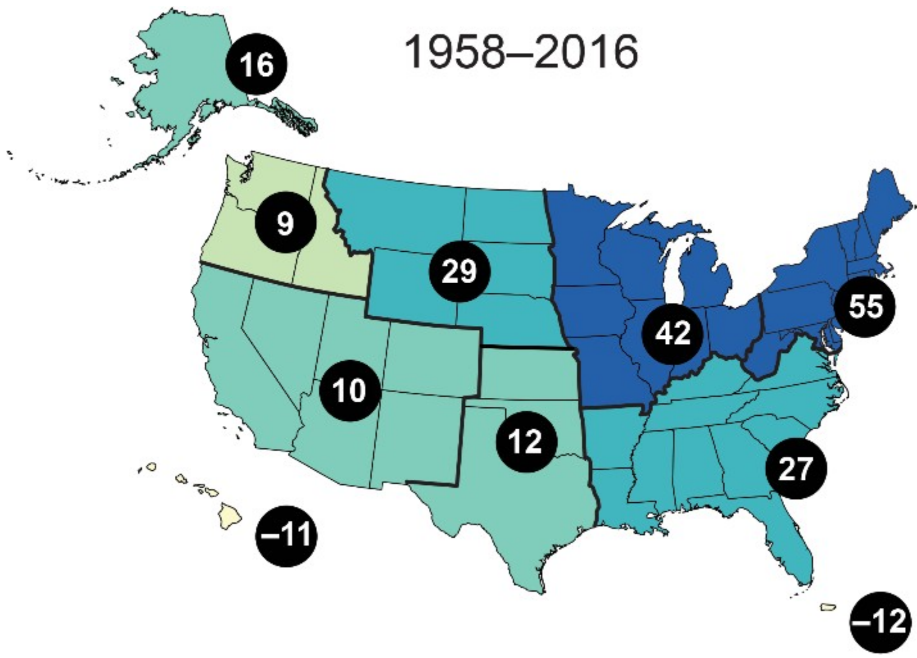

Figure 4.16: Map of observed changes in heavy precipitation.

4.12.6. | Vulnerability and Impacts

Severe winter weather has the potential to paralyze the entire town. Heavy snow and ice can yield dangerous travel conditions and result in public transportation closures. Prolonged closures of roads and public transportation systems can inhibit the delivery of critical services or the ability to obtain vital resources. Heavy snow has the capacity to cause power outages or frozen pipes. Extended power outages, the cost of snow removal, and repairing damages can have severe economic impacts on smaller communities. The elderly and the sick are populations of particular concern during these events. While there are no senior housing or medical facilities within Dunstable, most residents are on private wells and have no access to drinking water during a power outage (2015 Hazard Mitigation Plan for the Northern Middlesex Region).

Winter storms were one of the highest priority hazards according to the public survey. **Residents in Dunstable expressed concern at the CRB workshop about the increased frequency of freezing rains. While many residents have generators,**

attendees recalled there have been recent storms that caused power outages of over a week in length across Dunstable. The community relies on National Grid to restore power, but due to its low density and lack of regional critical facilities, Dunstable is often delayed in getting power restored. As a result, many residents stated that they had their own generators. Residents also noted how quickly the community comes together to assist with snow removal for the elderly and infirmed.

A resident who took the public survey reminded that no power often means no water.

Table 4.25: Impacts of Severe Winter Storms on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death and injury • Increased instances of frostbite and hypothermia • Stranded or isolated communities
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Heavy snow loads may cause roof collapse • Increased heating demands • Frozen pipes
Systems	Impacts to transportation systems, and electricity and water systems: • Power outages • Transportation disruptions due to low visibility, icy road conditions, or heavy snow • Communications disruptions from damaged infrastructure due to ice and freezing rain • Water supply interruptions caused by frozen pipes that burst
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Historic buildings may not be capable of handling snow loads and may be more susceptible to roof collapse • Flooding may occur after rapid melting of snow • Chemicals used to treat roadways may contaminate natural environments and water bodies if used in large quantities
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being:

Asset Category	Likely Impacts
	• Increased heating costs • Disruption of essential services • Reduced economic activity • Expensive response and recovery costs • School closures

4.13. Tornadoes

4.13.1. | Description

"A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The observable aspect of a tornado is the rotating column of water droplets, which captures dust and debris in the column. Tornadoes are the most violent of all atmospheric storms. Tornadoes are measured on the Enhanced Fujita (EF) scale, which ranges from EF0 (light damage) with three-second gust wind speeds of 65–84 miles per hour, to EF5 (incredible damage) with three-second guest wind speeds of over 200 miles per hour. Tornadoes tend to form when cold, dry air clashes with warm, humid air.

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 (i.e., from southeast at the surface to west aloft)
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e., 20 miles per hour at the surface and 50 miles per hour at 7,000 feet)
- Very warm, moist air near the ground, with unusually cool air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

Tornadoes can form along severe thunderstorm squall lines, from individual supercell thunderstorms, or from tropical cyclones. Most tornadoes occur in the late afternoon and evening hours when the temperatures are the highest. The most common months for tornadoes to occur in Massachusetts are June, July, and August, although the 1995 Great Barrington, Massachusetts, tornado occurred in May, and the 1979 Windsor Locks, Connecticut, tornado occurred in October.

A tornadic waterspout is a rapidly rotating column of air extending from the cloud base (typically a cumulonimbus thunderstorm) to a water surface, such as a bay or the ocean. They can be formed in the same way as regular tornadoes. Tornadic waterspouts can have wind speeds of 60 to 100 miles per hour, but since they do not move very far, vessels can often navigate around them. They can become a threat to land if they move onshore." (ResilientMass, 2023)

4.13.2. | Location

Dunstable, like much of the Commonwealth, is not located in a region known for frequent tornado activity. However, there is still the possibility of a tornado occurring in Dunstable. In general, tornadoes can develop anywhere, but they are most likely to occur in areas with certain characteristics. Areas with flat terrain are more conducive to tornadoes. Tornadoes often form along or near weather fronts. Dunstable experiences a variety of weather conditions; thus it is possible that the town many be affected by weather systems that produce tornadoes, particularly during the spring and summer months. Additionally, low-lying areas have a higher risk of tornado formation than areas with higher elevations or steep slopes.

4.13.3. | Severity/Intensity

"Tornadoes are among the most dangerous of local storms. If a major tornado were to strike in a populated area of the Commonwealth, damage would be significant. Fatalities could be high, many people would be displaced for an extended period of time, buildings would be damaged or destroyed, and businesses would suffer damage and loss.

Additionally, utilities and infrastructure, particularly communications, energy, and rail infrastructure, could experience significant damage, disruption, and a long period of recovery of physical assets and functions, leaving people without critical services. Massachusetts ranks 35th among the states for frequency of tornadoes, 14th for frequency of tornadoes per square mile, 21st for injuries, and 12th for cost of damage.

The National Weather Service rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives three-second gusts estimated at the point of damage based on the assignment of one out of eight degrees of damage to a range of different structure types. These estimates vary with the height of a damaged structure (damage above the ground) and exposure of the event. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity after an event (ResilientMass, 2023)."

Table 4.26: Fujita Scale

EF-Scale	Class	Wind Speed (Mph)	Description
EF-0	Weak	65-85	Gale
EF-1	Weak	86-110	Moderate
EF-2	Strong	111-135	Significant
EF-3	Strong	136-165	Severe
EF-4	Violent	166-200	Devastating
EF-5	Violent	>200	Incredible

4.13.4. | Previous Occurrences and Frequency

The United States experiences an average of about 1,000 tornadoes per year; in 2021, there were 1,376 tornadoes across the country (Insurance Information Institute, 2022). Because Massachusetts experiences far fewer tornadoes than other parts of the country, residents may be less prepared to react to a tornado. There have been no tornadoes reported in Dunstable since the last Hazard Mitigation Plan update.

While the number of tornadoes is small in Massachusetts compared to other areas of the country, the Commonwealth experiences between two to five tornadoes per year and past tornadoes have caused significant damage. Given these factors, the likelihood that a tornado event will occur within the Commonwealth is high. However, given the challenge of identifying specific parts of Massachusetts that are more at risk from tornadoes, mitigation measures to reduce the risk of high winds that tornadoes and other extreme weather events generate should focus on the assets and populations most at risk, such as mobile homes and other manufactured buildings; people with characteristics that make them most at risk from tornadoes; and lifeline infrastructure, including utilities, infrastructure, and critical assets such as hospitals and schools. Removing debris, storing hazardous waste and materials, and removing or enclosing critical equipment and assets located on roofs or outside of structures can make a significant difference in reducing the damage from tornadoes and other high-wind events.

Attendees of the CRB workshop did not recall a tornado occurring in Dunstable, but did recall a microburst that skirted through Dunstable in 2021 or 2022.

A respondent to the public survey noted that the tornado warning in late 2023 was concerning.

While there have been no tornadoes recorded in Dunstable, there have been two tornados that passed through Middlesex County since the previous hazard mitigation plan update. The first tornado was an EF-1 that occurred on August 22, 2016 in Concord. The second tornado was an EF-0 that occurred on August 23, 2021 In Marlborough and Stow. The combined damage from these two tornadoes totaled 1.01 million dollars. (NOAA Storm Events Database, 2023)

4.13.5. | Probability of Future Hazard Events, including Due to Climate Change

“Current climate models predict an increase in severe thunderstorms, which have the potential to produce tornadoes. However, it is unclear if tornado frequency will increase with climate change. Some studies suggest there will be a decrease in the number of tornado days, but an increase in the number of tornadoes per day. Given that less than 10 percent of severe thunderstorms produce tornadoes, it is difficult to draw firm conclusions about the processes leading up to a tornado and how these processes might be influenced by climate change (Treisman, 2021). Additionally, given that the tornado record only dates to 1950 in the United States and varies significantly from year to year, it is difficult to identify long-term trends.” (ResilientMass, 2023)

4.13.6. | Vulnerability and Impacts

Tornadoes can cause severe injury or even death. Tornadoes can destroy homes, businesses, and other structures, leaving people without shelter and their possessions destroyed or lost. Tornadoes can also cause economic impacts, such as lost wages, business interruption, and increased insurance premiums. Infrastructure such as power lines, communication towers, water mains, and gas mains are vulnerable to tornadoes. Damage to such infrastructure can cause power outages, disruptions to communication, and water contamination. Tornadoes can also disrupt transportation systems, including roads, railways, and airports, by blocking them with debris, making them impassable or unsafe to use.

Table 4.27: Impacts of Tornadoes on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death or injury • Flying debris can cause death or injury • Mental health impacts such as anxiety or PTSD • Displacement
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Damage to buildings and infrastructure from high winds and flying debris • Critical facility damage • Power outages
Systems	Impacts to transportation systems, and electricity and water systems: • Damage to roadways, bridges, and other transportation infrastructure can disrupt daily travel • Damage to telecommunications infrastructure can disrupt communications • Downed power lines can cause power outages • Damage to water treatment plants, pump stations, or water distribution systems can lead to a loss of clean drinking water and sanitation services
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Uprooting or damaging trees • Destroyed vegetation or altered landscapes • Downed utility lines can cause wildfires

Asset Category	Likely Impacts
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Decreased economic activity • Business closures • School closures

4.14. Wildfires

4.14.1. | Description

"A wildfire is an uncontrolled, unplanned fire that spreads through natural or unnatural vegetation. Severe wildfires have the potential to threaten lives and property and can cause smoke-related accidents and illnesses. Fire is a natural process that occurs in the landscape and has helped shape the landscape and maintain the ecological integrity of many natural communities in Massachusetts. However, increased development within the wildland-urban interface (WUI), the legacy of historical fire suppression practices, climate change, and invasive insects, pests, and plants have increased the risks associated with wildfire. Wildfires in Massachusetts are caused by natural events (such as lightning) and human activity. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes. Fast-moving fires typically occur from March to June. Deep-burning duff fires can occur in the drier months of June through November. April is historically the month in which wildfire danger is the highest. However, drought, snowpack level, and local weather conditions can impact the timing and length of the fire season." (ResilientMass, 2023)

4.14.2. | Location

In Dunstable, the risk of wildfires is moderate compared to the Commonwealth of Massachusetts, as seen in Figure 4.17 below. The figure shows wildfire hazard potential on a scale from 1 (low) to 8 (high), with Dunstable in the scale of hazard potential 3-4.

