Leyden Community Resilience Building and Hazard Mitigation Plan

Adopted by the Leyden Select Board on October 11, 2022

Approved by FEMA on October 18, 2022

Prepared by
Leyden Core Team
(Local Planning Team)

and

Franklin Regional Council of Governments
12 Olive Street, Suite 2
Greenfield, MA 01301
(413) 774-3167
www.frcog.org

This project was funded by a grant received from the Massachusetts Office of Energy and Environmental affairs.

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

FEMA

October 18, 2022

Dawn Brantley, Acting Director
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, Massachusetts 01702-5399

Acting Director Brantley:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division has approved the Leyden Community Resilience Building and Hazard Mitigation Plan effective **October 14, 2022** through **October 13, 2027** in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

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

The plan must be updated and resubmitted to the FEMA Region I Mitigation Division for approval every five years to remain eligible for FEMA mitigation grant funding.

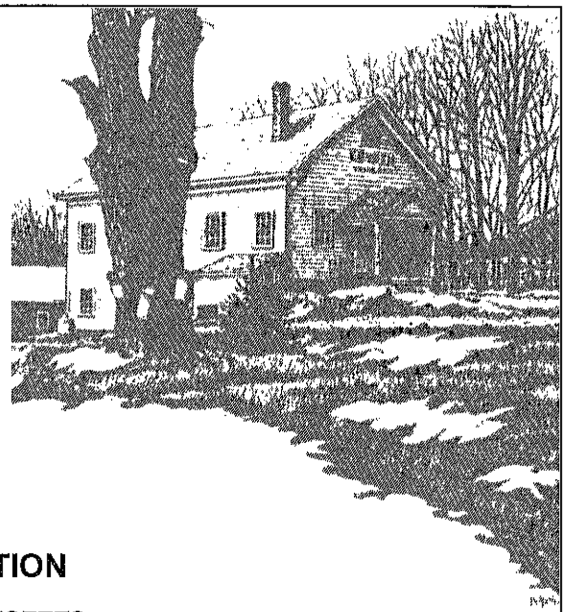
Thank you for your continued commitment and dedication to risk reduction demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please contact Brigitte Ndikum-Nyada at (617) 378-7951 or brigitte.ndikum-nyada@fema.dhs.gov.

Sincerely,

Paul F. Ford
Deputy Regional Administrator
DHS, FEMA Region I

PFF: bnn

cc: Jeffrey Zukowski, Hazard Mitigation Planner, MEMA
Marybeth Groff, CFM, Hazard Mitigation & Climate Adaptation Coordinator
Beth Dubrawski, Hazard Mitigation Contract Specialist, MEMA



CERTIFICATE OF ADOPTION

Town of Leyden, **MASSACHUSETTS**

SELECT BOARD

A RESOLUTION ADOPTING THE Town of Leyden

LEYDEN COMMUNITY RESILIENCE BUILDING AND HAZARD MITIGATION PLAN

WHEREAS, the Town of Leyden established a Committee to prepare the 2022 Leyden Community Resilience Building and Hazard Mitigation Plan; and

WHEREAS, the Town of Leyden Community Resilience Building and Hazard Mitigation Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Leyden and

WHEREAS, a duly-noticed public meeting was held by the SELECT BOARD on May 18,2022 and

WHEREAS, the Town of Leyden authorizes responsible departments and/or agencies to executes their responsibilities demonstrated in the plan, and

NOW, THEREFORE BE IT RESOLVED that the Town of Leyden SELECT BOARD adopts the 2022 Leyden Community Resilience Building and Hazard Mitigation Plan, in accordance with M.G.L. Ch. 40.

ADOPTED AND SIGNED October 11, 2022.

William Glabach	Katherine DiMatteo	Glenn Caffery
Chair, Leyden Select Board	Leyden Select Board	Leyden Select Board

Office of the Board of Selectmen
TOWN OF LEYDEN
7 Brattleboro Road, Leyden, Massachusetts 01337 413-774-4111

Acknowledgements

The Leyden Select Board thanks the Leyden Core Team (Local Planning Team) for their work on this project.

Michele Giarusso, Municipal Assistant
Elizabeth Kidder, Public Safety Advisory Committee Chair
Barbara Wallace, Public Safety Advisory Committee Member
William Brooks, Highway Department Superintendent
Erica Jensen, Selectboard Member
Bill Glabach, Selectboard Chair
Katherine DiMatteo, Town Moderator

The Leyden Select Boards offer thanks to the Massachusetts Emergency Management Agency (MEMA) for developing the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, which served as a resource for this plan. Technical assistance was provided by staff of the Franklin Regional Council of Governments.

Peggy Sloan, Director of Planning & Development
Kimberly Noake MacPhee, Land Use & Natural Resources Program Manager
Allison Gage, Senior Land Use & Natural Resources Planner
Tamsin Flanders, Land Use & Natural Resources Planner
Ryan Clary, Senior GIS Specialist

Recommended Citation
Town of Leyden. (2022) *Town of Leyden Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan*. Franklin Regional Council of Governments.

Cover photo courtesy of David Rainville of the Greenfield Recorder

Contents

Table of Tables

Table of Figures

1 PLANNING PROCESS

1.1 INTRODUCTION

The Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA) define Hazard Mitigation as any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards such as flooding, storms, high winds, hurricanes, wildfires, earthquakes, etc. Mitigation efforts undertaken by communities will help to minimize damages to buildings and infrastructure, such as water supplies, sewers, and utility transmission lines, as well as natural, cultural and historic resources. The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) supports climate change resiliency planning and implementation of priority projects through the Municipal Vulnerability Preparedness grant program (MVP). Communities who complete vulnerability assessments and develop action-oriented resiliency plans through the MVP planning process become certified as an MVP community and are eligible for MVP Action grant funding and other opportunities. Funding for planning work is awarded to communities by the State. This plan covers the elements of hazard mitigation planning, as well as MVP planning to ensure the Town of Leyden is building resilience against the impacts of climate change.

Planning efforts, like the one undertaken by the Leyden, make mitigation a proactive process. Pre-disaster planning emphasizes actions that can be taken before a natural disaster occurs. Future property damage and loss of life can be reduced or prevented by a mitigation program that addresses the unique geography, demography, economy, and land use of a community within the context of each of the specific potential natural hazards that may threaten a community. In this combined plan, the vulnerability assessment produced through multi-hazard mitigation planning is complemented by the MVP process, which also inventories the emergency preparedness and response capacities of Leyden.

Preparing and updating a hazard mitigation plan every five years can save the community money and facilitate post-disaster funding. Costly repairs or replacement of buildings and infrastructure, as well as the high cost of providing emergency services and rescue/recovery operations, can be avoided or significantly lessened if a community implements the mitigation measures detailed in the plan.

FEMA requires that a community adopt a pre-disaster mitigation plan as a condition for mitigation funding. For example, the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance Program (FMA), and the Building Resilient Infrastructure and Communities Program (BRIC) are programs with this requirement.

1.2 CORE TEAM

Producing the Leyden Hazard Mitigation and MVP Preparedness Plan involved a core team comprised of the following members:

- Michele Giarusso, Municipal Assistant, Project Lead
    - Michele was responsible for organizing meetings, posting notices and project materials on the MVP webpage on the Town website, and reviewing deliverables.

- Elizabeth Kidder, Public Safety Advisory Committee Chair
- Barbara Wallace, Public Safety Advisory Committee Member
    - Elizabeth and Barbara attended all meetings as representatives of the Public Safety Advisory Committee. The Public Safety Advisory Committee is charged with the task of reviewing the Public Safety needs of Leyden in order to make recommendations to the Selectboard designed to ensure that Leyden has the most efficient and effectively run public safety services possible. These services include: police, fire, emergency medical, and emergency management.

- William Brooks, Highway Department Superintendent
    - Bill attended all meetings and reported on hazards that affect the Town's roadways and emergency response operations and ideas for potential projects to mitigate the impacts of natural hazards and climate change.

- Erica Jensen, Selectboard Member
- Bill Glabach, Selectboard Chair
- Katherine DiMatteo, Town Moderator
    - Erica, Bill, and Katherine attended all meetings and were liaisons between their respective boards and the work of the Core Team. These Core Team members shared their boards' concerns and priorities regarding hazard mitigation, climate resiliency, vulnerable populations and threats to infrastructure, natural resources and public health from natural hazards and climate change. Their input allowed for coordination amongst town Boards, and ensured the Action Plan reflects the needs and priorities of the Town.

The Planning process for the Town included the following tasks:

- Hosting a kick-off meeting with local and regional stakeholders to introduce the Community Resilience Building (CRB) workshop and the MVP Program.
- Hosting a Community Resilience Building (CRB) workshop with local and regional stakeholders who identified Leyden's key natural and manmade hazard vulnerabilities and strengths and proposed actions to build infrastructural, social, and environmental resilience to climate change.
- Reviewing and incorporating existing plans and other information including changes in development in the years since the Town's previous hazard mitigation planning process
- Updating the natural hazards that may impact the community from the previous plan.
- Conducting a Vulnerability/Risk Assessment to identify the infrastructure and populations at the highest risk for being damaged by the identified natural hazards, particularly flooding.
- Identifying and assessing the policies, programs, and regulations the community is currently

implementing to protect against future disaster damages.
- Identifying deficiencies in the current hazard mitigation strategies and establishing goals for updating, revising, or adopting new strategies.
- Adopting and implementing the final updated Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan.

The key products of this planning process are the development of a Summary of Findings Report, an Action Plan with a Prioritized Implementation Schedule, a set of maps and matrices summarizing strengths and vulnerabilities of Leyden' infrastructure, societal, and natural resource risk profiles, and prioritized community actions that reduce or eliminate long term vulnerability to identified hazards and climate change.

Meetings

February 9, 2022
The Core Team hosted a public meeting met to kick off the project, plan for the MVP workshop, and begin updating the Hazard Mitigation Plan.

March 22, 2022
Held a first Community Resilience Building workshop as part of the Municipal Vulnerability Preparedness (MVP) designation process. The objectives of the workshop were to:
- Present findings from community outreach
- Define the top natural and climate-related hazards of local concern
- Identify existing and future strengths and vulnerabilities

April 19, 2022
Held a second Community Resilience Building workshop as part of the Municipal Vulnerability Preparedness (MVP) designation process. The objectives of the workshop were to:
- Develop prioritized actions for the community
- Identify immediate opportunities to collaboratively advance actions to increase resilience.