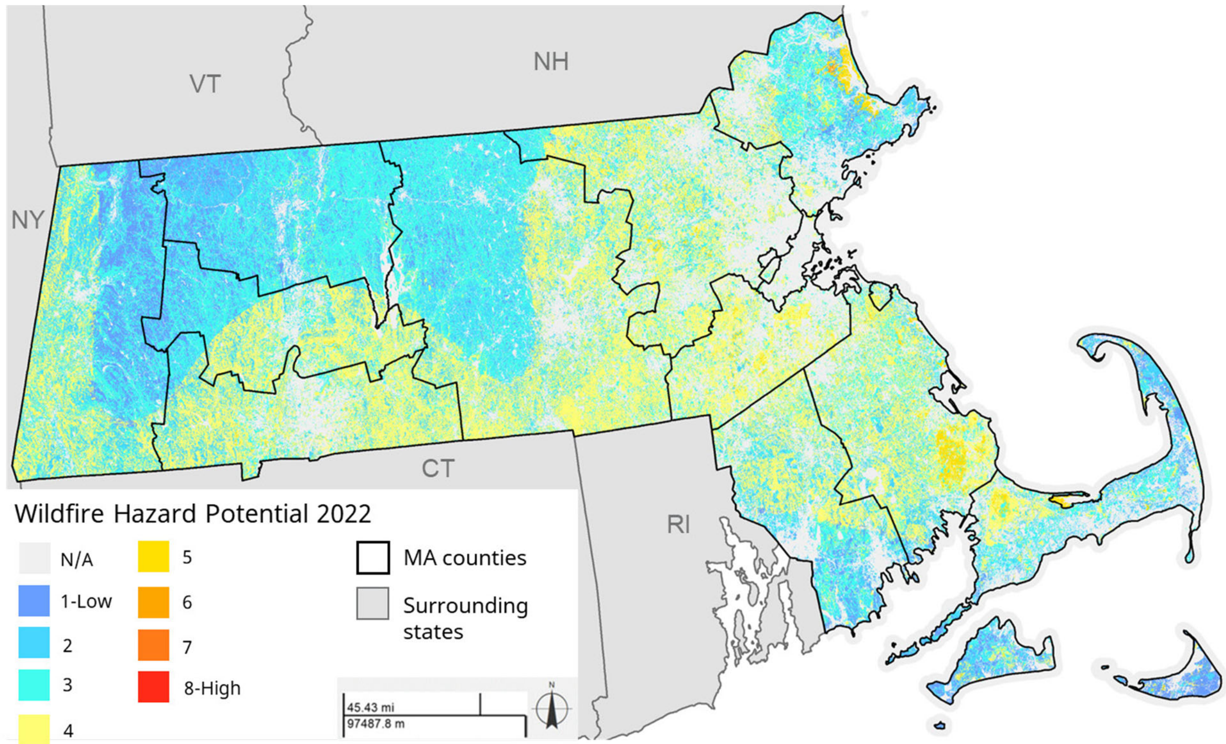

Figure 4.17: Wildfire hazard potential for the Commonwealth of Massachusetts.

Source: Map created by ERG using data from Northeast-Midwest Wildfire Risk Explorer (2022).

There are certain factors that can contribute to the likelihood of wildfires and areas of vulnerability. Portions of Dunstable with dense forests, particularly those with a high concentration of flammable vegetation such as pine or scrub oak, may be more susceptible to wildfires. These areas provide fuel for fires to ignite and spread and also make it difficult for emergency response to access the fire. Open spaces and fields can be vulnerable to fires, especially during periods of drought when the vegetation becomes dry and prone to ignition. Other weather conditions such as dry and windy weather allow wildfires to spread rapidly. Wildfire risk increases near roadways, as they can be started by human activities such as discarded cigarettes and sparks from vehicles.

4.14.3. | Severity/Intensity

"The National Wildfire Coordinating Group defines seven classes of wildfires:

- Class A: 0.25 acre or less
- Class B: more than 0.25 acre, but less than 10 acres
- Class C: 10 acres or more, but less than 100 acres
- Class D: 100 acres or more, but less than 300 acres
- Class E: 300 acres or more, but less than 1,000 acres
- Class F: 1,000 acres or more, but less than 5,000
- Class G: 5,000 acres or more

Unfragmented and heavily forested areas of the Commonwealth are vulnerable to wildfires, particularly during droughts. However, wildfires are part of the history of these forests and are not, by themselves, a risk. Risk is determined by the conditions and context within which the wildfire occurs. Conditions are being influenced by climate change, with droughts, invasive species, and extreme heat all increasing and affecting wildfire risk. The context of surrounding land use also increases the risk. The greatest potential for significant damage to life and property from fire exists in areas designated as WUI areas. A WUI area defines the conditions where development has been placed in or adjacent to wildlands and forestlands. These development areas have been sighted in lands that have burned throughout history. The presence of development within and adjacent to wildlands and forestlands makes managing these lands challenging and significantly increases the risk associated with wildland fires, even those that are historically beneficial and necessary in fire-dependent ecosystems.

Fire intensity is measured by the energy released from the fire as well as characteristics such as flame length. A commonly used measure of fire intensity is fireline intensity, which refers to the rate of heat transfer per unit length of fire (measured in kW m^{-1} or kilowatt meters) and measures the energy released from the flame (Keeley, 2008). Fireline intensity tends to correlate with flame length.

Fire severity is a quantitative measure of the effects of fire on an ecosystem that measures the loss of or change in aboveground and belowground organic matter. Fire severity is described on a spectrum ranging from unburned/low severity to moderate severity and to high severity (Berger et al., 2018). Fire severity measurements can vary depending on the ecosystem in which the fire burns. In forests, fire severity is measured based on canopy loss or tree mortality. In shrublands, where all aboveground biomass is usually burned, the same fire severity measures used in forests are generally not relevant. In these cases, ecosystem indicators of fire severity may include resprouting success and seed bank survivorship (Keeley, 2008) (ResilientMass, 2023)."

4.14.4. | Previous Occurrences and Frequency

Attendees of the CRB workshop noted there was a brush fire in 2022 and shared that there do not appear to be as many brushfires now as there may have been in the 1930s, due to change in landscape in town.

Several notable wildfires have occurred in Massachusetts history, although none has ever resulted in a disaster declaration by the U.S. Federal Emergency Management Agency. Wildfires in the Commonwealth tend to be around five acres. Due to the relatively small size of the incidents compared to larger fires in California and other parts of the West, it can be difficult to consistently track and record these fires since they are not federally declared events. As such, it is difficult to compile a consistent historical record of wildfires for the Commonwealth. In 2017, DCR began working to improve fire reporting data.

Therefore, the most accurate wildfire data for the Commonwealth is available starting for 2017. As of November 28, 2022, 1,027 fires had burned 2,716 acres in 2022. Large fires in Essex County (164 fires burned 603.9 acres total) and Worcester County (153 fires burned at least 446.7 acres total) contributed to 2022 being the largest fire year of the past six years in terms of acres burned (Massachusetts Department of Conservation and Recreation, 2022).

4.14.5. | Probability of Future Hazard Events, including Due to Climate Change

"Precipitation changes, prolonged drought, rising temperatures, and increased frequency of lightning are expected to contribute to increased frequency and severity of wildfire. As droughts become more frequent and severe, forest types that do not usually burn and are not fire adapted will be more likely to burn. Wildfires are projected to increase worldwide by 14% by 2030, 30% by 2050, and 50% by 2100 (ResilientMass, 2023)."

4.14.6. | Vulnerability and Impacts

Wildfires can have extensive and far-reaching impacts. First and foremost, wildfire smoke can contain harmful pollutants that can cause respiratory problems, especially for people with pre-existing conditions like asthma or COPD. Exposure to smoke can also lead to eye irritation, headaches, and other health effects. Wildfires can also cause physical injuries such as burns and can even potentially be fatal. During wildfire events, people may be displaced from their homes due to the need to evacuate. Wildfires can cause severe structural damage to homes and businesses alike, as well as other property. The loss of personal possessions and cherished belongings can have emotional and financial impacts on individuals and families. Wildfires can destroy or damage critical lifelines such as power lines, water treatment facilities, and transportation infrastructure. This can lead to disruptions in basic services such as electricity, clean water, and transportation. Wildfires can cause soil erosion and other changes to the landscape that impact water quality. This can lead to contamination of drinking water supplies. Wildfires can also impact air quality, which can have implications for the health of individuals and for the operation of critical infrastructure such as airports. Lastly, wildfires can decimate natural landscapes as well as local populations of flora and fauna.

Attendees of the CRB workshop shared that access roads are limited into wooded areas, limiting ability to put out brushfires and therefore increasing risk to the community.

Table 4.28: Impacts of Wildfire on Dunstable

Asset Category	Likely Impacts
People	Impacts to people's health, welfare, and safety, including underserved communities and socially vulnerable populations: • Death or injury • Displacement or evacuation

Asset Category	Likely Impacts
	• Loss of property • Mental health impacts such as anxiety or PTSD • Worsening of chronic respiratory illnesses due to smoke and increased particles in the air
Structures	Impacts to buildings, facilities, lifelines, and critical infrastructure: • Burning structures • Charring of exterior surfaces • Damage to roofs, walls, or windows • Heat generated by wildfires can weaken or melt building materials
Systems	Impacts to transportation systems, and electricity and water systems: • Wildfire can damage utility infrastructure, including power lines, gas pipelines, and water lines, leading to disruptions in services • Damage to infrastructure such as roads or bridges can disrupt travel and emergency responses
Natural/Cultural/Historic Resources	Impacts to ecosystems, natural habitats, community areas, historical facilities and locations, and cultural resources: • Wildfires can decimate habitats and harm or displace wildlife • Displacement of wildlife can lead to conflicts with human populations • Post-fire landscapes are vulnerable to colonization by invasive plant species which can outcompete native vegetation and disrupt ecosystem function
Economic and Community Assets	Impacts to people's ability to work and make a living, and impacts to activities that benefit the community by increasing community morale and well-being: • Increased insurance claims • Reduced economic activity in areas affected by wildfire • Need for emergency shelters • Expensive response and recovery costs

4.15. Summary

Table 4.29 provides definitions of hazard location, extent, frequency, and probability. The definitions support the basis of determination in Table 4.30.

Table 4.29: Description of Natural Hazard Risks for the Town of Dunstable

Points	Description
Hazard Extent (Severity/Intensity)	
Minor	Limited damages to property, no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., one or two neighborhoods); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.
Serious	Scattered major property damage (more than 10% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services briefly interrupted up to 1 day; some minor injuries.
Extensive	Consistent major property damage (more than 25%); major damage public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and possible fatalities.
Catastrophic	Property and public infrastructure destroyed (more than 50%); essential services stopped for 30 days or more, multiple injuries and fatalities.
Present Frequency of Hazard	
Very Low	Events that occur less frequently than once in 100 years (less than 1% chance per year).
Low	Events that occur from once in 50 years to once in 100 years (1% to 2% chance per year).
Medium	Events that occur from once in 5 years to once in 50 years (2% to 20% chance per year).
High	Events that occur more frequently than once in 5 years (greater than 20% chance per year).
Future Probability of Hazard	
Very Low	Events that are projected to occur less frequently than once in 100 years (less than 1% chance per year).
Low	Events that are projected to occur from once in 50 years to once in 100 years (1% to 2% chance per year).

Points	Description
Medium	Events that are projected to occur from once in 5 years to once in 50 years (2% to 20% chance per year).
High	Events that are projected occur more frequently than once in 5 years (greater than 20% chance per year).
Location of Hazard	
N/A	Hazard has not yet affected town area
Small	Less than 10% of the town is or could be affected by the hazard
Medium	Between 10-50% of the town is or could be affected by the hazard
Large	More than 50% of the town is or could be affected by the hazard

Table 4.30, below, provides a summary of the natural hazards affecting Dunstable. This evaluation takes into account historical records, the extent, frequency, location, and anticipated future probability. Information regarding future projections for specific scenarios is not available for every natural hazard, each hazard section contains best available science, and discusses projections in the context of specific future scenarios when available and appropriate.

Table 4.30: Summary of Natural Hazard Risks for the Town of Dunstable

Natural Hazard	Previous Occurrence of Hazard Event in Dunstable	PRESENT			FUTURE
		Extent	Frequency	Location	Probability of Occurrence
Average / Extreme Temperatures	Yes	Serious	High	Large	High
Changes in Groundwater	Yes	Minor	Low	Medium	Medium
Drought	Yes	Minor	High	Large	High
Earthquakes	No	Catastrophic	Low	N/A	Low
Flooding from Precipitation	Yes	Minor	High	Medium	High

Natural Hazard	Previous Occurrence of Hazard Event in Dunstable	PRESENT			FUTURE
		Extent	Frequency	Location	Probability of Occurrence
Hurricanes / Tropical Cyclones	Yes	Extensive	Medium	Large	High
Invasive Species	Yes	Minor	High	Large	High
Landslides / Mudflows	No	Minor	Very Low	N/A	Very Low
Other Severe Weather	Yes	Serious	High	Large	High
Severe Winter Storms	Yes	Serious	High	Large	High
Tornadoes	No	Catastrophic	Low	N/A	Low
Wildfires	No	Serious	Low	N/A	Medium

Based on discussion at CRB Workshop #1, the attendees each prioritized natural hazards affecting Dunstable. Each attendee voted for three natural hazards. Results are as follows:

- **Severe Winter Weather/Nor'easters (10)**
- **Invasive Species (8)**
- **Flooding from Precipitation & Extreme Temperatures (6)**
- **Changes in Groundwater (4)**
- **Drought (3)**
- **Hurricanes/Tropical Storms & Wildfire / Brush Fire (1)**

No votes were received for Earthquakes, Tornadoes, or Landslides due to low risk to Dunstable.