April 19, 2022
The Core Team met to complete the Hazard Identification and Risk Analysis.

May 18, 2022
A public review period for the draft plan was open from May 16, 2022 through May 30, 2022. A public forum was held on May 18th via Zoom to elicit feedback on the draft mitigation strategies and plan.

Agendas and sign-in sheets for each meeting can be found in Appendix A. While not all members of the Core Team were able to attend each meeting, all members collaborated on the plan and were updated on progress by fellow team members after meetings occurred.

Local and Regional Agencies Involved in Planning Activities

In March and April 2022, Leyden held a series of Community Resiliency Building workshops. The workshops were part of the Massachusetts Municipal Vulnerability Preparedness (MVP) designation program. The workshops were critical to enabling participants to think about and engage across different sectors. The Municipal Assistant, Highway Superintendent, members of the Public Safety Advisory Committee, Select Board, Board of Health, Finance Committee and residents, all came together to determine the most threatening hazards to the Town of Leyden and to agree upon high priorities and actions to address them. The Franklin Regional Council of Governments (FRCOG), the regional planning agency for Leyden and all 26 towns in Franklin County, facilitated the MVP workshops.

In addition to the Hazard Mitigation and MVP process, FRCOG regularly engages with the Town of Leyden as part of its regional planning efforts, which include the following:

- Developing the Sustainable Franklin County Plan, which advocates for sustainable land use development.

- Developing and implementing the Franklin County Comprehensive Economic Development Strategy, which includes goals and strategies to build the region’s economic resilience.

- Developing the Franklin County Regional Transportation Plan and Franklin County Regional Pedestrian Plan, which includes a focus on sustainability and climate resilience, and implementing the Franklin County Transportation Improvement Program to complete transportation improvements in our region.

- Planning in the Deerfield River Watershed, including the Deerfield River Watershed Based Plan and A Framework for Resilience in th Deerfield Watershed.

- FRCOG Emergency Preparedness Program staff work with four regional committees: the Mohawk Area Public Health Coalition, the Franklin County Regional Emergency Planning Committee, the Franklin County Emergency Communications System Oversight Committee, and the Western Mass. Health and Medical Coordinating Coalition. Working with these committees and with local governments, the FRCOG works to provide integrated planning and technical assistance to improve and enhance our communities’ ability to prepare for, respond to, and recover from natural and man-made disasters.

All of these FRCOG initiatives consider the impact of natural hazards on the region and strategies for reducing their impact to people and property through hazard mitigation activities. The facilitation of the Leyden Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan by FRCOG ensured that information from these plans and initiatives were incorporated into the Hazard Mitigation Planning process.

Agencies that Have the Authority to Regulate Development

The Planning Board is the primary Town agency responsible for regulating development in town. In addition, the Franklin Regional Council of Governments, as the Regional Planning Agency, collaborates with all agencies that regulate development in Leyden, including the municipal entities listed above and state agencies.

Participation by the Public, Businesses, and Neighboring Communities

The plan development and public meetings were advertised on the Town's websites and were posted at the Town Offices and at other designated public notice buildings. A copy of the draft plan was available to the public on the Town's website at www.townofleyden.com.

A public forum was held on May 16, 2022 and provided an opportunity for the public and other stakeholders to provide input on the mitigation strategies and to prioritize action items. Stakeholder letters were sent to Town boards, committees, and departments, and to the neighboring communities of Colrain, Bernardston, and Greenfield, inviting them to the public forum and to review the plan and provide comments. The public forum and subsequent comment period was advertised via a press release in the Greenfield Recorder and on the Town website. The final Public Comment Period was held from May 16 to May 30, 2022 (See Appendix A, Public Participation Process, for copies of all press releases and stakeholder letters mailed to solicit comments on the draft Plan). No comments were received during the Public Comment Period.

The Core Team and FRCOG staff reviewed and incorporated the following existing plans, studies, reports and technical information, which are cited in footnotes throughout this plan:

- 2010 Leyden Open Space and Recreation Plan
- 2014 Leyden electronic Comprehensive Emergency Management Plan (eCEMP)
- 2016 Leyden Hazard Mitigation Plan
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- 2018 High Risk Stream Crossings in Lfeyden, MA
- 2021 Town of Leyden Culvert Assessment
- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Additional data sources cited in footnotes throughout this Plan

2 LOCAL PROFILE AND PLANNING CONTEXT

2.1 COMMUNITY SETTING

The Town of Leyden is situated in north-central Franklin County, along the Vermont border. The hills of the Green Mountain Range rise around the town and the Green River runs along its western border. It is is bordered by Guilford, Vermont to the north, Bernardston to the east, Greenfield to the south; and Colrain to the west.

Agriculture, waterpower, and a remote upland location have all had an influence on the development and growth of Leyden as a small rural hill town. The Town was established as a separate district in 1784 and incorporated as a town in 1809. Development of a town center was fairly late in Leyden, as the town's steep hills did not offer the rich farmland found in surrounding valley floodplains.

Even so, agriculture has played a prominent role in Leyden throughout its history. While the town lacked extensive high quality cropland, pastureland covered many hillsides. Sheep, beef, pork, dairy, and poultry farming were important agricultural enterprises. In time, agriculture waned as the primary economic life style for Leyden, as residents sought employment and economic security outside of town boundaries.

Waterpower has had a less obvious influence on the town's development, because large manufacturing enterprises were never built within Leyden. However, small saw and gristmills were powered by the town's swiftly moving waters in a number of locations until the late 1800s. Water powered industry faded with the development of other energy sources.

Land Cover
In May 2019, MassGIS released a new land cover/land use dataset. This statewide dataset contains a combination of land cover mapping from 2016 aerial and satellite imagery, LiDAR and other data sources. Land use mapping is derived from standardized assessor parcel information for Massachusetts. This land cover/land use dataset does not conform to the classification schemes or polygon delineation of previous land use data from MassGIS (1951-1999; 2005) so comparisons of land use change over time can't be made using this current data.[1]

The 2016 MassGIS land cover/land use dataset shown in Table 2-1 reveals the relationship between land cover and land use in Leyden.

[1] https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use

Table 2-1: Leyden 2016 MassGIS Land Cover and Land Use Data				
Total Acres = 11,497				
Land Cover	**Acres**		**Land Use**	**Acres**
Bare Land	74		Agriculture	1,278
Cultivated	26		Commercial	2
Deciduous Forest	3,387		Forest	719
Developed Open Space	235		Industrial	4
Evergreen Forest	6,062		Mixed use, other	189
Grassland	401		Mixed use, primarily residential	2,471
Impervious	167		Open land	2,255
Palustrine Aquatic Bed	1		Recreation	659
Palustrine Emergent Wetland	72		Residential - multi-family	191
Palustrine Forested Wetland	70		Residential - single family	1,912
Palustrine Scrub/Shrub Wetland	10		Right-of-way	273
Pasture/Hay	986		Tax exempt	1,515
Scrub/Shrub	14		Unknown	2
Water	46		Water	28

Approximately 82% of Leyden's land cover is forest. Another approximately 9% of the town is classified as agricultural cover (cultivated or pasture/hay). Agricultural land use constitutes 11% of Leyden's land area, the additional 2% of agricultural use being maple syrup production. Residential land use comprises 18% of Leyden, with much of that land use in forest cover. Less than 0.01% of the total area in town is comprised of commercial or industrial land uses.

Population Characteristics

According to the 2019 American Community Survey (ACS), there are 710 residents in Leyden (no change since 2010 and a 1.2% decrease since 2000). Nearly 21% of Leyden residents are over the age of 65. Leyden contains 283 households and has a population density of 39.5 people per mile. Median income levels among residents are significantly higher than the average for Franklin County, at an estimated $79,886 in 2019.[1]

Environmental Justice Populations

The State of Massachusetts defines an environmental justice community if any of the following conditions are met:

- Block group whose annual median household income is equal to or less than 65% of the statewide median ($62,072 in 2010); or

[1] American Community Survey 5-Year Population Estimates, 2015-2019

- 25% or more of the residents identifying as minority; or
- 25% or more of households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

According to these criteria, Leyden does not currently have any environmental justice populations based on race, income, or language proficiency. An estimated 100% of the town's population is white. At $79,886, the annual median household income in Leyden is above 65% of the state's annual median household income of $68,563. And as of 2019, approximately 10 households have LEP speakers.

Current Development Trends

Between 1971 and 1999, the town experienced an increase of residential land use on lots greater than a half-acre. The development of new single-family housing along existing public ways spread along many of Leyden's roads, but was most dense along West Leyden Road, East Hill Road, Alexander Road, Kately Hill Road, Eden Trail Road, Greenfield Road, South Schoolhouse Road, and River Road. Though the development of new houses slowed in the 2000s, most of the new residential construction over the years has continued to take place on lots larger than two acres in size and the majority of this construction has been for single-family housing development. Between 2000 and 2010, despite a decline in population, 33 residential building permits were issued, all for single-family homes. According to information provided by the Franklin County Cooperative Inspection Program, between January 1, 2012 and December 31, 2021, eight residential building permits for new construction were issued and one residential building permit for a replacement structure was issued.

Table 2-2 provides a summary of new residential permits issued over the past ten years.

Table 2-2: New residential permits issued in Leyden 2011-2020	
Year	**# of building permits issued**
2012	1
2013	2
2014	1
2015	0
2016	1
2017	0
2018	1
2019	2
2020	1 (replacement)
2021	0
Total	**9**

FRCOG staff reviewed the addresses of the building permits and determined, based on information described below, that the new development occurred outside of known hazard areas such as floodplains and followed the recent pattern of development outside of Leyden Center.

According to 2016 MassGIS land use data, 165 acres lie within the 100-year floodplain in Leyden and three (3) dwelling units are located on 3.5 acres of floodplain. Using this number and Leyden's estimated average household size (2.51 persons per household), it is estimated that 7.5 people, or 0.01% of Leyden's total population, resides in the floodplain. All 0.6 acres of commercial land use in town is also within the floodplain, as well as 0.29 acres of public/institutional land uses. There is no industrial land use in the floodplain.

Newer Mass GIS land use/land cover data from 2016 indicate no change in the number of acres in the floodplain in Leyden or in the number of dwelling units located within the floodplain. However, the two land use data sets – 2005 and 2016 – utilize different methodologies and cannot be directly compared. As noted below, FEMA is currently updating the floodplain maps for Leyden. FRCOG's analysis is limited by Franklin County's lack of digital floodplain maps. Once the update is complete, a more accurate understanding of any recent development within the floodplain will be possible.

The small amount of development that has occurred in Leyden since the previously approved plan is outside known hazard prone areas and is not expected to increase the town's overall vulnerability to flooding or other hazards. To assess and update the community's vulnerability to hazard events, the Core Team completed an exercise to discuss the results of the Risk Assessment (see Section 3) and used the results to update the Overall Hazard Vulnerability Rating for each hazard. The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, the anticipated probability of occurrence, severity of impacts, and area of occurrence for each hazard given historical and climate change data, and a discussion of the type and location of current development trends and new development in town, and other local knowledge.

There are no significant transportation corridors in Leyden. Leyden is home to a network of local roads used mostly by residents going to and from their homes and the few local businesses. As with many rural communities, the transport of people and goods is limited. The Town's current zoning and steep topography limit future expansion of roads. The layout and road widths within the current road network limit the use of these local roads for commercial transport. And the town's distance from major employment centers furthermore reduces the likelihood of any significant development pressure in the future.

Leyden is comprised of a single zoning district, the Residential-Agricultural District. A Floodplain Overlay District applies in the FEMA-mapped floodplain. In 2014, Leyden's zoning was revised to encourage creative and flexible development of new homes in a way that fits into the rural character of town and permanently preserves open space. The Natural Resource Protection Zoning (NRPZ) bylaw allows for smaller lot sizes and utilizes a conservation analysis to determine where on a parcel homes should be located to avoid impacts to natural resources. According to the bylaw, "The Town wishes to encourage the use of NRPZ because it results in the preservation of contiguous open space and important environmental resources, while allowing design flexibility. NRPZ reduces development impacts on farmland, forests, wildlife habitat, large tracts of contiguous open space, environmentally sensitive areas, steep slopes, hilltops, and historically significant areas.” Natural Resource Protection Zoning is allowed by right, and must be used for new subdivisions outside of a quarter mile radius of Town Hall, also called the “Center Village District,” unless the project is issued a Special Permit by the Planning Board. Eighty% of the parcel must be permanently preserved as open space.

National Flood Insurance Program Status

Leyden is a participating member of the National Flood Insurance Program. Currently there no flood insurance policies in effect and no losses have been paid in Leyden. Leyden’s Flood Insurance Rate Map (FIRM) was issued in 1975. The Town complies with the NFIP by enforcing floodplain regulations, and providing the floodplain maps for public review and use. Other strategies to mitigate flood related hazards are included in Section 4.2 and Table 4-1. Table 4-1 includes a fully summary of all Zoning Bylaws relevant to mitigating floods. Additionally, the Town of Leyden recognizes their current Floodplain Bylaw requires updates to meet current NFIP standards. The Town will work to update this bylaw using the Massachusetts 2020 Model Floodplain Bylaw. Updating the Floodplain Bylaw is a High Priority in the 2022 Leyden Hazard Mitigation Prioritized Action Plan.

In 2018, the Federal Emergency Management Agency (FEMA) initiated a 5-10 year process to update the floodplain maps for Franklin County towns, which will primarily involve using recent LiDAR topographic mapping and limited field surveys to create digital floodplain maps and correcting some anomalies in the existing maps (floodplains on the tops of hills) that may be revealed by the LiDAR mapping.

Infrastructure

Most of the infrastructure in Leyden consists of roads and bridges. Leyden’s transportation infrastructure may prove problematic in the case of a natural disaster such as flooding, because some potential evacuation routes run alongside streams and rivers, and may be impassable.

Roads and Highways

Running parallel to the Glen Brook is the Town of Leyden’s principal roadway, Greenfield Road. This is a north-south byway linking Leyden with Greenfield and Franklin County to the south. Greenfield Road intersects with Brattleboro Road near the Town Center and provides a northern link through Guilford, Vermont to Brattleboro, Vermont. Leyden residents gain access to Route 2 through Greenfield. Route 2 is a major east-west highway in northern Massachusetts that intersects with Interstate 91, a major north-south route. Likewise, the Brattleboro connection offers access to Route 9, a major east-west Vermont state road, which links again to Interstate 91, the north-south route. Approximately 69% (24 miles) of Leyden’s roads are gravel.[2]

Rail

There are no rail lines that run through Leyden.

[2] Massachusetts Department of Transportation, 2007.

Public Transportation
There is no regular public transportation in Leyden. The Franklin Regional Transportation Authority (FRTA) provides on-demand transportation for the elderly and people with disabilities.

Public Drinking Water Supply
Leyden has no community groundwater wells. The public water system (PWS) at the Town Offices/former Pearl E. Rhodes Elementary School is categorized as a non-community groundwater well. All Leyden residences and businesses are serviced by private wells. However, Leyden is also the origin of two of Greenfield's principal drinking water sources, the Leyden Glen Reservoir and the Green River.

Sewer Service
There are no public sewer systems in the Town of Leyden. All public and private facilities are served by septic systems.

Internet
As of early 2021, all residents in Leyden who applied for the service had a Fiber-Optic-To-The-Home (FTTH) high-speed internet network connection. The network is owned by the Town and operated by Whip City Fiber, an internet service powered by Westfield Gas & Electric.

Emergency Shelters
Leyden has no designated emergency shelters; Greenfield Community College in Greenfield, a mass care shelter/reception center, is the closest emergency sheltering facility. The Town currently considered the following facilities as places that can accommodate residents for warming and feeding, but they do not have any sheltering, heating, cooling, or feeding plans in place for those facilities:

- Leyden Town Hall
- Leyden Town Offices/ former Pearl Rhodes Elementary School

Leyden Town Hall has a back-up generator, but is poorly insulated. The Town Offices have purchased a generator and have a kitchen.

In the case of activation, warming/feeding facilities will be managed by Leyden Public Safety Advisory Committee. Shelter facilities will be activated at the direction of the EMD or EOC Manager. The Town uses reverse 911, the Emergency Alert System (radio), a battery-run flashing highway/utility sign, emergency vehicles, sirens, and door-to-door canvassing as warning and notification methods to alert residents of emergency conditions and instructions. In the event that shelter capability is needed, Leyden will rely on regional programs. The Town is currently participating in a regional sheltering project coordinated by the Franklin County Regional Emergency Planning Committee (REPC).

The forthcoming emergency management plan should review the available shelters to determine each facility's potential occupancy, accessibility via evacuation routes, susceptibility to hazards (such as floods and high winds), access to back-up utilities, and available supplies. The plan should also outline emergency activation and distribution plans for feeding, heating, cooling, and sheltering.

Natural Resources

Leyden is composed primarily of three north-south upland ranges that are part of the eastern foothills of Vermont's Green Mountains. These uplands generally range between 1,000 and 1,300 feet in elevation, with the highest point being Frizzell Hill (1,310 feet). Because the town has high peaks located not far from open valleys, its topography commands a number of extensive viewsheds. Ball Mountain, 1,250 feet above sea level, offers a view of the Connecticut Valley. From Gates Hill, on the west side of town, a view of the Green Mountains to the north and the Berkshire Mountains to the west can be seen. From North County Road, a view to the northeast includes Mt. Monadnock in New Hampshire.

Steep-walled valleys surround a number of Leyden's brooks and the Green River, along the Town's western border with Colrain. Narrow fertile valleys are interspersed between the upland hills, most notably, Beaver Meadows and an agricultural tract along Glen Brook, south of the village center. The lowest point in town is only 240 feet in elevation, where the Green River crosses into Greenfield.

Water Resources

Leyden contains approximately 96 acres of fresh open water. The majority of the town's land area falls within the Green River Watershed. The Green River Watershed drains 82.8 square miles, including portions Leyden, Bernardston, Shelburne, Greenfield, and Colrain, and five communities in Vermont. The watershed is predominantly forested, though agricultural land is present, and the majority of roads are unpaved.

The Green River forms the border between Colrain and Leyden for 8.5 miles. It boasts an undeveloped river corridor, in part due to its steep terrain and geologic features. Many small brooks contribute to its flow that at one time powered small grist and sawmills. The Green River is part of Greenfield's water supply system; the Greenfield water supply dam is just downstream from the Colrain/Greenfield town line near the covered bridge on Eunice Williams Drive.

There are eight tributaries to the Green River in Leyden. From north to south, these include:

- Thorne Brook
- Harris Brook
- West Hollow Brook
- Hibbard Brook
- Kately Brook
- Brandy Brook
- Glen Brook
- East Glen Brook

There are four brooks in Leyden that drain to the Connecticut River via Bernardston:

- Beaver Meadow Brook

- Keets Brook
- Shattuck Brook
- Couch Brook

There are no large lakes or ponds in Leyden aside from the Leyden Glen Reservoir on Glen Brook, which serves the Town of Greenfield as a drinking water source. According to MassGIS and US Geological Survey documents, Leyden does not contain any areas considered large high-yield aquifers. However, the following areas support low-yield aquifers:

- The entire Green River, especially the three-mile segment between the confluence with Thorne Brook and Kately Brook;
- Green River, from its confluence with Colrain's Browning Brook to the Greenfield town line;
- Thorne Brook northeast of River Road;
- An area approximately one mile long in Beaver Meadow;
- An area approximately one half mile long on Keets Brook, south of the town line with Guildford, Vermont; and
- An area about one and one half miles long on the town's southern border with Greenfield, which is part of the large Greenfield aquifer.

Most of the town's wetlands are associated with the headwaters of brooks. Three prominent wetlands are located along roads: Pelog's Bog, the Brattleboro Road wetland, and the Bell road wetlands.