The public had a similar response, as shown in Figure 4.18.

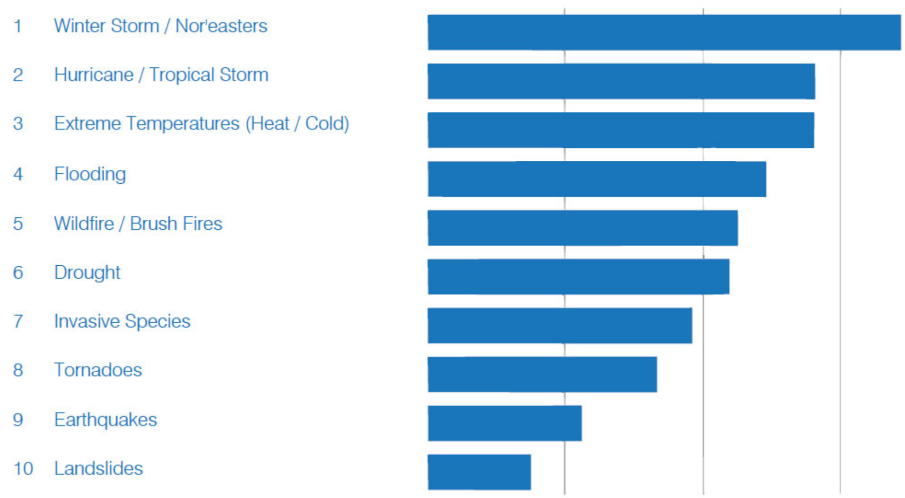

Figure 4.18: Natural Hazards Considered a Priority in Dunstable by the Public.

Figure 4.19 shows which natural hazards the public has experienced in Dunstable. The most common are winter storms/ Nor'easters, then extreme temperatures (hot and cold), and then hurricanes and tropical storms.

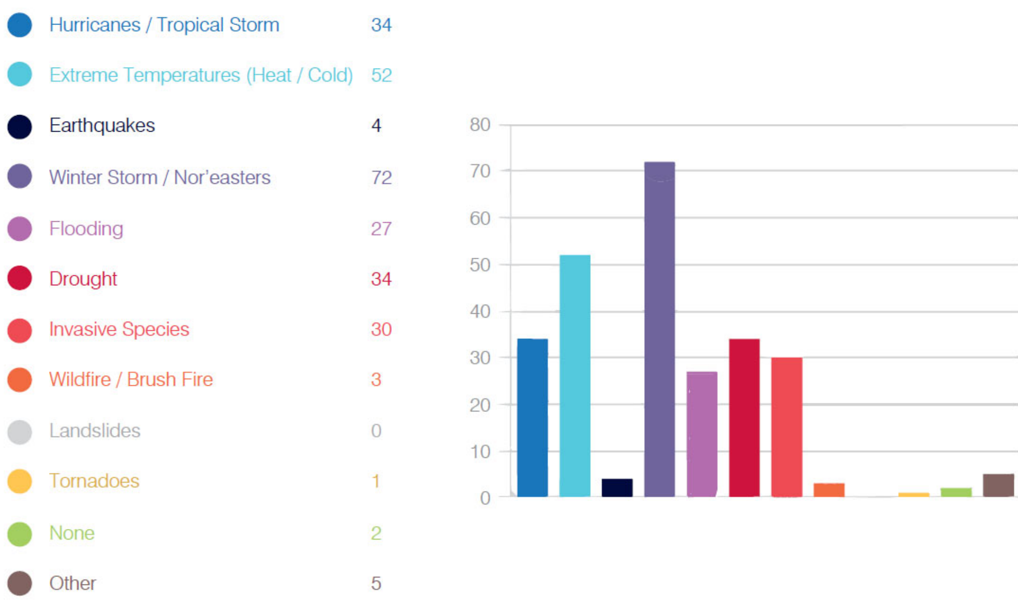

Figure 4.19: Natural Hazards Experienced in Dunstable.

The public shared how natural hazards has affected their lives (Figure 4.20) and what problems due to natural hazards concern them the most (Figure 4.21). Power outages are a clear concern.

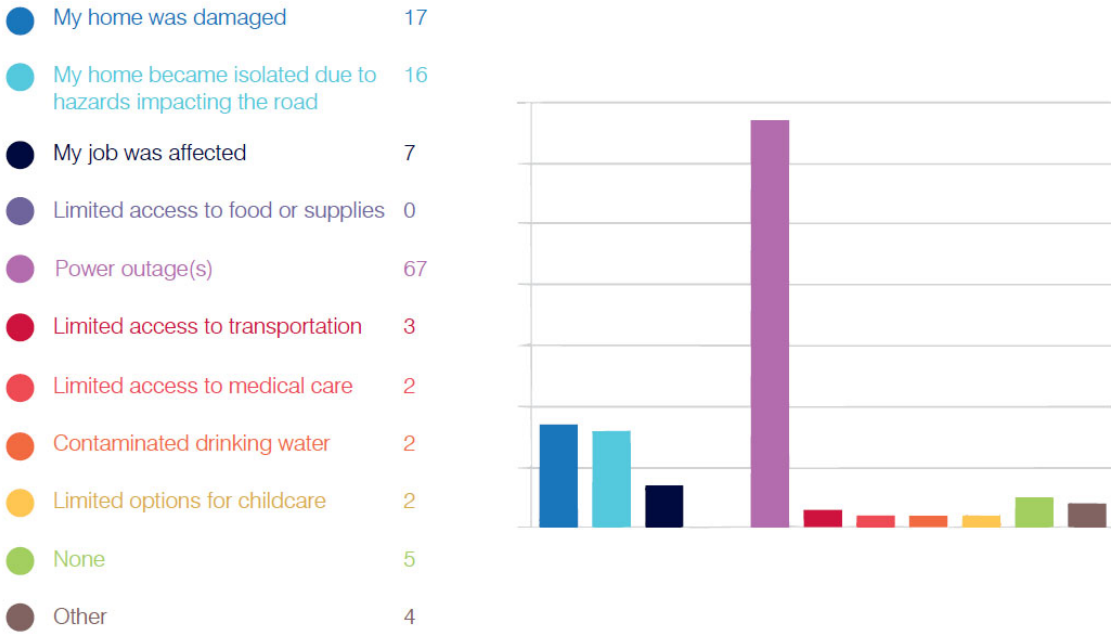

Figure 4.20: Public Input on how Natural Hazards have Affected the Community

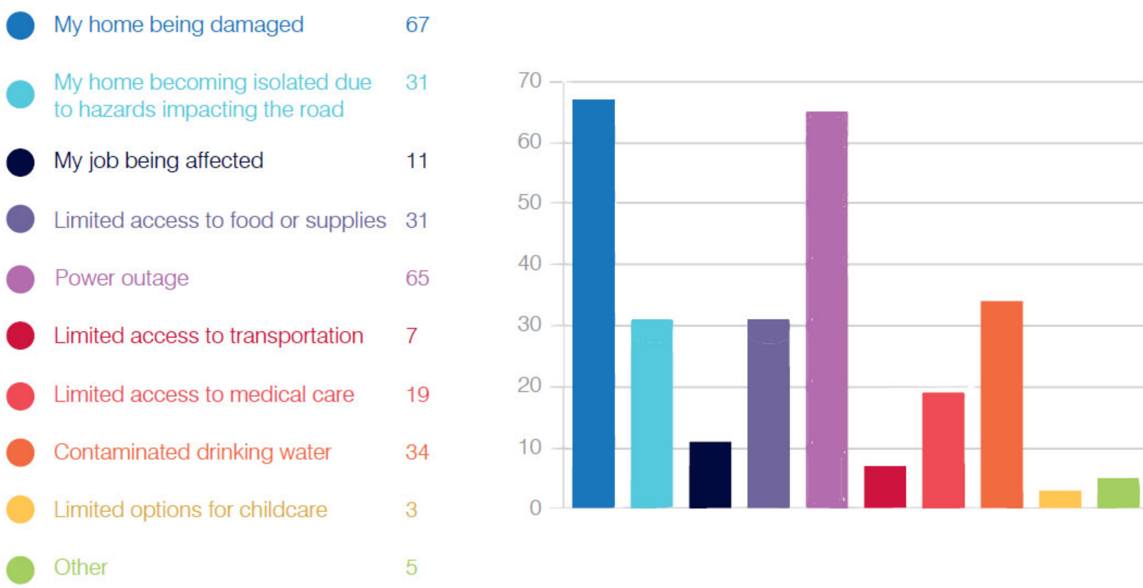

Figure 4.21: Public Input on what Natural Hazard Impacts are most Concerning.

5

5. Community Capabilities

The Town of Dunstable has a unique set of capabilities, in the form of laws, polices, programs, staff, funding, and other resources to carry out the HMP and to increase local climate resilience. This chapter reviews the Town's capabilities and describes the resources Dunstable has available to accomplish hazard mitigation and reduce disaster losses now and in the future. There are five types of mitigation capabilities in accordance with FEMA's Local Mitigation Planning Handbook:

1. **Compliance with the National Flood Insurance Program**.
2. **Planning and regulatory capabilities** are the codes, ordinances, policies, laws, plans, and programs that guide growth and development.
3. **Administrative and technical capabilities** are the town's staff, skills, and tools.
4. **Financial capabilities** are the resources to fund mitigation actions.
5. **Education and outreach capabilities** are programs and methods that can communicate about and encourage risk reduction.

In each section, the Town's existing capabilities and gaps in capabilities are discussed.

5.1. National Flood Insurance Program Compliance

Communities across the country build their floodplain management capabilities by participating in the National Flood Insurance Program (NFIP). The NFIP supports flood risk reduction before and after disasters. It helps reduce the socioeconomic impact of floods. The NFIP allows property owners and renters in participating communities to purchase federal flood insurance policies to recover financial losses after a flood. To participate in the NFIP, communities adopt and enforce floodplain management policies to reduce the effects of flooding.

5.1.1. | Existing Capabilities

Staff Resources

There is not dedicated staff for NFIP compliance in Dunstable. The Conservation Commission oversees local regulations applicable to flood hazard areas.

Road commission, Fire, and Police generally are involved in review of damage following a natural hazard event.

Regulation

The Town of Dunstable entered the National Flood Insurance Program on November 29, 1974 (https://www.fema.gov/cis/MA.pdf). The initial Flood Insurance Rate Map became effective on July 5, 1982 (https://www.fema.gov/cis/MA.pdf). The current effective FIRM date is June 4, 2010 (https://www.fema.gov/cis/MA.pdf). Preliminary maps for the town of Dunstable are dated June 8, 2023 (FEMA Map Service Center). These maps are not yet effective. FEMA will notify the town when these FIRMs become effective. At that time, the town will need to update their floodplain management bylaw to adopt the most recent effective FIRMs. All construction after adoption of the new maps will be held to that standard.

Building in the floodplain is regulated by the Town's Conservation Commission through the Wetlands Protection Act local bylaw. The Board of Health reviews any septic system construction in the flood plain. Monitoring and compliance throughout the construction process may be overseen by Conservation Commission, the Town's engineer, or the building inspector.

Community Rating System

The Town of Dunstable does not currently participate in FEMA's Community Rating System Program (https://www.fema.gov/cis/MA.pdf).

Insurance Summary

According to MEMA, as of January 19, 2024, there are no repetitive loss properties located in the Town of Dunstable.

NFIP Compliance History

The Town is not aware of any outstanding NFIP compliance issues.

5.1.2. | Capability Gaps

Based on evaluation with the NFIP Compliance, the following gaps in capabilities are identified and can be incorporated into the mitigation strategy:

- Dunstable could benefit by identifying a dedicated local Floodplain Manager. This would likely need to be added to the job roles and responsibilities for an existing employee, not by adding a new dedicated employee.