Forests

Forests constitute the most abundant natural resource in Leyden. According to 2016 MassGIS land use data, Leyden has approximately 9,449 acres of forest, comprising 82% of the town's total land. Large blocks of contiguous forest, found in the northern third and the southeast corner of Leyden, provide both recreational opportunities and critical habitat for many wildlife species. Much of the town's forestland is permanently protected, particularly in the southern and eastern areas of town. This state-owned land includes the Leyden Wildlife Management Area (WMA), consisting of 772 acres owned by the Department of Fish and Game that is located in the far southern area of town. This area is well maintained and has a high recreation value, including opportunities for hiking and hunting. In addition, the Department of Conservation and Recreation owns the Leyden State Forest, a 60-acre parcel located in the north central area of town off North County Road. The State Forest offers opportunities for hunting, hiking, and nature observation

Cultural and Historic Resources

The importance of integrating cultural resource and historic property considerations into hazard mitigation planning is demonstrated by disasters that have occurred in recent years, such as the Northridge earthquake in California, Hurricane Katrina in New Orleans, or floods in the Midwest. The effects of a disaster can be extensive—from human casualty to property and crop damage to the disruption of governmental, social, and economic activity. Often not measured, however, are the possibly devastating impacts of disasters on historic properties and cultural resources. Historic structures, artwork, monuments, family heirlooms, and historic documents are often irreplaceable, and may be lost forever in a disaster if not considered in the mitigation planning process. The loss of these resources is all the more painful and ironic considering how often residents rely on their presence after a disaster, to reinforce connections with neighbors and the larger community, and to seek comfort in the aftermath of a disaster.[3]

Historic properties and cultural resources can be important economic assets, often increasing property values and attracting businesses and tourists to a community. While preservation of historic and cultural assets can require funding, it can also stimulate economic development and revitalization. Hazard mitigation planning can help forecast and plan for the protection of historic properties and cultural resources.

Cultural and historic resources help define the character of a community and reflect its past. These resources may be vulnerable to natural hazards due to their location in a potential hazard area, such as a river corridor, or because of old or unstable structures. The 2014 Leyden CEMP identifies cultural resources in Leyden, some of which contain historic documents and cultural artifacts (Table 2-3).

Table 2-3: 2014 Leyden CEM Plan Cultural Resources

Resource Name	Resource Location	Resource Type	Materials Contained
East Hill Cemetery	East Hill Rd.	Cemetery	
Robertson Memorial Library	849 Greenfield Rd.	Library	Archives
South Cemetery	South Rd.	Cemetery	
West Leyden Cemetery	West Leyden Rd.	Cemetery	

The Massachusetts Cultural Resource Information System (MACRIS)[4] lists a total of 52 areas, buildings, burial grounds, objects, and structures of cultural and/or historic significance in Leyden. The list includes the Leyden United Methodist Episcopal Church, Leyden's cemeteries, the Post Office building, former schoolhouses, and dozens of historic houses. Designation on this list does not provide any protective measures for the historic resources but designated sites may qualify for federal and state funding if damaged during a natural or manmade hazard.

Community Facilities and Resources

A community's critical facilities include important municipal structures (i.e., Town Hall), emergency service structures (i.e., municipal public safety complex, shelters, and medical centers), and locations of populations that may need special assistance (i.e., nursing homes, day cares, schools, prisons) and major employers or other areas where there is a dense concentration of people. In Leyden, the identified critical shown on the Critical Facilities and Infrastructure Map at the end of Section 2 and in Table 2-4

---

[3] Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning, State and Local Mitigation Planning How-To Guide, FEMA 386-6 / May 2005.
[4] http://mhc-macris.net/Results.aspx

below.

Table 2-4: 2022 Leyden Critical Infrastructure	
Resource Type	**Resource Location**
Highway Office and Garage	16 West Leyden Road
Fiber Network Hut	Brattleboro Road across from the Town Offices
Fire Station	16 West Leyden Road
Library	849 Greenfield Road
Police Office	7 Brattleboro Road
Town Hall	16 West Leyden Road
Town Office	7 Brattleboro Road

2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to affect Leyden, and must be accounted for in planning for the mitigation of future hazard events. In 2017, the Commonwealth launched the Massachusetts Climate Change Clearinghouse (Resilient MA), an online gateway for policymakers, planners, and the public to identify and access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of Resilient MA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepare for climate change impacts. Climate projections for Franklin County available through Resilient MA are summarized in this section. Additional information about the data and climate models is available on the Resilient MA website: http://resilientma.org

Figure 2-1 identifies primary climate change impacts and how they interact with natural hazards assessed in the State Hazard Mitigation and Climate Adaptation Plan. Following is a summary of the three primary impacts of climate change on Franklin County: rising temperatures, changes in precipitation, and extreme weather. How these impacts affect individual hazards is discussed in more detail within Section 3: Hazard Identification and Risk Assessment.

Figure 2-1: Climate Change and Natural Hazard Interactions from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan

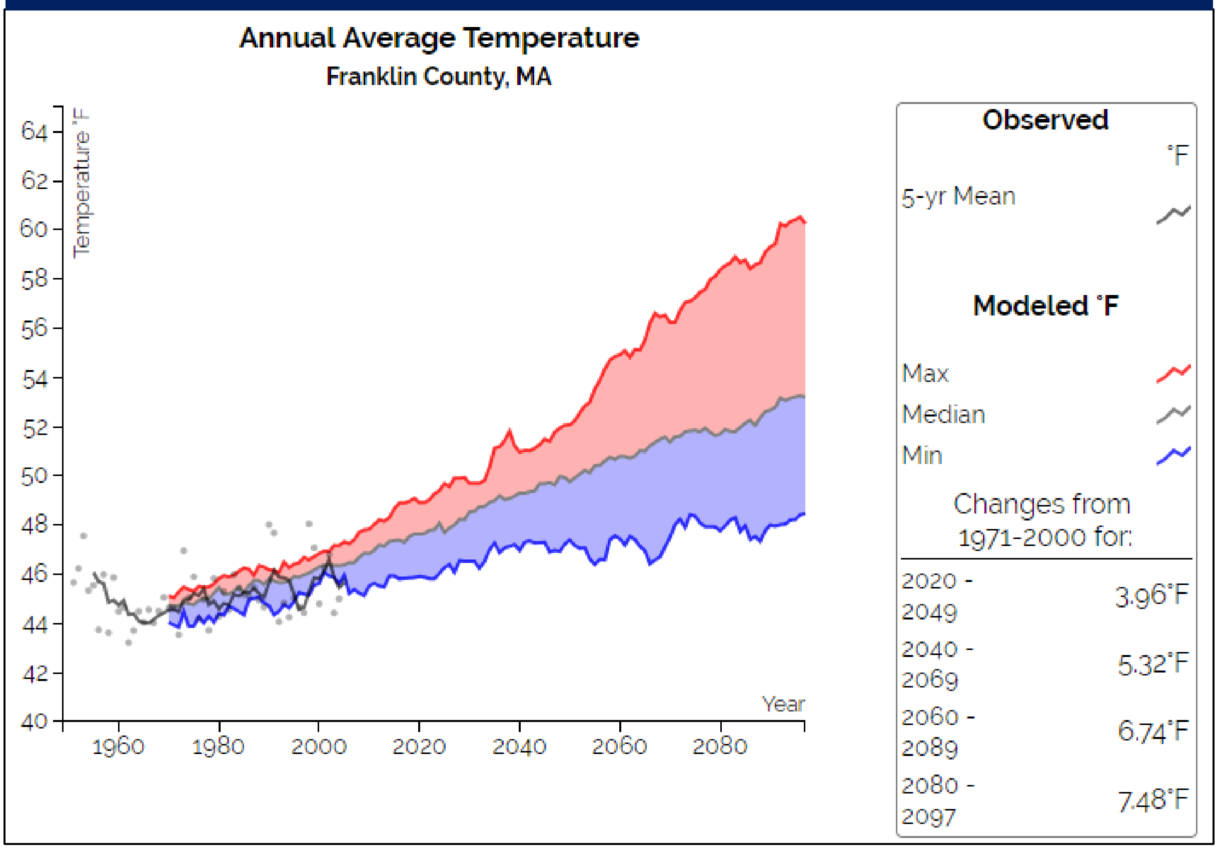
Primary Climate Change Interaction	Natural Hazard	Other Climate Change Interactions	Representative Climate Change Impacts
Changes in Precipitation	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
Sea Level Rise	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss and subsidence of wetlands
	Coastal Erosion	Changes in Precipitation, Extreme Precipitation	
	Tsunami	Rising Temperatures	
Rising Temperatures	Average/Extreme Temperatures	N/A	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, drying of streams and wetlands, eutrophication of lakes and ponds
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
Extreme Weather	Hurricanes/Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm / Nor'easter	Rising Temperatures, Changes in Precipitation	
	Tornadoes	Rising Temperatures, Changes in Precipitation	
	Other Severe Weather (Including Strong Wind and Extreme Precipitation)	Rising Temperatures, Changes in Precipitation	
Non-Climate-Influenced Hazards	Earthquake	Not Applicable	There is no established correlation between climate change and this hazard

Rising Temperatures

Average global temperatures have risen steadily in the last 50 years, and scientists warn that the trend will continue unless greenhouse gas emissions are significantly reduced. The nine warmest years on record all occurred in the last 20 years (2017, 2016, 2015, 2014, 2013, 2010, 2009, 2005, and 1998), according to the U.S. National Oceanographic and Atmospheric Administration (NOAA).

The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (Resilient MA, 2018). Figure 2-2 displays the projected increase in annual temperature by mid-century and the end of this century, compared to the observed annual average temperature from 1971-2000. The average annual temperature is projected to increase from 45.3 degrees Fahrenheit (°F) to 50.6°F (5.32°F change) by mid-century, and to 52.8°F (7.48°F change) by the end of this century. The variation in the amount of change in temperature shown in Figure 2-4 is due to projections that assume different amounts of future GHG emissions, with greater change occurring under a higher emissions scenario, and less change occurring under a lower emissions scenario. For example, under a high emission scenario, the annual average temperature by the end of the century could be as high as 60°F.

Figure 2-2: Projected Annual Average Temperature



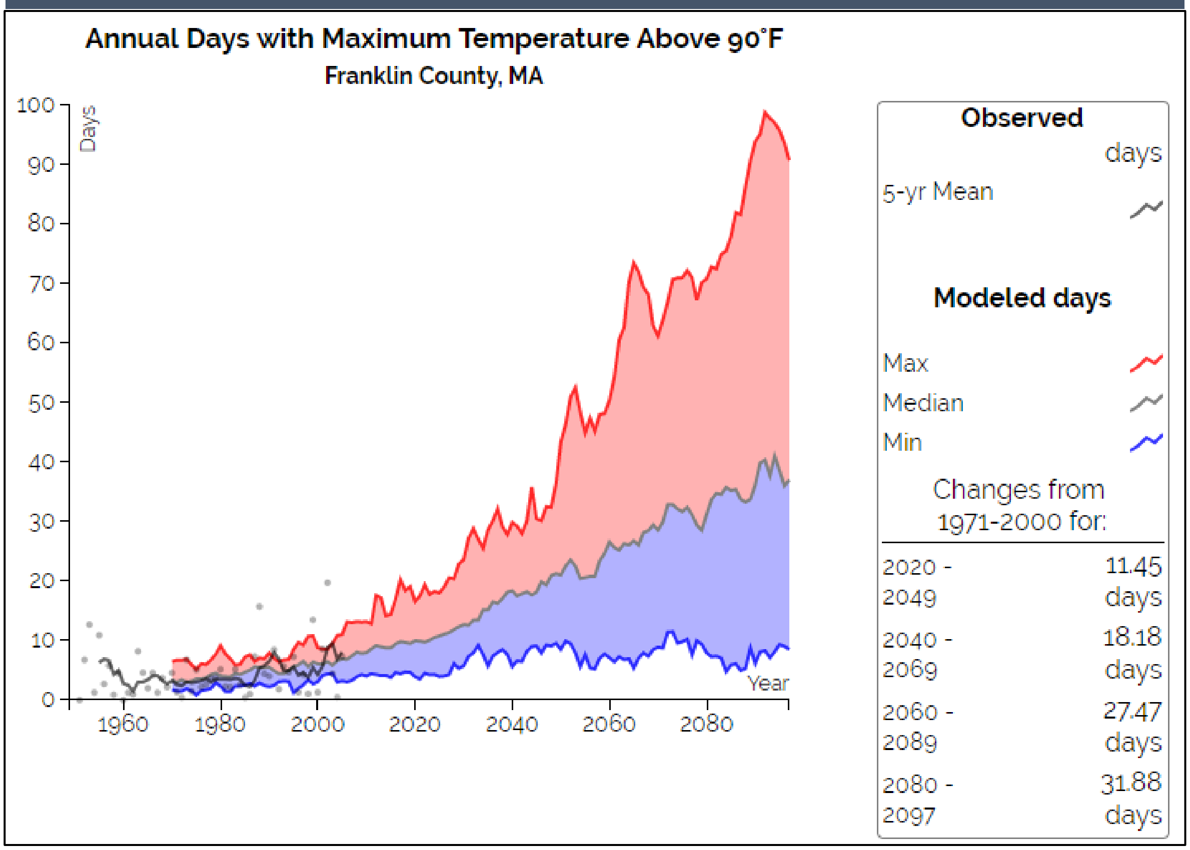
Source: Resilient MA

Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. Currently

Franklin County experiences an average of 169 days per year with a minimum temperature below freezing (32°F). The number of days per year with daily minimum temperatures below freezing is projected to decrease anywhere from 13 to 40 days by the 2050s, and by 15 to as many as 82 days (down to 87 days total) by the 2090s. Figure 2-2 shows annual average temperatures in Franklin County rising to approximately 53° by the end of the century, an increase of nearly 7.5°.

Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 2-5 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 2-3: Projected Annual Days with a Maximum Temperature Above 90°F



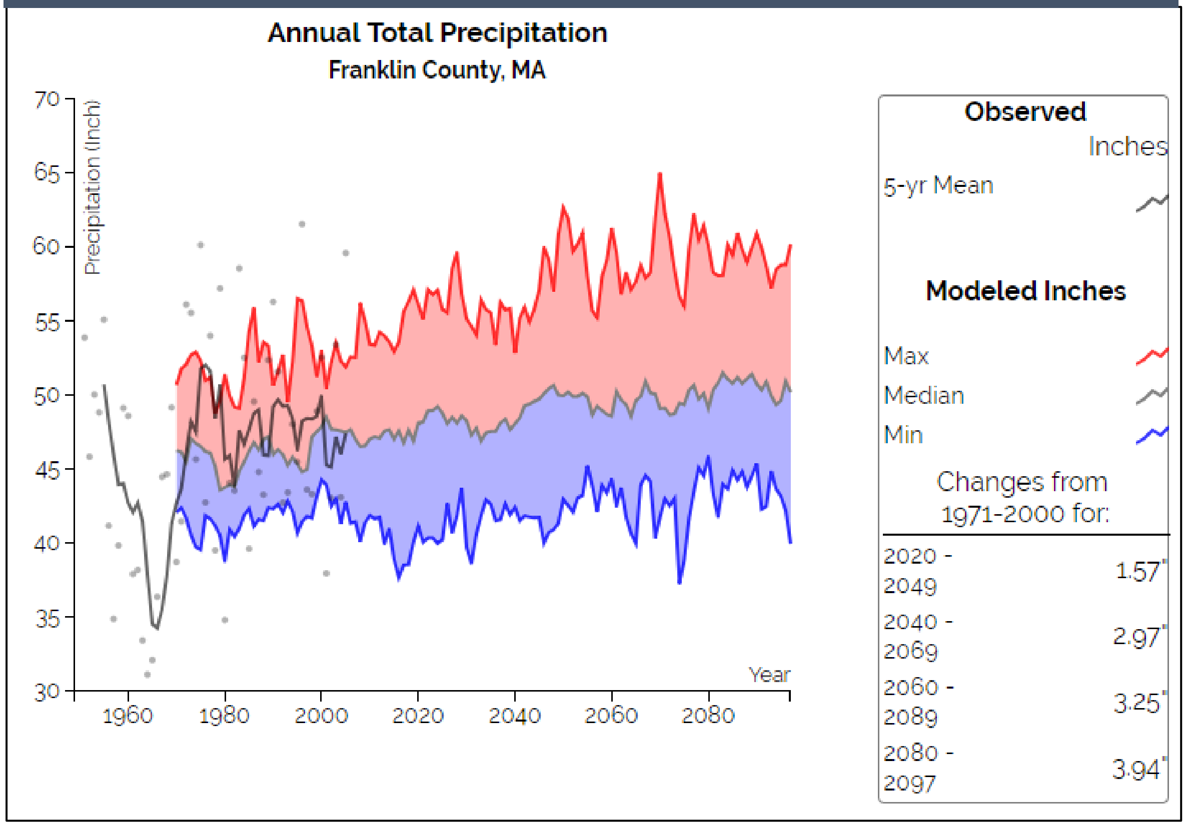
Source: Resilient MA, 2018

Changes in Precipitation

Changes in the amount, frequency, and timing of precipitation—including both rainfall and snowfall—

are occurring across the globe as temperatures rise and other climate patterns shift in response. Precipitation is expected to increase over this century in Franklin County. Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century (see Figure 2-3). This will result in up to 52 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 48 inches per year in Franklin County. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century. In general, precipitation projections are more uncertain than temperature projections.[5]

Figure 2-4: Projected Annual Total Precipitation (Inches)



Source: Resilient MA

Extreme Weather

Climate change is expected to increase extreme weather events across the globe, as well as right here in Massachusetts. There is strong evidence that storms—from heavy downpours and blizzards to tropical cyclones and hurricanes—are becoming more intense and damaging, and can lead to devastating impacts for residents across the state. Climate change leads to extreme weather because of warmer air and ocean temperatures and changing air currents. Warmer air leads to more evaporation from large water bodies and holds more moisture, so when clouds release their precipitation, there is more of it. In addition, changes in atmospheric air currents like jet streams and ocean currents can cause changes in

[5] http://resilientma.org/datagrapher/?c=Temp/county/pcpn/ANN/25011/

the intensity and duration of stormy weather.

In Franklin County, recent events such as Tropical Storm Irene in 2011, and the February tornado in Conway in 2018, are examples of extreme weather events that are projected to become more frequent occurrences due to climate change. While it is difficult to connect one storm to a changing climate, scientists point to the northeastern United States as one of the regions that is most vulnerable to an increase in extreme weather driven by climate change.

2.3 SUMMARY OF MUNICIPAL VULNERABILITY PREPAREDNESS WORKSHOP FINDINGS

2.3.1 COMMUNITY RESILIENCE BUILDING WORKSHOP

In the face of the changes outlined in the previous section, municipalities are working to increase their resilience and adapt to natural hazards and extreme weather events. Recent events in Franklin County have reinforced the need for resiliency planning and compelled communities like the Town of Leyden to proactively plan and mitigate potential risks. This type of planning will reduce the vulnerability of Leyden's people, infrastructure and natural resources, and will empower Leyden's officials and citizens to take steps to protect themselves and their community.

As a State-certified MVP Provider, the Franklin Regional Council of Governments helped Leyden engage in a community-driven process that brought together climate change information and local knowledge to conduct community outreach and the Community Resilience Building (CRB) workshop, whose central objectives were to:

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

Workshop participants considered climate change impacts most likely to affect Leyden, including rising and extreme temperatures, extreme weather events and increased precipitation, both in quantity and intensity.

The workshop was critical to enabling participants to think about and engage with people from different sectors. People representing emergency management, fire, administration, select board, local conservation groups, the municipal light plant, and interested residents came together to discuss the most threatening hazards to the Town of Leyden and to agree upon high priorities and actions to address them.

2.3.2 STAKEHOLDER OUTREACH

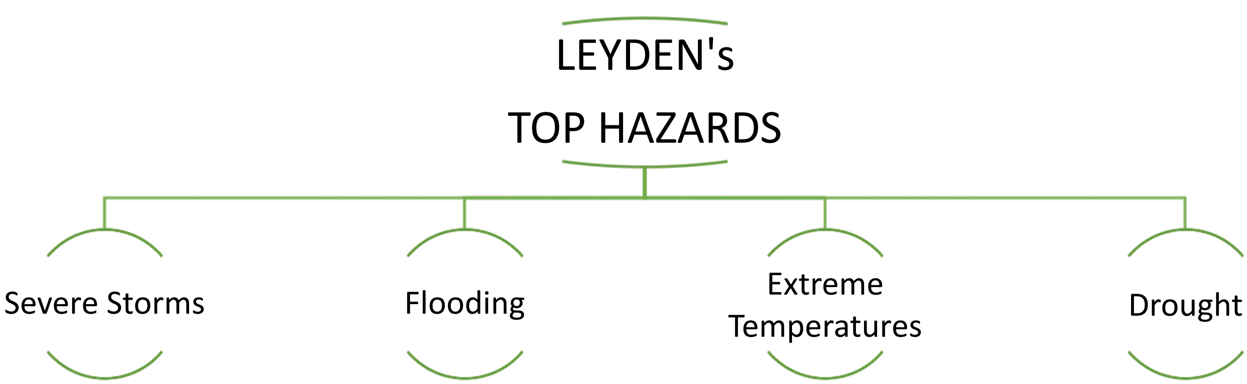
The Town of Leyden held their Community Resilience Building Workshops in March and April 2022. In place of an all-day in-person workshop, the Core Team devised a plan to conduct two shorter workshops. At the first workshop, participants identified all of Leyden's strengths and vulnerabilities in terms of the Town's infrastructure, society, and environmental resources. During the second workshop, participants brainstormed and prioritized resiliency actions.