- Dunstable may be interested in participating in FEMA's Community Rating System Program (https://www.fema.gov/cis/MA.pdf). The CRS program is an incentive program that promotes floodplain management regulations that go beyond the minimum requirements set by the NFIP. The CRS program has 19 creditable activities. When communities implement these activities, they receive points. The more points a community scores, the greater the discount on flood insurance premiums will be for citizens of that community. In order to join the CRS program, Dunstable must remain in good standing with the NFIP and have enough credit points (500) to achieve a Class 9 rating. The first step to joining the program is completing an application and providing a letter of interest to FEMA.

5.2. Planning and Regulatory Capabilities

Planning and regulatory capabilities encompass a wide range of tools such as codes, bylaws, policies, laws, plans, and programs that guide growth and development. These capabilities play a crucial role in either supporting risk reduction or creating areas that are more vulnerable to disasters. These strategies are aimed at breaking the cycle of disaster damage and reconstruction. Additionally, effective law and regulation for disaster risk reduction are critical in shaping choices for sustainable development and building resilience to disasters.

5.2.1. | Existing Capabilities

The following discusses Dunstable's current planning and regulatory capabilities to address natural hazards.

Building Code

A challenge for the capabilities of a community can be the use of an updated building code which reflects industry best practices and standard of care. Currently, the Town of Dunstable utilizes the latest Commonwealth of Massachusetts Building Code (Ninth Edition), which is Code of Massachusetts Regulations 780. According to the mass.gov website, "the Massachusetts State Building Code includes international model codes and state specific amendments adopted by the Board of Regulations and Standards (BBRS). The BBRS regularly updates the state building codes as new information and technology becomes available and change is warranted."

The Massachusetts building code addresses natural hazards through elevation requirements aligning with guidance from FEMA, hazard-resistant standards from ASCE 24 and ASCE 7, recognition of floodplain overlay districts, and enforcement.

Land Use / Development Bylaws and Regulations

The following discusses various municipal codes related to natural hazard mitigation and climate change resilience.

General Wetlands Bylaw

The General Wetlands Bylaw (Dunstable, General Bylaws, Adopted 5/13/19) was instituted to protect developed or undeveloped wetland resources including public water supply, private water supply, groundwater supply, flood control, erosion control, storm damage prevention, water pollution, fisheries, shellfish, wildlife, recreation, and aesthetics. This bylaw prohibits new permanent structure or impervious surface (greater than 100 square feet in the aggregate) be within 60 feet of any freshwater wetland.

Stormwater Management and Erosion Control Bylaw

The Stormwater Management and Erosion Control Bylaw (Dunstable, General Bylaws, Adopted 5/9/16) aims to protect water quality in Dunstable and limit stormwater runoff. It also ensures that Dunstable complies with federal regulations set by the Environmental Protection Agency regarding water quality and pollutant discharge. It establishes stormwater management and erosion control standards to minimize adverse impacts from development in downstream or offsite areas. The bylaw protects water resources, prevents pollutants from entering municipal storm drains, controls the volume and rate of runoff resulting from development, requires practices to treat stormwater runoff, protects groundwater and surface water from degradation or depletion, promotes infiltration and the recharge of groundwater, and requires practices that minimize soil erosion and sedimentation. It also ensures that stormwater management is incorporated into the site plan review process.

Water Supply Protection Bylaw

The Water Supply Protection Bylaw (Dunstable, General Bylaws, Adopted 5/12/08) ensures an adequate quality and quantity of drinking water for the residents of the Town of Dunstable. It preserves and protects existing and potential sources of drinking water supplies, conserves the natural resources of the Town of Dunstable, and prevents temporary and permanent contamination of the environment.

Zoning Code

Through the Zoning Bylaws, the Town of Dunstable enforces a Floodplain Overlay District, the boundaries of which are determined by the 100-year floodplain designated in the Flood Insurance Rate Map dated June 4, 2010. All development must be in compliance with the Wetlands Protection Act and the Massachusetts State Building Code, which addresses floodplain and coastal high hazard areas. Furthermore, a base flood elevation is required for all subdivision proposals or other development greater than 5 acres. The Zoning Code requires that the Board of Health review all water and sewer facilities proposed to be located in the Floodplain Overlay District. (Dunstable, Zoning Bylaws, 2021).

Local Plans

There are a variety of local plans that inform and relate to the Hazard Mitigation Plan. These plans include:

- Stormwater Management Plan (2021)
- Open Space and Recreation Plan (2018-2025)
- Comprehensive Master Plan (2018)
- Capital Improvement Plan (FY 2022)

These plans present an opportunity for synthesized planning efforts. Action items found in these plans can and should be aligned with action items identified in the hazard mitigation plan, and vice versa.

5.2.2. | Capability Gaps

Based on evaluation with the planning and regulatory capabilities, the following gaps in capabilities are identified and can be incorporated into the mitigation strategy:

- A review of local bylaws & regulations for climate resilience provisions could be completed to enhance the ability to regulate approaches to mitigation the impact of natural hazards on community assets.
- When local plans are updated or developed, HMP Mitigation Actions discussed in Section 6.2.2 should be integrated and incorporated, for more effective implementation of Mitigation Actions.

5.3. Administrative and Technical Capabilities

Administrative and technical capabilities are the Town's staff, skills and tools, as well as capacity. They also include the ability to access, coordinate and implement natural hazard mitigation resources effectively. Administrative and technical capabilities are "people-powered" capabilities. This category includes other public and private sector resources, such as county, regional, quasigovernmental or nongovernmental agencies, community-based organizations, and grassroots groups.

5.3.1. | Existing Capabilities

The following discusses Dunstable's current administrative and technical capabilities to address natural hazards.

Staff Capacity and Training

The Core Team feels the town is generally understaffed when it comes to preparing for and responding to hazard events, especially in regard to the Highway and Fire departments.

Dunstable relies on a volunteer Emergency Management Director.

Internal and External Communications

Communication during a disaster is critical for ensuring the safety and well-being of the affected community.

The Core Team report there is generally effective communication infrastructure among town departments. The Town has regular department head and staff meetings to discuss a variety of topics. During issues of emergencies, as needed, the response teams constantly communicate through phone, cell, text, and email, and meet, as needed. Additionally, there is an annual capital planning process through the Town Administrator's Office and ultimately managed, reviewed, and approved by the Capital Planning Committee where infrastructure needs are addressed that affect our resiliency and preparedness.

- The Dunstable website is used for external communication.
- The Town is active on both Facebook and Instagram, and is able to alert residents via these avenues to hazards in the area such as flooding or road closures.
- The Town also pays for a form of “Reverse 911” to be able to phone residents quickly.
- The Core Team also identified its schools and libraries as effective ways to communicate information to the community.
- There is also a board at Town Hall where residents can obtain information, which was emphasized as being effective at the MVP CRB Workshops. The Town also disseminates information via cable television alerts and emails.

Regional Coordination and Collaboration

Natural hazards do not adhere to jurisdictional boundaries and therefore regional coordination and collaboration during a disaster event is crucial for an effective response.

- The Town of Dunstable partners with the Town of Pepperell for water system management. The Water Division from the Department of Public Works in Pepperell provides operational and maintenance services to the Dunstable Water Department. They provide routine checks of the wells and reading meters, and conduct distribution system maintenance activities.

- Dunstable has previously partnered with the Town of Groton for emergency dispatch, but recently approved a partnership with Patriot Regional Emergency Communications Center. The Patriot RECC provides an emergency notification system, CodeRED, by which town officials can notify Dunstable residents by telephone, cell phone, text message, or electronic mail about time-sensitive emergency situations or community alerts. The system is capable of sending messages only to localized areas or to the entire town.

- The Core Team indicated effective collaboration among the Emergency Management Department, the Fire and Police departments, the Highway department, National Grid, and the Board of Selectmen during emergency responses.

- Additionally, the Town of Dunstable coordinates with the towns of Tyngsborough and Groton for use of their emergency shelters as needed.

- The Town of Dunstable has a mutual aid agreement with The Northeastern Massachusetts Law Enforcement Council (NEMLEC). NEMLEC is a consortium of police departments in Middlesex and Essex Counties and two County Sheriff's departments (nemlec.com). Member agencies can share resources and personnel, especially in times of emergency.

Local Committees and Task Forces

The Capital Planning Committee was established in 2014 and is responsible for reviewing capital projects in order to analyze and determine the essentials, costs, and benefits of proposed projects.

The Conservation Commission prepares, adopts, and enforces all wetland regulations. They protect the wetlands of Dunstable from activities that could have an adverse impact. They also provide stewardship, education, and advocacy of the Town's natural and recreational assets.

The Board of Health reviews all water and sewer facilities that are proposed to be located within the floodplain.

The PACH Food Bank in Pepperell has food available food in times of need. Meals on Wheels supports those with need on a regular basis, including before, during, and after natural hazard events.

The Dunstable Grange is a fraternal organization of men, women and children of all ages who serve the community in many ways, including the annual grant of a scholarship to a graduating high school senior from Dunstable, providing refreshments for the Memorial Day Parade, memorial benches and gifts, as well as reaching out with donations to a number of charities and community organizations. The Annual Grange Fair from every August is a very popular event that is open to all members of the community.

Assistance from Non-Governmental Organizations

The Dunstable Rural Land Trust was established in 1974 to protect and maintain the character and landscapes of Dunstable. The Trust's mission is to preserve and protect the rural character of the Town of Dunstable. The Trust holds in excess of 800 acres and holds and additional 200 acres of easements (drlt.org). The Trust contributes to floodplain management by creating and maintaining open space in the Town of Dunstable.

The Nashua River Watershed Association was founded in 1969 to lead the clean-up of one of the nation's most polluted rivers. The NRWA acts as a regional leader in natural resource protection, water quality improvement, and environmental education. There are 32 watershed communities within the NRWA. They aim to restore and protect water quality and quantity, conserve open spaces, and encourage careful land use with well-planned development.

The Northern Middlesex Council of Governments works with the communities of the Greater Lowell region to support and enhance a wide range of land use planning objectives. These objectives include environmental protection, economic development, transportation and transit planning, and the building and maintenance of community character. They provide technical assistance to member communities in designing, facilitating, and implementing community planning projects.

5.3.2. | Capability Gaps

Based on evaluation with the administrative and technical capabilities, the following gaps in capabilities are identified and can be incorporated into the mitigation strategy:

- The Core Team noted the town would benefit from increased funding for additional staff positions.
- The Town may want to consider training on hazard response and hazard mitigation for staff members.
- Formalizing an in-person emergency communications plan would be beneficial as most outreach capabilities rely on electronic communication.
- Enacting a program to encourage signups for outreach systems would help more community members get information prior to, during, and following a natural hazard event. In particular, priority populations should be targeted.
- The Town could develop a list of Emergency Shelters in other communities (including Pepperell) to improve regional coordination and collaboration.
- Developing policies for use for Library/Council on Aging will support equitable use of these important facilities for priority populations.

5.4. Financial Capabilities

Financial capabilities are the resources to fund mitigation actions. Talking about funding and financial capabilities is important because mitigation actions have different costs. Mitigation actions like outreach programs are lower cost and often use staff time and existing budgets. Other actions, like earthquake retrofits, could require substantial funding from local, state and federal partners.

5.4.1. | Existing Capabilities

The Core Team identified the following financial methods as being used in the recent past to fund mitigation activities:

- Capital improvement project funding
- Authority to levy taxes for specific purposes
- Fees for water, gas, or electric
- State funding programs
- Impact fees for new development
- Incurring debt through general obligation bonds and/or special tax bonds
- Other federal funding programs

5.4.2. | Capability Gaps

The Core Team indicated the desire and need to apply for state and federal grant funding for additional monies for hazard mitigation activity. The Town of Dunstable should target FEMA funding sources such as the Hazard Mitigation Grant Program, Flood Mitigation Assistance grants, or Building Resilient Infrastructure and Communities grants. There are also state-level grant programs available such as the Municipal Vulnerability Preparedness Action Grant. Historically, a barrier to applying for these grants has been staff capacity.

5.5. Education and Outreach

Education and outreach to the community are vital components of both preparedness and response. These capabilities are programs and methods that can communicate about and encourage risk reduction and may be run by the Town or a community-based partner.

5.5.1. | Existing Capabilities

- The Dunstable website is used for education and outreach. The website contains links to information such as extreme cold safety tips and Coronavirus updates from the Massachusetts Emergency Management Agency. The website also contains links to Ready.Gov, FEMA, and the Executive Office of Public Safety and Security. The website also provides a link where residents can subscribe to E-Alerts from the Town.

- The Town is active on both Facebook and Instagram and is able to share educational information with the community via these methods.