The Town was committed to gathering input from community members in order to build the recommendations presented in the plan. Before the initial kickoff meeting, a StoryMap was posted on the Town's website introducing the project and allowed for residents to respond to several surveys. A newsletter article was also circulated in *Leyden Life*, which invited residents to join the planning process and view the StoryMap.

Outreach packets, the Community Resilience Building Matrix, and workshop materials are presented in Appendicies A and B.

2.3.3 TOP HAZARDS AND VULNERABLE AREAS

Workshop participants discussed a number of hazards that affect Leyden, deliberating on how frequent, how intense, and how widespread each hazard has been and could potentially be in the future. Hazards discussed included dam failures, severe winter storms/ice storms, earthquakes, hurricanes, wind storms/microbursts, tornadoes, flooding, wild fires, landslides, droughts, human-made hazards and extreme temperatures. Top hazards identified by the participants are as follows:



2.3.4 AREAS OF CONCERN

Infrastructure and Transportation:
Limited backup water supply; outdated fire suppression supply information and lack of agreements with private landowners; aboveground power lines and utilities that are vulnerable to all hazards; poor stormwater drainage on gravel and dirt roads; more frequent freeze/thaw cycles damaging roadways; failing culverts; limited options for emergency evacuation routes; risk of dam failure following heavy precipitation events; extended internet outages and poor cell phone service that could delay important services during a storm.

Facilities and businesses:
Economic impacts of flooding, extreme heat, and drought on farms; economic impacts of severe storms on local businesses; unseasonably warm weather disrupting freeze/thaw cycles and impacting maple syrup production; no designated emergency shelters.

Public health:
Insect-borne diseases such as Lyme disease; respiratory illness associated with higher temperatures; residents on private wells at risk of losing their water supply during a drought or power outages.

People:
Elders throughout Town; seniors on fixed incomes or low-income residents who may not be able to make costly repairs due to damage from hazardous events; homes in the mapped and unmapped floodplain and/or wildland urban interface; need for effective communications with residents prior to and during emergencies; isolation caused by the Covid pandemic; many homes in remote woodland settings; need for heating and cooling shelters.

Ecosystems and natural resources:
Increase of invasive species crowding out native species; unprotected farmland; decline in northern hardwood species due to climate change and pests; declining insect and pollinator populations; increased severity of brushfires due to drier conditions; beavers impoundments at many locations presenting a risk of flooding; risk of deteriorating water quality due to an increase in stormwater runoff.

2.3.5 CURRENT CONCERNS AND CHALLENGES PRESENTED BY HAZARDS AND CLIMATE CHANGE

Community members and participants in the workshop discussed a number of hazards that have affected the community in recent years, such as:

- Changes in precipitation including more ice and rain in the winter and increased amounts of precipitation falling in a short period;
- Short-term, acute weather events including severe wind events, extreme and erratic temperatures;

- Prolonged periods of drought and dry conditions, such as the summer of 2020, which increase the potential for a wildfire outbreak and the drying up of wells.

Participants in the workshop expressed concern about the impacts of severe storms, with an emphasis on the impacts of severe wind and heavy rain events. Leyden is very hilly, with many areas of high elevation susceptible to wind damage. Community members recalled recent severe wind events that led to prolonged power outages and downed trees. Recent heavy precipitation events have caused multiple road washouts.

Although Leyden does not contain much floodplain area because of its steep topography (1.5% of town is in the floodplain), flooding still affects Leyden residents. In 2011, Tropical Storm Irene changed the course of the Green River along the Leyden border with Colrain and caused damage to roads, bridges, and a few homes. Throughout Leyden, heavy precipitation events cause inundation flooding and erosion of roads and road infrastructure, especially where road drainage infrastructure is undersized or already failing. There is also concern about a number of beaver dams that could cause flood damage if they fail. Flooded roads and road washouts pose a risk for residents in a variety of circumstances, ranging from evacuations or needing to receive emergency assistance, to simply transporting schoolchildren on buses after storms.

Temperature extremes such as high heat and freezing temperatures were another top concern. The elderly are particularly vulnerable to extreme temperatures and may lack air conditioning or ways to heat their homes adequately. Extreme heat can also contribute to poor air quality by trapping emitted pollutants close to the ground, affecting people with asthma and other respiratory diseases as well as young children and the elderly. Additionally, a delayed frost in fall can lead to a longer habitable period for pests such as mosquitoes and deer ticks, which is a public health concern. Continuous freeze/thaw cycles associated with extreme temperature also damage roads, causing increased need for road repair and slower emergency response.

Drought was another top hazard identified by workshop participants. The drought that lasted through much of 2020, reaching Level 3 (Critical) status by September 2020, was highlighted during workshop discussions. Concerns were also raised with regard to heavy rains after long periods of drought, which can increase the severity of issues with stormwater runoff. Prolonged droughts can also increase the Town's vulnerability to a wildfire outbreak. Nearby towns in Franklin County such as Leverett and Orange experienced wildfires during the July and August of 2020, which burned a total of more than 60 acres of land in each Town. These fires demonstrated how even mild drought conditions can increase the threat of wildfires. In addition to fire risk, droughts also affect water supply and road conditions. Leyden's dirt roads are also negatively affected by dry weather. Dry roads kick up dust that can be damaging to the health of residents along the roadside, though this has improved since the Highway Department started applying pea stone to the roads in place of gravel. Though more of a nuisance than an ongoing hazard, washboarding occurs on dry gravel roads with regular traffic and causes a corrugated texture across the road surface. Leyden's road conditions were worsened by the 2020 summer drought.

2.3.6 SPECIFIC CATEGORIES OF CONCERNS AND CHALLENGES

Developing an Emergency Management Plan: The newly formed Public Safety Advisory Committee is actively working to improve the Town's emergency response and emergency preparedness planning. The Committee is in the process of writing an emergency management plan that will address many of the emergency preparedness planning concerns identified in this plan, including drinking water resiliency, warming/cooling, feeding, sheltering, fire suppression, and food security of residents. In the meantime, many of those potential scenarios lack operations plans and designated point people. Once these plans are in place, the Town will also need to communicate how newly established emergency policies will work to the community.

Vulnerability Related to Wildfire: Participants voiced concerns with regard to the possibility of a wildfire outbreak and the Town's ability to manage a fire. The summer of 2020 saw a numerous wildfire outbreaks across Massachusetts. Leyden is approximately 82% forest cover, with large tracts of contiguous forest that increase the difficulty of controlling a wildfire. Combined with other factors, such as unmaintained private forestland and stands of Eastern hemlocks and northern hardwood species dying from pests, pathogens, and changing climate, brushfires have the potential to spread very quickly in a droughty year.

Another concern related to the Town's ability to manage a wildfire is a lack of up-to-date information about water sources for firefighting. Although water sources have likely not changed since the last study was completed many years ago, many of the resources are located on private land and the Town needs to establish agreements with private landowners for accessing ponds and dry hydrants. The Town also has a need for a brush truck for firefighting in woodland settings and for an off-road rescue vehicle.

Vulnerable Populations: Participants discussed how climate change might affect the ability of many seniors to age in place. Leyden seniors on fixed incomes, as well as other low-income residents, are impacted by the rising cost of certain services. There are concerns that vulnerable populations are not able to receive necessary services like health care, repairs, and basic snow removal, etc. due to rising costs, availability of services, and accessibility during emergencies. Concerns were also raised about some seniors not having air conditioning in the summer months and being reluctant to turn on the heat in winter due to the high cost of fuel.

In addition, residents may not have reliable access to information concerning emergencies or access to regular, reliable public transportation. Further, the Town does not have up to date information on where vulnerable populations are located or what their needs are during a hazard event, which may limit emergency evacuation or response efforts.

Road Drainage and Bridge/Culvert Replacements:
Approximately 70% of the roads in Leyden are unpaved. Dirt and gravel roads are more prone to deterioration and washout under a range of weather conditions, including heavy rain events, flooding,

and freeze and thaw cycles. Poor road conditions add to wear and tear on Town vehicles. Workshop participants noted 2022 had the worst mud season in 8 years.

The condition of a number of culverts and bridges in Leyden is critical. Many culverts are undersized or are used too infrequently and cannot accommodate heavier stormwater flows, leading to localized flooding and/or road or infrastructure washouts. The FRCOG recently completed a culvert assessment for the Town of Leyden that rates the condition of all culverts in Leyden. The 18 culverts in critical condition because they are in need of repair and the 75 culverts in critical condition due to blockage are listed in section 3.3 of this plan. The Town has had recent success with receiving grant funding to improve the road or road infrastructure on Coates Road, East Hill Road, and Simon Keets Road, and the Highway Department Superintendent clears culverts and drainage ditches as time allows. However, the cost of steel has increased dramatically in recent years, state funding for culvert replacement is limited, and the Highway Department can only do so much maintenance with Town funding.

Leyden also has one bridge that is significantly vulnerable to flooding and erosion: the bridge over Thorne Brook on River Road is in critical condition. The Ten-Mile Bridge on River Road held up during Tropical Storm Irene and has a good structural rating, but could be vulnerable to a flood event the size of Tropical Storm Irene or larger.

Energy Resilience: Leyden has no solar battery backups—all town buildings run on generators. Workshop participants identified a need for more backup power for public buildings. The Town is discussing a pole-mount system for the Town Offices. While many residents have generators, others are vulnerable to long-term power outages. Nearly 21% of Leyden residents are senior citizens (65+). Residents who rely on medical devices that require power but do not have backup may be vulnerable during a severe storm event. Some residents moving towards solar and battery storage in order to be able to offer back-up energy to neighborhood areas.