5.5.2. | Capability Gaps

Based on evaluation with the education and outreach capabilities, the following gaps in capabilities are identified and can be incorporated into the mitigation strategy:

- The Core Team indicated a need to increase education and outreach to the community regarding preparedness and hazard mitigation. Preparing a formal Communication Plan for priority populations will improve equity in outreach.
- The Town may consider developing Education & Outreach related to Invasives, Wells, Trees, and Flooding, among other topics.
- The public noted that email updates from the Town related to hazard mitigation would be the preferred method of communication in the future.

5.6. Community Input on Capabilities

According to public input received during development of this plan, the town treats winter roads (salting and sanding) well and completes snow removal well, to prepare for natural hazard events.

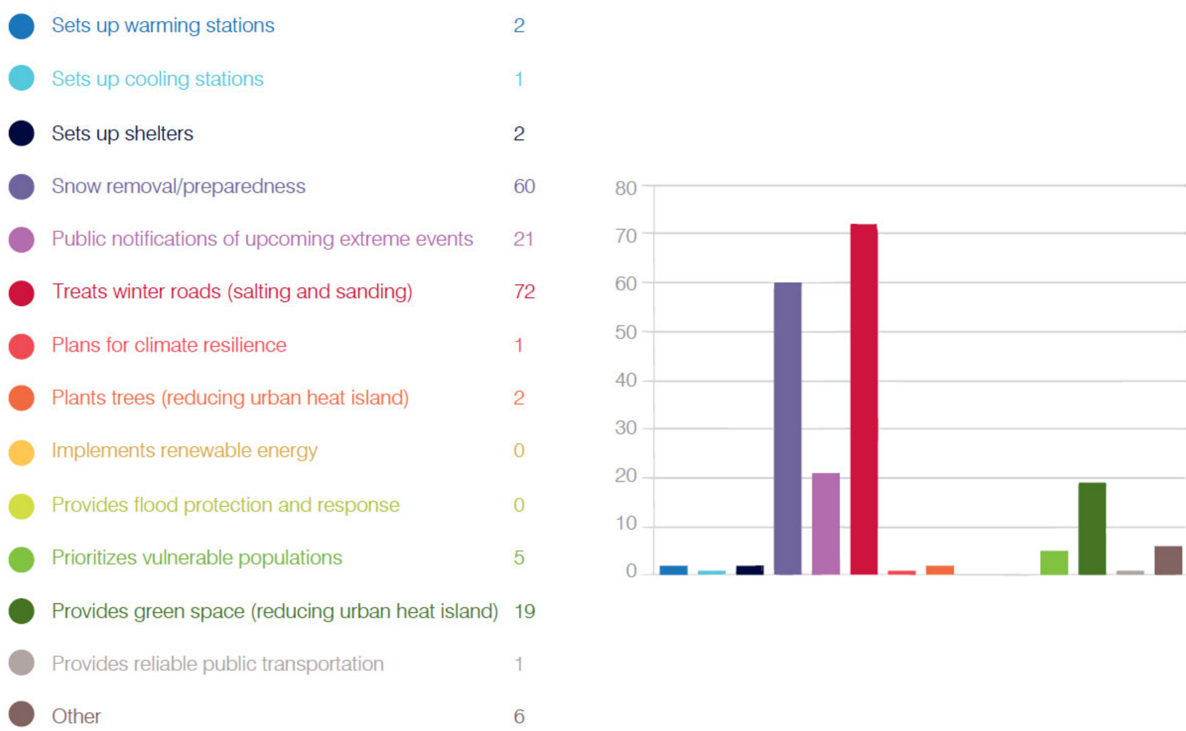

Figure 5.1: Community Input on Dunstable's Capabilities for Natural Hazard Preparedness.

According to public input received during development of this plan, Dunstable could improve preparedness for natural hazards by implementing renewable energy, planning for climate resilience, and providing public notification of upcoming extreme events.

Set up warming stations	14
Set up cooling stations	14
Set up shelters	15
Snow removal/preparedness	13
Public notifications of upcoming extreme events	26
Treat winter roads (salting and sanding)	13
Plan for climate resilience	29
Plant trees (reducing urban heat island)	10
Implement renewable energy	32
Provide flood protection and response	16
Prioritize vulnerable populations	24
Provide green space (reducing urban heat island)	2
Provide reliable public transportation	3
Other	12

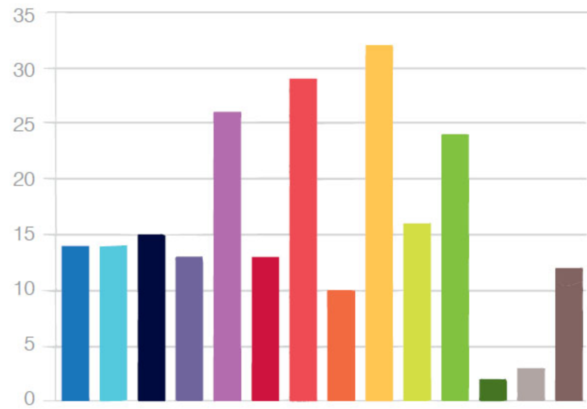

Figure 5.2: Community Input on Potential Natural Hazard Preparedness Improvements

6

6. Mitigation Actions

The mitigation actions are one of the most important components of the Hazard Mitigation Plan. They serve as the blueprint for reducing the potential losses identified in the risk and vulnerability assessment. They can be a measure, project, plan, or activity proposed to achieve the Town's mission and goals and reduce current and future vulnerabilities described in the risk assessment (Chapter 4).

There are many different types of hazard mitigation actions that generally fall into the following four categories (FEMA, Local Mitigation Planning Handbook, 2023):

Local Plans and Regulations: These actions include government authorities, policies or codes that influence the way land and buildings are developed and built.

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.

Natural Systems Protection and Nature-based Solutions: This type of action can include green infrastructure and low impact development, nature-based solutions, Engineering with Nature and bioengineering to incorporate natural features or processes into the built environment.

Education and Awareness Programs: These types of actions keep residents informed about potential natural disasters. Many of these types of actions are eligible for funding through the FEMA HMA program.

Through the stakeholder and community engagement process discussed in Chapter 2, mitigation actions and an action plan for implementation were developed to help achieve the mitigation goals (See Chapter 1 Section 1.5 for mitigation goals). This provides a framework to prioritize and implement actions to reduce risks from hazards. Chapter 6 reviews the mitigation actions created in 2015 and outlines mitigation actions for Dunstable for the next five years.

6.1. Status of 2015 HMP Mitigation Actions

Town staff reviewed the mitigation measures identified in the 2015 HMP and determined whether measures identified in that plan had been implemented or deferred. For implemented projects, they were categorized as either complete or in progress, with the latter referring to projects were still under development or had begun but not yet completed. If measures had been deferred, the Core Team evaluated whether the measure should be deleted or carried forward into this 2023 HMP Update. The decision on whether to delete or retain a particular measure was based on the STC's assessment of the continued relevance or effectiveness of the measure and whether the deferral of action on the measure was due to the inability of the town to take action on the measure. Table 6.1 lists all mitigation actions from the 2015 HMP and their current status.

Table 6.1: Status of 2015 HMP Mitigation Actions

Description of Action	Implementation Responsibility/ Status	Status	Notes
Prepare study of flooding problems along Main Street near Sweets Pond.	Town Board of Selectmen and Conservation Commission	Deleted	New culvert has been installed in area and flooding has been minimized. Study no longer needed.
Study the Community Rating System to determine appropriateness for Dunstable	Town Emergency Manager and building inspector, MEMA and FEMA	Deferred	Included in 2024 HMP Update

Description of Action	Implementation Responsibility/ Status	Status	Notes
Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	In Progress	Included in 2024 HMP Update
Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Town Administrator, DCR Office of Dam Safety, dam owners	In Progress	Included in 2024 HMP Update
Incorporate Hazard Mitigation into subdivision regulations, Master Plan and Open Space Plan Updates.	Town Planning Board and Conservation Commission. The town's Open Space Plan currently addresses hazard mitigation.	Deferred	Included in 2024 HMP Update
Participate in DCR's Fire Wise Program for the forested sections of town.	DCR and Town Fire Department	Deferred	Included in 2024 HMP Update
Upgrade and expand the Route 113 water line, which will improve fire suppression capabilities.	Town Water Department	Completed	Note: Dunstable does not have fire suppression capabilities.
Purchase communication equipment with interoperability capabilities.	Town police and fire departments	Completed	

Description of Action	Implementation Responsibility/ Status	Status	Notes
Replace Main Street/Salmon Brook Bridge.	Highway department and MassDOT. The bridge replacement project is currently under design	Completed	
Study regional consolidation of 911 dispatch services by establishing an RECC	Town public safety officials, NMCOG and the State 911 Department	Completed	
Repair the next phase of the Route 113 retaining wall in order to keep the roadway open and replace culvert.	MassDOT and the Town Highway Department. This project is currently under design	Completed	
Ensure that administrators of schools, businesses, and municipal buildings have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Deferred	Included in 2024 HMP Update
Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event.	Town Emergency manager, Board of Selectmen, and building inspector	Deferred	Included in 2024 HMP Update
Revise subdivision regulations, erosion control regulations, and Board of Health regulations to improve floodplain management as needed	Town Planning Board, Conservation Commission and Board of Health	Deleted	Local and state regulations are sufficient to cover this previous action.

Description of Action	Implementation Responsibility/ Status	Status	Notes
Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	In Progress	
Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	In Progress	
Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Deleted	There are no major parking lots or impervious areas that need extensive snow removal. There is sufficient space at schools and other town facilities for site-specific snow removal.
Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Deleted	Captured in updated hazards list.
Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Deleted	Has not been a concern.

Description of Action	Implementation Responsibility/ Status	Status	Notes
Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Deleted	
Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Deleted	Combine with firewise/updated Mitigations

6.2. MVP Actions Identified at Community Resilience Building Workshop

At the Community Resilience Building workshops held in October 2023, attendees in groups (Groups 1, 2, and 3) brainstormed a number of potential mitigation strategies to address severe weather/ nor'easters, invasive species, flooding from precipitation, and extreme temperatures (top hazards identified as previous discussed in Section 4.15) for assets (See Section 3.2) identified.

Each group ranked their list and reported out to the larger workshop about their top three mitigation strategies. Strategies were organized by asset category (People, Structures, Systems, Historic/Natural/Cultural Resources), and Economy & Activities with Value to the Community.

Attendees prioritized the list of mitigation strategies to undertake in Dunstable. Each attendee voted for three mitigation strategies.

Based on the results of votes at the CRB & HMP Stakeholder Workshop Day 2, the following priority actions were identified:

- Fire Department Station/ Lot Resilience
- Road infrastructure evaluation and management plan
- Woodwards Mill Pond Dam Repairs
- Communication plan for priority populations
- Create cooling areas (e.g., natural approaches & structures) at Larter Field, Town Common, school parking lot
- Culverts & Dams: inventory & evaluation and flood study regarding prevention

- Education & Outreach for:
    - Invasives
    - Wells
    - Trees
- Install mixer at water tower
- Complete a review of bylaws & regulations for climate resilience
- Add AC to school for shelter use/ designation

Other Actions were also identified but not ranked as high priority:

- Implement Building Envelope Actions at Union School
- Improve access roads to open / wooded spaces for fire management and emergency response
- Mitigate potential impacts of flooding and other natural hazards at new development projects
- Flood study for DPW
- Develop policies for use for Library/Council on Aging
- Provide access to drinking water from town on public properties (e.g., water fountains, fill stations)
- Improve and create affordable senior housing options
- Adapt community activities to seasons/weather (time to avoid natural hazards)
- Develop procedure and obtain equipment for fire department to pump basements
- Gas / power / energy resilience study
- Regional Coordination re Cow Pond Dam
- Police Department resilience study
- Hydrant inventory & code identification
- In-person emergency communications plan
- Encourage signups for outreach systems, priority populations in particular
- Downtown flooding study
- Generators for heating/cooling at critical buildings
- Beaver management planning
- Ongoing maintenance of trees surrounding critical facilities, pre storm event
- Resilient Bandstand at Town Common

These actions have been incorporated into the overall mitigation and adaption strategy for Dunstable.

6.3. Mitigation Action and Adaptation Strategy for 2024-2028

The Core Team developed an updated mitigation action and adaptation strategy for this HMP Update. The actions were developed from a multi-faceted approach, including the following:

- The goals and objectives endorsed by the Core Team; more detail about this is available in Chapter 1.
- Input from stakeholders through the CRB Workshops and the community through public meetings and survey input; more detail about this is available in Chapter 2.
- Identified community assets, described in Chapter 3.
- A hazard and climate change risk and vulnerability assessment; more detail about this is available in Chapter 4.
- The Town's capacity to mitigate and respond to hazard events as described in Chapter 5.
- The progress of actions from the 2015 HMP; more detail about this is available in Chapter 6 Section 6.1
- Actions included in related town plans and reports; more detail about this is available in Chapter 2.3.

The actions include both specific projects and recognize broader results to be achieved by implementing a project. The level of specificity differs based on the input received and the currently available data associated with the mitigation action. In some cases, actions are broader because the specific steps to accomplish the result may not be determined at this point in time. These actions will all be tracked an updated during the annual plan maintenance and review, discussed in greater detail in Chapter 7.

6.3.1. | Prioritization of Potential Actions

Actions were prioritized using FEMA's Guidance. If the action satisfied the criteria, it received points. If it did not, it received no points. Points were added to yield a total score. Scores were then categorized into low (8-16 points), medium (16-22 points) or high (23+ points) priority.

All actions were identified to have a beneficial impact on businesses, residents, and properties in the Town and to proactively reduce the risk of a natural hazard. The questions used to evaluate priorities are shown in Table 6.2.

Table 6.2: Prioritization of Potential HMP Mitigation Actions

Question	Potential Answers	Point System
Is there sufficient staff to implement the project?	Yes No	2 0
Is training required for the staff to implement the project?	Yes No	2 0
Is there political support for the project?	Yes No Maybe	2 0 1

Question	Potential Answers	Point System
Does the community have the legal authority to do the project?	Yes Maybe No	2 1 0
What is the cost of the project? *	$ = <$50,000 $$ = $50,000 to <$250,000 $$$ = $250,000 or more	2 1 0
Does the community have the funds for the project on the whole or the local match?	Yes Maybe No	2 1 0
Des the action advance other local objectives or plans?	Yes No	2 0
What is the scale of the overall benefit?	High (town-wide or regional) Medium (neighborhood/area/portion of town) Low (site specific/limited population)	2 1 0
Will the action adversely affect priority populations?	Yes Maybe No	2 1 0
Does the action build resilience for priority populations?	Yes Maybe No	2 1 0
What priority was this action assigned at the MVP Community Resilience Building Workshops? **	High Medium Low N/A (from 2015 HMP)	2 1 0 0

* Costs listed in the prioritization are estimated and are based on the cost of similar projects and professional estimates. Actual costs may vary based on the specific site, project, and scope of work. Cost estimates should be verified during the financial planning stage of a project.

** During Workshop #2, each group (Groups 1, 2, and 3) brainstormed a number of potential mitigation strategies to address Severe Weather/ Nor'easters, invasive species, flooding from precipitation, and extreme temperatures for assets identified in Workshop Day 1. Each group ranked their list and reported on their top three mitigation strategies. Strategies were organized by asset category (People, Structures, Systems, Historic/Natural/Cultural Resources), and Economy & Activities with Value to the Community). Attendees prioritized the list of mitigation strategies to undertake in Dunstable. Each attendee voted for three mitigation strategies.

The mitigation strategy, or action plan, is the heart of the plan and the primary tool to get funding, assign priorities, guide decisions, and track progress in future plan updates.

Table 6.3 presents the prioritized list potential mitigation actions.

Table 6.3: Prioritized List of Potential Mitigation Actions

#	Action Description	Is there sufficient staff to implement the project?	Is training required for the staff to implement the project?	Is there political support for the project?	Does the community have the legal authority to do the project?	What is the cost of the project?	Does the community have the funds for the project on the whole or the local match?	Does the action advance other local objectives or plans?	What is the scale of the overall benefit?	Will the action adversely affect priority populations?	Does the action build resilience for priority populations?	What priority was this action assigned at the MVP Community Resilience Building Workshops?	Overall Priority
		Yes No	Yes No	Yes No Maybe	Yes No Maybe	$ = <$50,000 $$ = $50,000 to <$250,000 $$$ = $250,000 or more	Yes No Maybe	Yes No	High (regional, town-wide) Medium (neighborhood specific) Low (site specific)	Yes No Maybe	Yes No Maybe	High Medium Low N/A (from 2015 HMP)	High Medium Low
1	Fire Department Station/ Lot Resilience	Yes	No	Maybe	Yes	$$	No	Yes	Low	No	No	High	Medium
2	Road infrastructure evaluation and management plan	Yes	Yes	Yes	Yes	$$	Maybe	Yes	High	No	Yes	High	High
3	Woodwards Mill Pond Dam Repairs	Yes	No	Yes	Yes	$$	Maybe	Yes	Medium	No	No	High	Medium
4	Communication plan for priority populations	Yes	No	Yes	Yes	$	Yes	No	Medium	No	Yes	High	High
5	Create cooling areas (e.g., natural approaches & structures) at Larter Field, Town Common, school parking lot	No	No	No	Yes	$$	Maybe	No	Medium	No	Yes	High	Low
6	Culverts & Dams: inventory & evaluation and flood study regarding prevention	Yes	Yes	Yes	Maybe	$$	Maybe	Yes	High	No	No	High	High
7	Education & Outreach for Invasives, Wells, Trees, Flooding	Yes	No	Yes	Yes	$	Yes	No	High	No	Yes	High	High
8	Install mixer at water tower	Yes	No	Yes	Yes	$$	Maybe	Yes	Medium	No	No	High	Medium
9	Complete a review of bylaws & regulations for climate resilience	Yes	No	Yes	Yes	$	Yes	Yes	High	Maybe	Maybe	High	High
10	Generators for heating/cooling at critical buildings	Yes	No	Yes	Yes	$$	Maybe	Maybe	Medium	No	Yes	High	High
11	Develop List of Emergency Shelters in other communities (including Pepperell)	Yes	No	Yes	Yes	$	Yes	Yes	Medium	No	Yes	High	High
12	Improve and create affordable senior housing options	Yes	No	Yes	Maybe	$$$	Maybe	Yes	High	No	Yes	High	Medium
13	Improve access roads to open / wooded spaces for fire management and emergency response	Yes	No	Yes	Yes	$$	Maybe	No	Medium	No	No	High	Medium
14	Add AC to school for shelter use/ designation	Yes	No	Yes	Yes	$	Maybe	Yes	Medium	No	Yes	High	High
15	Implement Building Envelop Actions at Union School	Yes	No	Yes	Yes	$$$	Maybe	Yes	Low	No	No	Medium	Medium
16	Mitigate potential impacts of flooding and other natural hazards at new development projects	Yes	No	Maybe	Maybe	$	Yes	Yes	High	Maybe	Maybe	Medium	High
17	Flood study for DPW	Yes	Yes	No	Yes	$	Maybe	Yes	Low	No	No	Medium	Medium
18	Develop policies for use for Library/Council on Aging	Yes	No	Yes	Yes	$	Yes	Yes	Low	No	Yes	Medium	High
19	Provide access to drinking water from town on public properties (e.g., water fountains, fill stations)	No	No	Maybe	Yes	$$	Maybe	Yes	Low	No	Yes	Low	Low
20	Adapt community activities to seasons/weather (time to avoid natural hazards)	Yes	No	Yes	No	$	Yes	Yes	Medium	No	Yes	Low	Medium
21	Develop procedure and obtain equipment for fire department to pump basements	Yes	No	Maybe	Yes	$	Maybe	Maybe	Medium	No	Yes	Low	Medium
22	Gas / power / energy resilience study	No	No	No	Maybe	$$	No	Maybe	High	No	Maybe	Low	Low
23	Regional Coordination for Cow Pond Dam	Yes	No	Maybe	Maybe	$	Yes	Yes	Medium	No	No	Low	Medium
24	Police Department resilience study	No	No	No	Yes	$$	No	No	Low	No	No	Low	Low
25	Hydrant inventory & code identification	Yes	No	Yes	Yes	$	maybe	Yes	Medium	No	Maybe	Low	Medium
26	In-person emergency communications plan	Yes	No	Yes	Yes	$	Yes	Maybe	High	No	Yes	Low	Medium
27	Encourage sign ups for outreach systems, priority populations in particular	Yes	No	Yes	Yes	$	Yes	Yes	High	No	Yes	Low	High
28	Downtown flooding study	No	Yes	Maybe	Yes	$$	No	Yes	Medium	No	Maybe	Low	Medium
29	Add cell tower for equal service in case of emergencies	No	No	Maybe	Maybe	$$$	No	Yes	High	No	Yes	Low	Low
30	Beaver management planning	Yes	No	Maybe	Yes	$	Yes	Yes	Medium	No	No	Low	Medium
31	Ongoing maintenance of trees surrounding critical facilities, pre storm event	Yes	No	Yes	Maybe	$	Yes	Yes	High	No	Maybe	Low	Medium
32	Resilient Bandstand at Town Common	Yes	No	Maybe	Yes	$$$	No	Maybe	Low	No	Yes	Low	Low
33	Splash pad at Larter Field	Yes	No	Maybe	Yes	$$$	No	Maybe	Low	No	Yes	Low	Low
34	Study the Community Rating System to determine appropriateness for Dunstable	Yes	No	Maybe	Yes	$$	No	Maybe	Medium	No	Yes	N/A	Medium
35	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly and those with health issues) can have access to air conditioning or shelter from the cold	No	Yes	Maybe	Yes	$$	Maybe	Yes	Medium	No	Maybe	N/A	Medium
36	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Yes	No	Yes	Yes	$	Yes	Yes	High	Maybe	Maybe	N/A	High
37	Incorporate Hazard Mitigation into subdivision regulations, Master Plan, and Open Space Plan updates	Yes	Yes	Yes	Yes	$	No	Yes	Medium	No	No	N/A	Medium
38	Participate in DCR's Fire Wise Program for the forested sections of town	Yes	Yes	Maybe	Yes	$	Yes	Maybe	Medium	No	No	N/A	Medium

Table 6.3: Prioritized List of Potential Mitigation Actions

#	Action Description	Is there sufficient staff to implement the project?	Is training required for the staff to implement the project?	Is there political support for the project?	Does the community have the legal authority to do the project?	What is the cost of the project?	Does the community have the funds for the project on the whole or the local match?	Does the action advance other local objectives or plans?	What is the scale of the overall benefit?	Will the action adversely affect priority populations?	Does the action build resilience for priority populations?	What priority was this action assigned at the MVP Community Resilience Building Workshops?	Overall Priority
39	Ensure that administrators of schools, businesses, and municipal buildings have a shelter plan in the event of a tornado warning	Yes	Yes	Yes	Yes	$	No	Yes	High	Maybe	Maybe	N/A	High
40	Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event	Yes	Yes	Yes	Maybe	$	Yes	Yes	High	No	No	N/A	High
41	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Yes	No	Maybe	Yes	$	Maybe	Yes	High	No	Yes	N/A	Medium
42	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	No	No	Maybe	Yes	$$	No	Maybe	Medium	No	Maybe	N/A	Low

6.3.2. | Dunstable's 2024 - 2029 Mitigation Actions

For each mitigation action considered to be part of the 5-year plan, the following characteristics were defined such that the Town is able to tie the actions to the risk assessment and mitigation goals, define who is responsible for implementing/ administering the identified mitigation action, understand general cost and benefit of an action, understand available funding source(s), determine the expected timeframe for the action, and confirm consistency with and integration into other local plans.

- **Action #:** Number for quick reference.
- **Action Description:** Brief narrative describing the action.
- **Hazards/Risks Addressed:** Actions may mitigate a single or multiple hazards, which will be indicated for each action. All the hazards discussed in Chapter 4 were addressed when developing the priority list, and there is at least one action associated with each hazard. Some actions address all hazards and are listed as such.
- **Goals Addressed:** This column lists which goals the mitigation action aims to accomplish. Some actions contribute toward more than one goal. The goals are listed in Section 1.5
- **Responsible Party:** Many hazard mitigation actions and climate adaptation measures will require a multi-department strategy where several departments share responsibility. The designation of implementation responsibility is assigned to a primary department based on the responsibility of each department.
- **Partner Agencies:** Some mitigation actions may require cooperation with outside entities, such as Massachusetts state departments, neighboring communities, regional organizations, or private entities. In those cases, the relevant entities are included in additional to the town department.
- **Overall Priority:** This column shows the ranking based on the process described in Section 6.2.1.
- **Cost Estimate:** Costs listed in the mitigation action spreadsheet are estimated and are based on the cost of similar projects and professional estimates. Actual costs may vary based on the specific site, project, and scope of work. Cost estimates should be verified during the financial planning stage of a project.
- **Potential Funding Source:** The Town's general funds are considered a default potential funding source unless the Town pursues additional funding. Annually, the Town funds various capital needs through its operating funds and aggressively seeks out grants and other funding sources to address Town needs. The identification of potential funding sources is preliminary and may vary depending on numerous factors. These factors include, but are not limited to, changes in grant eligibility criteria, program objectives, and funding availability. 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. Potential grants were assigned based on eligibility and competitiveness, but the recommendations may not be comprehensive. Please note that grant eligibility and scoring criteria should also be reviewed prior to applying. Grants may also only be a source of funding for a single stage of a project. In many cases, the actions will require a combination of funding sources.