Invasive species: Participants in the workshops voiced concerns about invasive species affecting forests and riparian areas. In particular, participants voiced concerns about bittersweet on Mid County Road choking and toppling trees, and Japanese knotweed along the Green River, Keets Brook/Shattuck Brook, and Couch Brook/Beaver Meadow Brook.

Vector-borne illness: Leyden residents are concerned about tick- and mosquito-borne diseases. Massachusetts has seen cases of once non-existent or very rare tick-borne illnesses rise, including Anaplasmosis, Babesiosis, Lyme, Powassan, Spotted fever rickettsiosis and Tularemia. Tick activity and tick-borne diseases occur year-round in Massachusetts. Although tick activity is weather dependent, there are two peaks during the year: the first begins in March/April and lasts through August and the second occurs in October-November. The majority of cases of tick-borne disease occur in June through August. Tick-borne diseases experienced by residents and identified in lab tests of ticks have increased in number and in kind across Franklin County due to climate change over the last ten years. Franklin County's rate of emergency department visits for tick-borne diseases is among the highest in the state.

Leyden residents are also worried about mosquito-borne illnesses. No cases of human EEE have presented in Leyden, but there has been one positive mosquito. Leyden joined the Pioneer Valley Mosquito Control District in 2020, Leyden recently joined the Pioneer Valley Mosquito Control District; in 2021 the State accepted the Town's alternative plan for mosquito management after they opted out of the state's aerial spraying programs.

Vulnerability of Town records and cyber security: No redundancy or digital backup exists for Town documents and historical records created prior to 2020. If the Town Offices were to be damaged during a storm or developed a mold problem, it is possible that the Town's records would be damaged or destroyed. It is of interest to the Town to work on backing up records, but noted the financial pressures are incredibly high and it would be a time intensive process.

The Municipal Assistant recently completed a cyber-security training and has hired a cyber-security consultant, but it does not have a robust cyber security protocol in place.

2.3.7 CURRENT STRENGTHS AND ASSETS

The Leyden community has a variety of social, environmental and infrastructural resources to draw upon to see it through natural hazard events. The Town is familiar with its vulnerabilities, but also its strengths and actions to address these vulnerabilities. Participants cited several strengths and assets that help keep their community resilient in the face of climate change and other challenges. They include:

Infrastructural Strengths:
The Leyden Highway Department is proactive and continually works to make repairs and upgrades before the issue becomes critical. Additionally, the Town has a good inventory of what road improvements are needed and has been successful in getting grants for road infrastructure. While there continues to be a lot of critical need, Leyden has done a good job tackling needed road infrastructure maintenance and upgrades.

In 2020, most Leyden households were hooked up to a Fiber-to-the-Home broadband internet network. The 35-mile fiber network improves communication between Leyden Town officials and residents. The concern remains, however, that storms could bring down service, as the broadband is connected to aboveground utility poles.

Societal Strengths:
Leyden's Public Safety Advisory Committee, formed in the fall of 2021, is developing an emergency management plan that will address many of the concerns identified in this plan, including water resiliency, warming/cooling, feeding, sheltering, and food security of residents.

Although Leyden does not have a designated emergency shelter, both the Town Hall and Town Offices recently acquired back-up generators, improving their ability to serve as short-term warming and feeding facilities and making it possible for the Town Offices to distribute water. Leyden also works with the regional sheltering program.

Leyden uses Reverse 911 to reach residents during an emergency. Broadband installations were completed in early 2021; now most residents are able to use their cell phones during emergencies despite poor cell coverage across town. In 2021, Franklin County Emergency Services migrated to the new CoMIRS system for dispatching emergency services. Most of Leyden is covered, although gaps in coverage exist in north Leyden along the Green River and along Keets Brook Road.

The Council on Aging is a support network in Leyden that adapted to the Covid-19 pandemic by providing drive-by lunches in place of serving meals in the Town Hall. Volunteers for the council arranged for volunteers to use a surplus vehicle to drive people to appointments and run errands, though workshop participants saw this program as underutilized.

The Town of Leyden has been very proactive with going for grants and has been awarded numerous grants over the past few years, including three road and road infrastructure grants, and two Community Compact grants.

Environmental Strengths:
Farms and contiguous forest cover most of the land area of Leyden, supporting large tracts of intact habitats and providing the "green infrastructure" that helps maintain water supply and water quality, and reduces damage caused by stormwater runoff. Open space in Leyden is protected in part by the Town's Natural Resource Protection Zoning Bylaw. The purpose of the bylaw is to protect agricultural land and land suitable for the production forest products. The bylaw encourages compact development patterns by means of flexible density requirements and lot dimensions. Encouraging compact development in turn protects the resource-based local economy, the town's water resources, and other environmental assets.

The fact that Leyden's critical municipal buildings are located in the hills means that these buildings are not as vulnerable to inundation flooding. There are no critical structures in the FEMA-mapped flood plain and very few residences in Leyden outside of those located along the Green River are at risk of flood damage.

A complete list of the Town's strengths is included in Section 4 of this plan.

2.3.8 TOP RECOMMENDATIONS AND STRATEGIES TO IMPROVE RESILIENCE

During Leyden's in-person MVP workshop, participants prioritized the resiliency actions brainstormed during the meeting. Action items were consolidated as appropriate to develop Leyden's top priority recommendations as shown below. Recommendations address key vulnerabilities while building upon current strengths.

Implementing action items relevant to maintaining the Town's roadways are The Town's highest priority. Leyden has already had all of their major road/stream crossings and drainage culverts assessed by the FRCOG, and has a list of which structures are at the highest risk of failure. However, funding is needed to make the necessary repairs and upgrades. As noted in the Action Plan in Section 4 of this plan, there is a potential opportunity to implement a Nature Based Solution on West Leyden Road in order to restore the wetland and right size the culvert that is subject to frequent blockages.

Additionally, the Town would like to secure funding for a Rural Roads/Dirt Road assessment to determine low maintenance, low cost climate resilient solutions on the Town's gravel roads. Flash flooding is an ongoing issue affecting the extensive network of gravel roads in the Town, which can be addressed by developing nature-based solutions such as green stormwater BMPs in combination with conventional strategies to mitigate runoff and erosion.

Updating the Town's outdated Open Space & Recreation Plan is another high priority for Leyden, as the current plan expired in 2017. An updated OSRP would provide a framework for stewarding the Town's valuable natural resources, wildlife habitat, and historic and scenic landscapes. The updated OSRP would also provide the Town with an opportunity to consider how climate change will affect its environmental resources, and to develop action items to increase resiliency.

Identifying vulnerable populations in Leyden and developing a communication and evacuation plan

for residents living on dead end roads is also a high priority that was identified by MVP workshop participants. The list of vulnerable residents is outdated, and organizations such as the Board of Health and Council on Aging are concerned they may not be aware of residents who would need help during a prolonged storm event. Residents who live on dead end dirt roads also emerged as a top concern, as there are not any formal communication or evacuation protocols. The Town would like to identify these areas and develop a plan for how residents would be assisted during a storm event.

The Community Resilience Building matrix was used as a tool during the workshop, and a completed copy is presented in Appendix B. All High, Medium, and Low priority action items are listed below. Section 4 of this Plan includes prioritized Action Tables for Hazard Mitigation Action Items and Preparedness and Response Action Items (Tables 4-3 and 4-4). Please reference those tables for information about the current status of each action item, responsible departments, and potential funding sources.

High Priority Action Items

- Use the 2021 Town of Leyden Culvert Assessment and 2018 Leyden High-Risk Stream Crossing Report to prioritize culvert upgrades and/or replacements. Seek funding for construction of properly designed/sized culverts, including “right-sizing” of drainage culverts to accommodate more frequent and intense storms due to climate change.
- Seek funding for a consultant to prepare designs for a culvert enhancement and wetland restoration project at the site known as “The Bog” on West Leyden Road.
- Obtain funding for a Rural Roads/Dirt Road assessment to determine low maintenance, low cost climate resilient drainage solutions on the Town’s gravel roads. Identify locations where nature based solutions would be most effective.
- Secure funding to prepare an update to Leyden’s 2010 Open Space & Recreation Plan, which would focus on climate resiliency.
- Assess additional mosquito/pest control options, including placing more pond dunks (larvicide) on public and private properties, determination of future risks due to increase in type and quantity of pests/disease vectors due to climate change, and development of an education and outreach program. Coordinate with the Board of Health to increase educational opportunities/awareness relating to pests and disease control and the Town’s participation in the Pioneer Valley Mosquito Control District.
- Develop and implement a record management plan to digitize and/ or duplicate important records housed in the Town Offices and other town facilities to mitigate the potential loss of information from a hazard event.
- To improve forest management and mitigate the risk of wildfires in Leyden, work with other Towns in the Mohawk Trail Woodlands Partnership region to implement recommendations from the recently completed Forest Resiliency Plan. Additionally, provide landowners with resources about programs such as the Keystone Foundation, Chapter 61 programs, Women on the Land, etc., to encourage good land stewardship.
- Evaluate shared emergency services for the Towns of Leyden and Bernardston.

- Finalize the updated Emergency Management Plan and distribute the plan to all Town Boards and Committees for review, and then distribute to residents.
- In line with the update of the Emergency Management Plan, identify vulnerable populations and foster a communications network in advance of a hazard event to facilitate communication efforts and outreach to those most in need of information and assistance. Focus should be on populations that may be more vulnerable to climate-induced risks, such as extreme temperatures, may lack appropriate shelter during increasingly intense storms, or that may be unprepared if stranded or cut off from supplies due to flooding or storm events. Develop a form to put in the annual town mailing from the Town Clerk that asks residents about what type of assistance they would need during a severe storm event.
- Develop a communication and evacuation plan for residents living on dead end roads who may become isolated during a severe event. Formalize neighborhood groups using the Village Neighbors Model.
- Continue to pursue Green Communities designation. Once designated, use funds to upgrade municipal buildings to make them more energy efficient.
- Update the Town's Floodplain Bylaw using the 2020 MA Model Floodplain Bylaw to ensure compliance with the NFIP program.