- **Timeframe to Start:** This column indicates whether or not the action is in progress. If the action is not yet in progress, the estimated time remaining until the project starts is listed.
- **Estimated Timeline for Completion:** This column indicates the estimated timeline for completing the mitigation action.
- **Integration Status:** It is crucial that the Hazard Mitigation Plan be aligned with other long-range planning documents for the Town of Dunstable. This column demonstrates areas where mitigation actions overlap with the intent of other planning documents.
- **Integration Opportunity into Local Plans:** For successful implementation of mitigation actions, they must be incorporate into local plans. This column indicates where mitigation actions may be integration into another local plan or planning mechanism.

The mitigation strategy, or action plan, is the heart of the plan and the primary tool to get funding, assign priorities, guide decisions, and track progress in future plan updates.

Table 6.4 presents the prioritized list of Dunstable’s 2024 - 2029 Mitigation Actions.

Table 6.4: Dunstable 2024 – 2029 Mitigation Actions

Action #	Action Description	Hazards / Risks Addressed	Goals Addressed	Responsible Party	Partner Agencies	Overall Priority	Cost Estimate	Potential Funding Source(s)	Timeframe to Start	Estimated Timeline for Completion	Integration Status	Integration Opportunity
					Can any stakeholders help carry out the action, and if so, who?	High Medium Low	$ = <$50,000 $$ = $50,000 to <$250,000 $$$ = $250,000 or more	Capital Budget Operating Budget Municipal Bond Grant Staff Time	In Progress Less than 1 year 1-2 years 2-5 years Annual	Short-term Medium-term Long-term	Action Identified in other Local Plan? Yes No	Action could support other local plan or planning mechanism? Yes No
1	Fire Department Station/ Lot Resilience	Precipitation flooding, winter storms	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Fire Dept	Select Board	Medium	$$	Capital Budget / Municipal Bond	In Progress	Long-term	Yes	No
2	Road infrastructure evaluation and management plan	Precipitation flooding,	1. Protect Health and Safety 5. Consider the Economy 6. Integrate Climate Change	Road Commission	Highway Department	High	$$	Capital Budget / Operating Budget / Grant	In Progress	Short-term	Yes	Yes
3	Woodwards Mill Pond Dam Repairs	Drought, precipitation flooding	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Select Board	Conservation Commsion	Medium	$$	Capital Budget / Grant	In Progress	Short-term	Yes	Yes
4	Communication plan for priority populations	All hazards	1. Protect Health and Safety 3. Increase Response Capacity 4. Protect Priority Populations 6. Integrate Climate Change	Police	Senior Center	High	$	Staff Time	Less than 1 year	Short-term	No	Yes
5	Create cooling areas (e.g., natural approaches & structures) at Larter Field, Town Common, school parking lot	Average/Extreme temperatures	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change 10. Be Sustainable	Selecdt Board	Community Preservation Committee	Low	$$	Grant	1-2 years	Short-term	No	Yes
6	Culverts & Dams: inventory & evaluation and flood study regarding prevention	Precipitation flooding	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Road Commission	Highway Department	High	$$	Capital Budget / Grant	In Progress	Medium-term	Yes	Yes
7	Education & Outreach for Invasives, Wells, Trees, Flooding	Invasive Species, drought, wildfires	1. Protect Health and Safety 2. Increase Outreach and Education 6. Integrate Climate Change	Town Forest Committee	Conservation Commsion	High	$	Staff Time / Grant	In Progress	Short-term	No	No
8	Install mixer at water tower	Drought	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Water Commission	Select Board	Medium	$$	Capital Budget / Municipal Bond	1-2 years	Short-term	Yes	Yes
9	Complete a review of bylaws & regulations for climate resilience	All hazards	1. Protect Health and Safety 2. Increase Outreach and Education 5. Consider the Economy 6. Integrate Climate Change 7. Encourage Smart Development 8. Be Sustainable	Planning Board	Zoning Board of Appeals / Conservation Commission, Select Board	High	$	Staff Time / Grant	Less than 1 year	Short-term	Yes	Yes
10	Generators for heating/cooling at critical buildings	Average/Extreme temperatures	1. Protect Health and Safety 3. Increase Response Capacity 4. Protect Priority Populations 6. Integrate Climate Change	Emergency Management Director	Police, Fire, Select Board	High	$$	Municipal Bond / Grant	1-2 years	Short-term	No	Yes
11	Develop List of Emergency Shelters in other communities (including Pepperell)	All hazards except changes in groundwater and invasive species	1. Protect Health and Safety 2. Increase Outreach and Education 4. Protect Priority Populations 6. Integrate Climate Change 8. Increase Coordination	Emergency Management Director	Select Board	High	$	Staff Time	Less than 1 year	Short-term	No	Yes
12	Improve and create affordable senior housing options	All hazards except changes in groundwater and invasive species	4. Protect Priority Populations 6. Integrate Climate Change 7. Encourage Smart Development	Affordable Housing Committee	NMCOG / Affordable Housing Committee	Medium	$$$	Staff Time / Grant	In Progress	Medium-term	Yes	Yes
13	Improve access roads to open / wooded spaces for fire management and emergency response	Wildfires	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Town Forest Committee	Road Commission	Medium	$$	Operating Budget / Grant	In Progress	Short-term	No	Yes
14	Add AC to school for shelter use/ designation	Average/Extreme temperatures	1. Protect Health and Safety 3. Increase Response Capacity 4. Protect Priority Populations 6. Integrate Climate Change	Schools	Emergency Management Director	High	$	Municipal Bond / Grant	1-2 years	Short-term	No	Yes
15	Implement Building Envelop Actions at Union School	Average/Extreme temperatures, precipitation flooding, winter storms, hurricanes, tornadoes, earthquakes	1. Protect Health and Safety 3. Increase Response Capacity 4. Protect Priority Populations 6. Integrate Climate Change	Select Board	CPC, Historical Commission	Medium	$$$	Capital Budget / Grant	1-2 years	Short-term	Yes	Yes

Table 6.4: Dunstable 2024 – 2029 Mitigation Actions

Action #	Action Description	Hazards / Risks Addressed	Goals Addressed	Responsible Party	Partner Agencies	Overall Priority	Cost Estimate	Potential Funding Source(s)	Timeframe to Start	Estimated Timeline for Completion	Integration Status	Integration Opportunity
					Can any stakeholders help carry out the action, and if so, who?	High Medium Low	$ = <$50,000 $$ = $50,000 to <$250,000 $$$ = $250,000 or more	Capital Budget Operating Budget Municipal Bond Grant Staff Time	In Progress Less than 1 year 1-2 years 2-5 years Annual	Short-term Medium-term Long-term	Action Identified in other Local Plan? Yes No	Action could support other local plan or planning mechanism? Yes No
16	Mitigate potential impacts of flooding and other natural hazards at new development projects	Precipitation flooding	1. Protect Health and Safety 2. Increase Outreach and Education 5. Consider the Economy 6. Integrate Climate Change 7. Encourage Smart Development 8. Be Sustainable	Planning Board	Zoning Board of Appeals / Conservation Commission	High	$	Staff Time / Grant	Less than 1 year	Short-term	Yes	Yes
17	Flood study for DPW	Precipitation flooding	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Road Commission	Town Engineer	Medium	$	Municipal Bond / Grant	1-2 years	Short-term	No	Yes
18	Develop policies for use for Library/Council on Aging	All hazards except changes in groundwater and invasive species	1. Protect Health and Safety 2. Increase Outreach and Education 4. Protect Priority Populations 6. Integrate Climate Change	Library Trustees	Council on Aging	High	$	Staff Time	Less than 1 year	Short-term	No	No
19	Provide access to drinking water from town on public properties (e.g., water fountains, fill stations)	Drought, average/extreme temperatures	1. Protect Health and Safety 2. Increase Outreach and Education 3. Increase Response Capacity 4. Protect Priority Populations 6. Integrate Climate Change	Water Commission	Planning Board, Select Board	Low	$$	Municipal Bond / Grant	2-5 years	Long-term	No	Yes
20	Adapt community activities to seasons/weather (time to avoid natural hazards)	All hazards	1. Protect Health and Safety 2. Increase Outreach and Education 4. Protect Priority Populations 6. Integrate Climate Change 8. Increase Coordination	Emergency Management Director	Cultural Council	Medium	$	Staff Time	Less than 1 year	Short-term	No	No
21	Develop procedure and obtain equipment for fire department to pump basements	Precipitation flooding	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Fire Dept	Emergency Management Director	Medium	$	Staff Time	In Progress	Short-term	No	No
22	Gas / power / energy resilience study	All hazards	1. Protect Health and Safety 3. Increase Response Capacity 5. Consider the Economy 6. Integrate Climate Change 7. Encourage Smart Development 10. Be Sustainable	Emergency Management Director	NMCOG	Low	$$	Grant	1-2 years	Long-term	No	No
23	Regional Coordination for Cow Pond Dam	Precipitation flooding	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change 8. Increase Coordination	Conservation Commisoin	NMCOG	Medium	$	Staff Time	Less than 1 year	Short-term	No	Yes
24	Police Department resilience study	All hazards	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change	Police	Select Board	Low	$$	Grant	1-2 years	Medium-term	No	No
25	Hydrant inventory & code identification	Wildfires	1. Protect Health and Safety 3. Increase Response Capacity	Fire Dept	Emergency Management Director	Medium	$	Staff Time	Less than 1 year	Short-term		No
26	In-person emergency communications plan	All hazards	1. Protect Health and Safety 2. Increase Outreach and Education 6. Integrate Climate Change	Police	Emergency Management Director	Medium	$	Staff Time	Less than 1 year	Short-term	No	Yes
27	Encourage sign ups for outreach systems, priority populations in particular	All hazards	1. Protect Health and Safety 2. Increase Outreach and Education 6. Integrate Climate Change	Select Board	Council on Aging	High	$	Staff Time	Less than 1 year	Short-term	No	No
28	Downtown flooding study	Precipitation flooding, hurricanes	1. Protect Health and Safety 4. Protect Priority Populations 5. Consider the Economy 6. Integrate Climate Change	Road Commission	Select Board, Town Engineer	Medium	$$	Grant	1-2 years	Medium-term	No	Yes
29	Add cell tower for equal service in case of emergencies	All hazards	1. Protect Health and Safety 3. Increase Response Capacity 8. Increase Coordination	Police, Fire	Select Board	Low	$$$	Municipal Bond / Grant	2-5 years	Long-term	No	Yes
30	Beaver management planning	Precipitation flooding	1. Protect Health and Safety 6. Integrate Climate Change	Board of Health	Road Commission Conservation Commission	Medium	$	Operating Budget / Grant	Less than 1 year	Long-term	Yes	Yes

Table 6.4: Dunstable 2024 – 2029 Mitigation Actions

Action #	Action Description	Hazards / Risks Addressed	Goals Addressed	Responsible Party	Partner Agencies	Overall Priority	Cost Estimate	Potential Funding Source(s)	Timeframe to Start	Estimated Timeline for Completion	Integration Status	Integration Opportunity
					Can any stakeholders help carry out the action, and if so, who?	High Medium Low	$ = <$50,000 $$ = $50,000 to <$250,000 $$$ = $250,000 or more	Capital Budget Operating Budget Municipal Bond Grant Staff Time	In Progress Less than 1 year 1-2 years 2-5 years Annual	Short-term Medium-term Long-term	Action Identified in other Local Plan? Yes No	Action could support other local plan or planning mechanism? Yes No
31	Ongoing maintenance of trees surrounding critical facilities, pre storm event	winter weather, hurricanes	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change 8. Increase Coordination	Road Commission	Town Forest Committee	Medium	$	Operating Budget / Grant	Annual	Long-term	No	Yes
32	Resilient Bandstand at Town Common	Average/extreme temperatures	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Select Board	Cultural Council	Low	$$$	Capital Budget / Municipal Bond / Grant	2-5 years	Medium-term	No	No
33	Splash pad at Larter Field	Average/extreme temperatures	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Emergency Management Director	Water CommissionCommunity Preservation Committee	Low	$$$	Capital Budget / Municipal Bond / Grant	2-5 years	Medium-term	No	No
34	Study the Community Rating System to determine appropriateness for Dunstable	Precipitation flooding	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Select Board	NMCOG	Medium	$$	Staff Time / Grant	1-2 years	Short-term	No	Yes
35	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly and those with health issues) can have access to air conditioning or shelter from the cold	Average/extreme temperatures	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Emergency Management Director	Police, Fire, Select Board	Medium	$$	Staff Time / Grant	annual	short-medium term	No	Yes
36	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Precipitation flooding	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Select Board	Road Commission Conservation Commission	High	$	Staff Time / Grant	1-2 years	medium term	No	Yes
37	Incorporate Hazard Mitigation into subdivision regulations, Master Plan, and Open Space Plan updates	All hazards	1. Protect Health and Safety 2. Increase Outreach and Education 5. Consider the Economy 6. Integrate Climate Change 7. Encourage Smart Development 8. Increase Coordination 10. Be Sustainable	Planning Board	Zoning Board of Appeals / Conservation Commission / Master Plan Committee	Medium	$	Staff Time	Less than 1 year	Short-term	No	Yes
38	Participate in DCR's Fire Wise Program for the forested sections of town	Wildfires	1. Protect Health and Safety 4. Protect Priority Populations 6. Integrate Climate Change	Fire Dept	Town Forest Committee	Medium	$	Staff Time	Annual	Long-term	No	Yes
39	Ensure that administrators of schools, businesses, and municipal buildings have a shelter plan in the event of a tornado warning	Tornados	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change 8. Increase Coordination	Schools	Police / Fire	High	$	Staff Time / Grant	Annual	Long-term	No	Yes
40	Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event	All hazards	1. Protect Health and Safety 3. Increase Response Capacity 6. Integrate Climate Change 8. Increase Coordination	Select Board	NMCOG	High	$	Staff Time	Annual	Long-term	No	Yes

7

7. Plan Maintenance

Hazard Mitigation Plans are intended to serve as living documents. In order to be impactful, they must be regularly updated to reflect the current state of hazards, vulnerabilities, goals, strategies, and public sentiment. The three main components of plan maintenance are: *monitoring*, *evaluating*, and *updating* the plan.

Included in this chapter is a multi-pronged strategy to always keep the HMP as effective as possible. Monitoring, evaluating, and updating the plan will be intertwined with public engagement, integration with other local, regional, and state planning mechanisms, and plan implementation. These processes will run on an ongoing basis with the expectation there is coordination and collaboration between monitoring, evaluating, and updating the plan.

The Town Administrator with the Select Board's guidance and oversight, will:

- Track the progress of the HMP Mitigation Actions and MVP (see Section 7.1);
- Reconvene the Core Team annually to monitor, evaluate, update, and integrate the plan (see Section 7.1, 7.2, 7.3, and 7.4);
- Share HMP and MVP progress with the public once a year (see Section 7.5);
- Make all monitoring information publicly available (see Section 7.1);
- Notify the public when new information has been posted or updated (see Section 7.5; and
- Provide the public opportunities to give input on this information (see Section 7.5).

7.1. Monitoring the Plan

According to FEMA, monitoring means tracking the implementation of the HMP and MVP Plan over time.

Who: The Town Administrator will take ownership of monitoring the plan.

How: The Town Administrator will monitor the status of mitigation actions (Chapter 6) through an internal tracking system using Excel. This should be made publicly available.

When: Monitoring will take place on an ongoing basis with annual meetings to formally update the status of Mitigation Actions and complete the MVP. In advance of this meeting, the Town Administrator will send out notices to the Core Team that will include a shared document where all Core Team members can collaborate to review status of mitigation actions and identify any new mitigation actions that may be under consideration or in progress as part of ongoing Town efforts.

7.2. Evaluating the Plan

According to FEMA, evaluating means assessing the effectiveness of the plan at achieving its stated purpose and goals.

Who and When: The Core Team will meet annually to evaluate the effectiveness of the plan. The Core Team may also be called to meet after a major event or storm to evaluate the effectiveness of the plan.

How: The Core Team will:

- Review the 2024 HMP Goals; and
- Discuss how mitigation actions are or are not meeting 2024 HMP Goals and where improvements or adjustments may be needed (e.g., re-prioritization of projects, integrating with other planning processes more effectively, adding new data to climate projections, etc.

7.3. Updating the Plan

The following discusses plan updates under three circumstances:

- Maintaining eligibility with FEMA
- Major disasters
- MVP requirements

7.3.1. | Plan Updates to Maintain FEMA Funding Eligibility

According to FEMA, updating means reviewing and revising the HMP at least once every five years.

Hazard Mitigation Plans expire five years from the date approved by FEMA. To maintain eligibility for certain types of non-emergency disaster assistance from FEMA, an entity such as the Town of Dunstable must have an approved active Hazard Mitigation Plan.

Hazard Mitigation Plans should be reviewed and updated at least every five years. The Town Administrator will initiate the process to complete a comprehensive update to the HMP. As a best practice, the comprehensive update should be initiated approximately 18 months prior to this HMP's expiration. This process generally includes:

- Re-engaging the Core Team;

- Considering expansion of the Core Team;
- Confirming FEMA's and MEMA's most recent requirements and guidance;
- Gathering updated information and relevant documents;
- Defining a list of stakeholders (such as the Stakeholders discussed in Chapter 2);
- Initiating an outreach and engagement process;
- Undertaking the planning steps to prepare required Hazard Mitigation Plan sections; and
- Completing and reviewing the draft Plan and submitting for approval.

The Town may elect to complete this process in-house or with guidance from an outside contractor.

7.3.2. | Plan Updates Due to Major Disaster Events or New Conditions

FEMA recommends that HMPs also be revisited and updated after a major disaster event (a State or Federally declared disaster) or if new conditions significantly change risk (such as new climate projections or local risk and vulnerability assessment efforts). The Town Administrator will initiate the process to complete any updates needed in these circumstances. The decision to update the plan will be based on the annual monitoring and evaluation process.

7.3.3. | Plan Updates to Address MVP Requirements

The MVP Summary of Findings must be reviewed and updated annually. The Town must use EEA's latest annual report template and submit the annual report to the Regional Coordinator once a year, at the end of the Town's fiscal year.

7.4. Integrating the MVP-HMP

In order to be impactful, the MVP-HMP must be effectively integrated into other Town planning mechanisms. This will increase co-benefits of hazard mitigation projects, streamline planning and implementation activities, and help secure funding for mitigation projects

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Integrating the ideas, information, and strategy of a mitigation plan into other planning mechanisms can be achieved through plan integration. Plan integration involves a two-way exchange of information and incorporation of ideas and concepts between hazard mitigation plans and other planning mechanisms. Some ways Dunstable can integrate the ideas, information, and strategy of a mitigation plan into other planning mechanisms are:

- **Next Master Plan and Open Space Plan:** Community planning mechanisms can be integrated into hazard mitigation plans to ensure that community needs and concerns are considered when developing hazard mitigation strategies.
- **Building and Zoning Regulations:** The local hazard mitigation plan can integrate with building and zoning regulations, if they are being updated, to ensure that new construction and development are designed to withstand potential hazards.

- **Partnerships:** Developing strong partnerships between planners and emergency managers in neighboring communities can help to fully integrate land use and hazard planning efforts

Integration will be a topic of discussion at each annual update meeting. MVP-HMP goals and mitigation actions will be integrated into other Town planning mechanisms. At each annual Core Team meeting, there will be an update on the progress of integration of mitigation actions into relevant planning mechanisms and a discussion of other planning mechanisms that should be integrated into the next five-year HMP update.

7.5. Public Participation throughout Plan Maintenance

Public engagement is a critical part of the plan maintenance process. Public input, education, and support are crucial to ensuring that the plan is effective, equitable, and impactful.

A coordinated public engagement effort will be led by the Town Administrator.

The public survey indicated that residents would like to be informed about future plan updates via emails from the Town, fact sheets on the Town website, or social media.

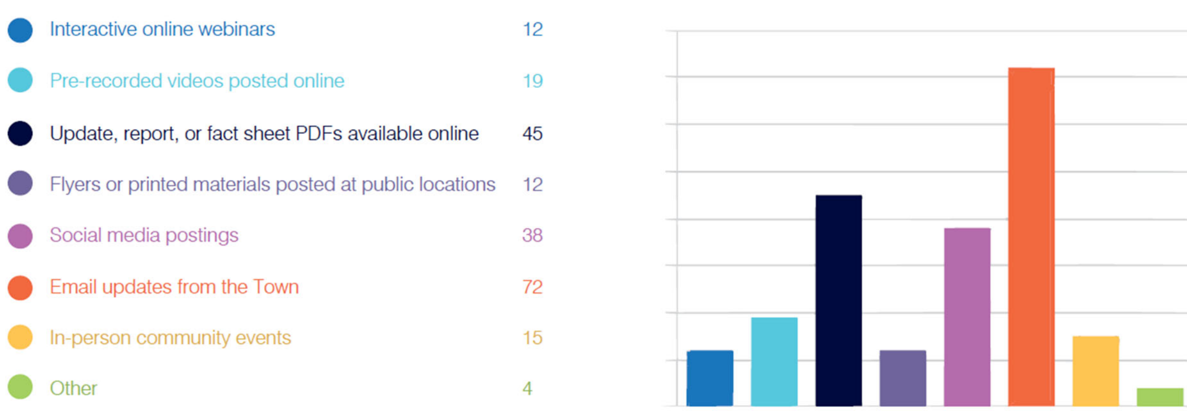

Figure 7.1: Community feedback related to best methods to receive information on hazard mitigation

The Town anticipates undertaking the following public outreach and engagement activities in alignment with the annual evaluation, monitoring, and plan update meetings, as well as with large storms or events at the discretion of the Core Team and Town Administrator.

- **Public Education:** The Town will annually provide:
  - A website update on the HMP-MVP;
  - A brief update to the Select Board and a public meeting; and

    - An email blast and social media posts to advertise the website and Select Board update.

- **Public Input:** Each year,
    - Attendees to the Select Board meeting can provide input and ask questions
    - Interested parties will be invited to attend the Core Team annual update meeting to provide input on the HMP-MVP progress.

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8. Adoption

Once the draft of the Dunstable Hazard Mitigation Plan is reviewed by the Core Team, Stakeholders, and the general public, the Plan is reviewed by MEMA and FEMA. When the Plan is finally approved by FEMA, it enters into the five year “maintenance” phase. In addition, because this is a combination MVP Summary of Findings Report, EEA will review the plan for consistency with MVP requirements.

This Section describes the timeline for plan adoption and includes documentation of the Plan adoption by the Board of Selectmen.

8.1. Timeline for Plan Adoption

The timeline for Plan Adoption is as follows:

The Dunstable Hazard Mitigation Plan 2024 Update was submitted to MEMA and EEA	Date TBD
MEMA reviewed the Plan and returned it to the Town with required edits	Date TBD
The Dunstable Hazard Mitigation Plan was submitted to FEMA for final review	Date TBD
FEMA issued an Approved Pending Adoption status	Date TBD
The Select Board officially adopted the Hazard Mitigation Plan 2024 Update during a regularly scheduled meeting.	Date TBD

8.2. Plan Adoption

The Certificate of Adoption is provided on the following page.

TOWN OF DUNSTABLE, MASSACHUSETTS
RESOLUTION NO. _____________

A RESOLUTION OF THE TOWN OF DUNSTABLE ADOPTING THE 2024 HAZARD MITIGATION PLAN UPDATE

WHEREAS the Board of Selectmen recognizes the threat that natural hazards pose to people and property within the Town of Dunstable; and

WHEREAS the Town of Dunstable has prepared a multi-hazard mitigation plan, hereby known as the Town of Dunstable 2024 Hazard Mitigation Plan Update, in accordance with federal laws, including the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended; the National Flood Insurance Act of 1968, as amended; and the National Dam Safety Program Act, as amended; and

WHEREAS the Town of Dunstable 2024 Hazard Mitigation Plan Update identifies mitigation goals and actions to reduce or eliminate long-term risk to people and property in the Town of Dunstable from the impacts of future hazards and disasters; and

WHEREAS the Board of Selectmen authorizes Departments to executive their responsibilities demonstrated in the 2024 Hazard Mitigation Plan Update; and

WHEREAS adoption by the Board of Selectmen demonstrates its commitment to hazard mitigation and achieving the goals outlined in the Town of Dunstable 2024 Hazard Mitigation Plan Update; now therefore be it

Resolved: That in accordance with M.G.L. 40 §4 or the charter and bylaws of the Town of Dunstable, the Board of Selectmen adopts the Town of Dunstable 2024 Hazard Mitigation Plan Update. While content related to the Town of Dunstable may require revisions to meet the plan approval requirements, changes occurring after adoption will not require the Town of Dunstable to re-adopt any further iterations of the plan. Subsequent plan updates following the approval period for this plan will require separate adoption resolutions.

ADOPTED by a vote of ____ in favor and ____ against, and ____ abstaining, this _____ day of ___________, 2024.

By: _________________________________ (print name)

ATTEST: By: _________________________________ (print name)
APPROVED AS TO FORM: By: _________________________________ (print name)