Medium Priority Action Items

- Examine strategies for improving the Town's existing hazard tree program, such as improving and encouraging coordination between Eversource and the Leyden Tree Warden and increasing funding for the Tree Warden's work. Look for ways to improve the process of identifying tree hazards.
- Investigate options for limiting the weight of vehicles that pass through Leyden, such as implementing seasonal weight limits for logging trucks traveling on dirt and gravel roads.
- Continue to review and update land use regulations and the development regulatory review process to include climate resiliency provisions such as Best Management Practices for River Corridor areas (FRCOG's River Corridor Toolkit). Measures should address impervious cover, manage stormwater runoff, new development within the 100-year floodplain and River Corridor, and slope and soil stability.
- Seek funding and hire a consultant to develop a regional comprehensive invasive species management from inventory stage through management planning and implementation to address existing invasive populations that threaten features such as open space or forests, both of which contribute to resiliency, as well as anticipate new invasives that are likely to move into the area as climates shift. Continue to manage the invasive plants in Town and explore alternative spraying options for Japanese knotweed. Assess biological control options for pests, including gypsy moths, and alternatives to spraying for invasives.
- To mitigate land erosion on farm fields and improve carbon sequestration, work with CISA/UMass Agricultural Extension to identify cover crops that could be used with changing growing seasons to limit dirt blowing off farm fields in the winter. Additionally, work with the NRCS to identify techniques that could help to minimize the amount of dust/soil blowing off of

fields such as inter-seeding between rows after crops are established, flail mowing instead of disking, etc. Techniques will need to be tailored to the farms' needs.

- Explore options for enhanced and effective emergency communication with residents, such as restarting the EMD column in the Leyden Life Newsletter. Utilize the Town's recently installed broadband internet, and increase transparency and awareness in Town. Pursue higher enrollment in the Reverse 911 Program.

Low Priority Action Items

- When digitized FEMA FIRMs become available, expand and update the Vulnerability Assessment for properties located within the 100-year floodplain, including information on property and crop damages, if available.
- Seek funding to hire a consultant to assess and identify projects that would help to manage erosion in the upper tributaries to the Green River.
- Re-assess and re-map all water sources for firefighting. These water sources were mapped many years ago, and the Town would like to have updated information about the location of sources, as well as formalized agreements between the Town and private landowners as needed. Seek funding to acquire easements and install pipes to identified water sources.
- Conduct more education and outreach on available weatherization, insulation, energy efficiency, and renewable energy technologies available through Mass Save and other state programs.
- Once the Town has an active Emergency Management Director, join the Franklin County Regional Emergency Planning Committee (REPC) to coordinate evacuation drills. Develop a communication plan for letting residents know of road closures; evacuation routes are likely to change depending on the size and scale of the hazard event.
- Continue to participate in the Franklin County Regional Emergency Planning Committee (REPC), which is currently working to complete and operationalize the Debris Management Plan. Coordinate with state and regional agencies to identify a location(s) in the Town for the temporary storage of contaminated and/or hazardous flood debris.

2.4 PROBLEM STATEMENTS

Based on findings from community outreach, Community Resilience Building Workshop, and working meetings, the Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Leyden's structures, systems, populations, and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to inform the vulnerability assessment for each hazard (Section 3) and identify the Town's greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4). Problem statements are presented in Table 2-5 below.

Table 2-5: Leyden Municipal Vulnerability Preparedness Planning Problem Statements

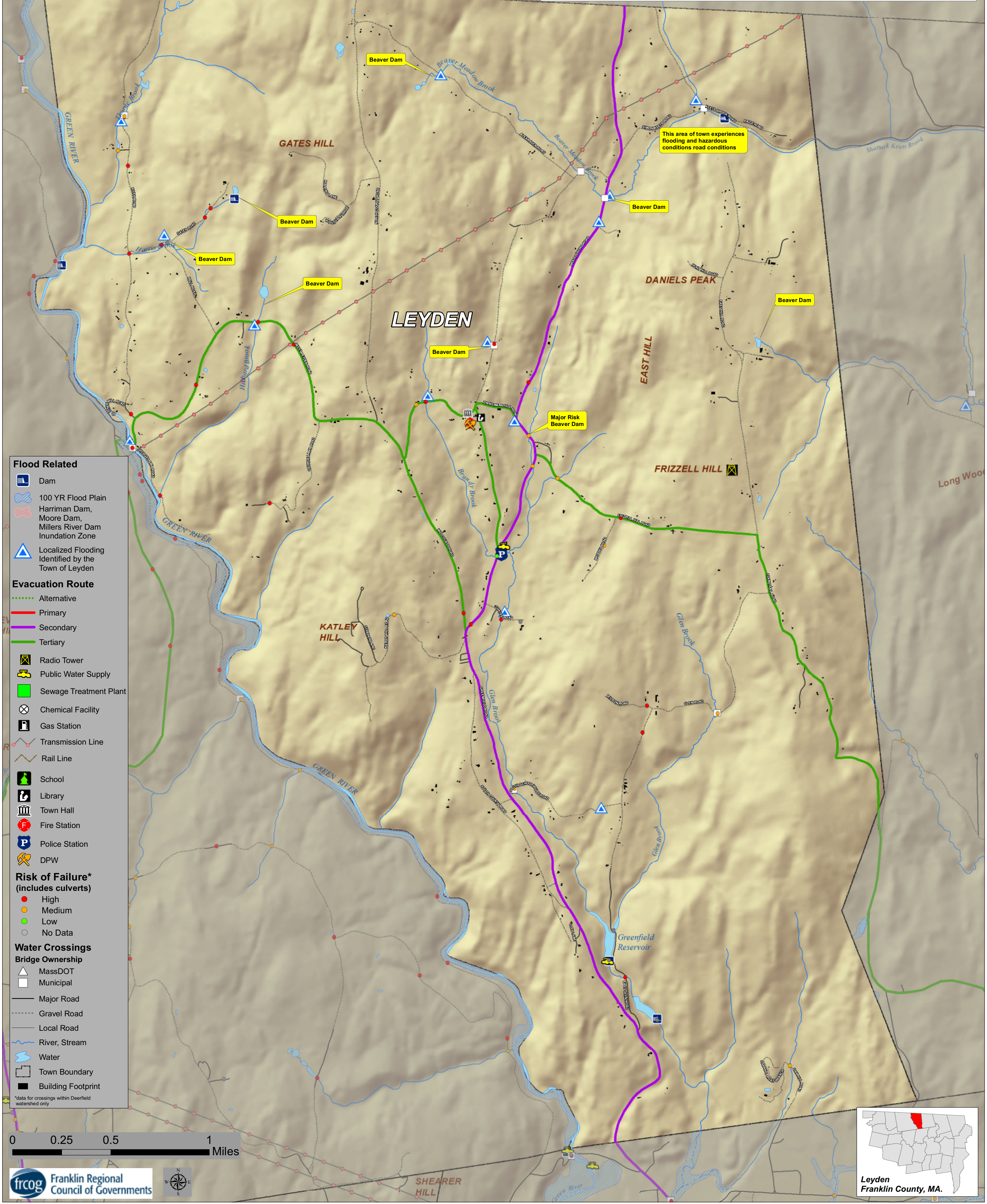
Applicable Hazards	Problem Statement
Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Tropical Storms, Severe Winter Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes, Extreme Temperatures	Leyden has no designated emergency shelter. While the kitchen and backup generator makes it a good candidate for sheltering, the Town Hall is poorly insulated.
Wildfire	Many residents in Leyden live within or adjacent to heavily forested areas in "intermix" and "interface" zones. This increases the risk of impacts to the population from a wildfire.
Wildfire	Leyden does not have a firefighting vehicle that can access wooded areas.
Wildfire, Drought, Extreme Temperatures	Extreme heat may worsen risk of wildfires and the availability of local water supplies for firefighting. Firefighters may already lack sufficient access to fire suppression supplies if access to privately owned supplies cannot be established.
Drought, Extreme Temperatures	All of Leyden's residents are serviced by private wells or springs that run the risk of going dry during prolonged drought.
Drought, Extreme Temperatures, Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Severe Thunderstorms / Wind / Microbursts, Severe Winter Storms, Tornadoes	Agriculture is an important industry in Leyden. Drought and extreme temperature fluctuations could severely limit crop production and/or impact livestock. Additionally, extended power outages may prevent dairy farms without backup generators from using essential equipment.
Flooding, Dam Failure, Earthquakes, Hurricanes / Tropical Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes	The Franklin County Regional Emergency Planning Committee is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is

Table 2-5: Leyden Municipal Vulnerability Preparedness Planning Problem Statements	
Applicable Hazards	**Problem Statement**
	being urged by MassDEP to select and provide disaster debris storage/disposal location(s).
Flooding, Hurricanes / Tropical Storms, Severe Thunderstorms / Wind / Microbursts	Culvert maintenance is continually needed throughout the Town; 12% of Leyden's culverts were found to be in critical condition by a FRCOG study conducted in the fall of 2021.
Hurricanes / Tropical Storms, Severe Thunderstorms / Wind / Microbursts, Severe Winter Storms, Tornadoes	Although National Grid follows a tree-maintenance plan in Leyden, they only treat areas around power lines, not the communications lines. There are many areas in Leyden in which overhead wires are in need of preventative tree maintenance.
Flooding, Extreme Temperatures	Approximately 70% of the roads in Leyden are unpaved, which can exacerbate existing issues with flooding and cause roads to become increasingly churned during quick freeze/thaw periods. Climate-resilient drainage solutions are needed on the Town's dirt roads.
Flooding	FEMA floodplain maps are of primary importance for mitigating the flood inundation hazards but are critically out of date and do not represent present-day landform data or climate change models.
Flooding, Severe Thunderstorms / Wind / Microbursts	The Town started digitally backing up records in 2020; no records prior to 2020 are safely backed up. Files are stored in the basement of the Town Offices, which is not climate controlled, and are therefore subject to mold. The Town is working on getting a new software system so that records from different departments will also be backed up in the future. Digitization of older records is needed.
Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Tropical Storms, Severe Winter Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes	The Town's evacuation routes may be impacted by flooding or by downed trees resulting from severe storms or ice. There are areas of Town where residents might become isolated if roads, bridges, or culverts were blocked or damaged during a hazardous event. If the culvert on West Leyden Road (at "The Bog") were to fail, the whole west side of town would be difficult to access.
Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Tropical Storms, Severe Winter Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes, Extreme Temperatures	Although the Town has a Reverse 911 Warning System, there is a need to expand the system and increase subscription among residents and businesses. Some residents have changed their phone numbers or opted out of their subscription. Additionally, education and outreach are needed to ensure that all residents are aware of emergencies and have access to evacuation and sheltering instructions, including options for residents with

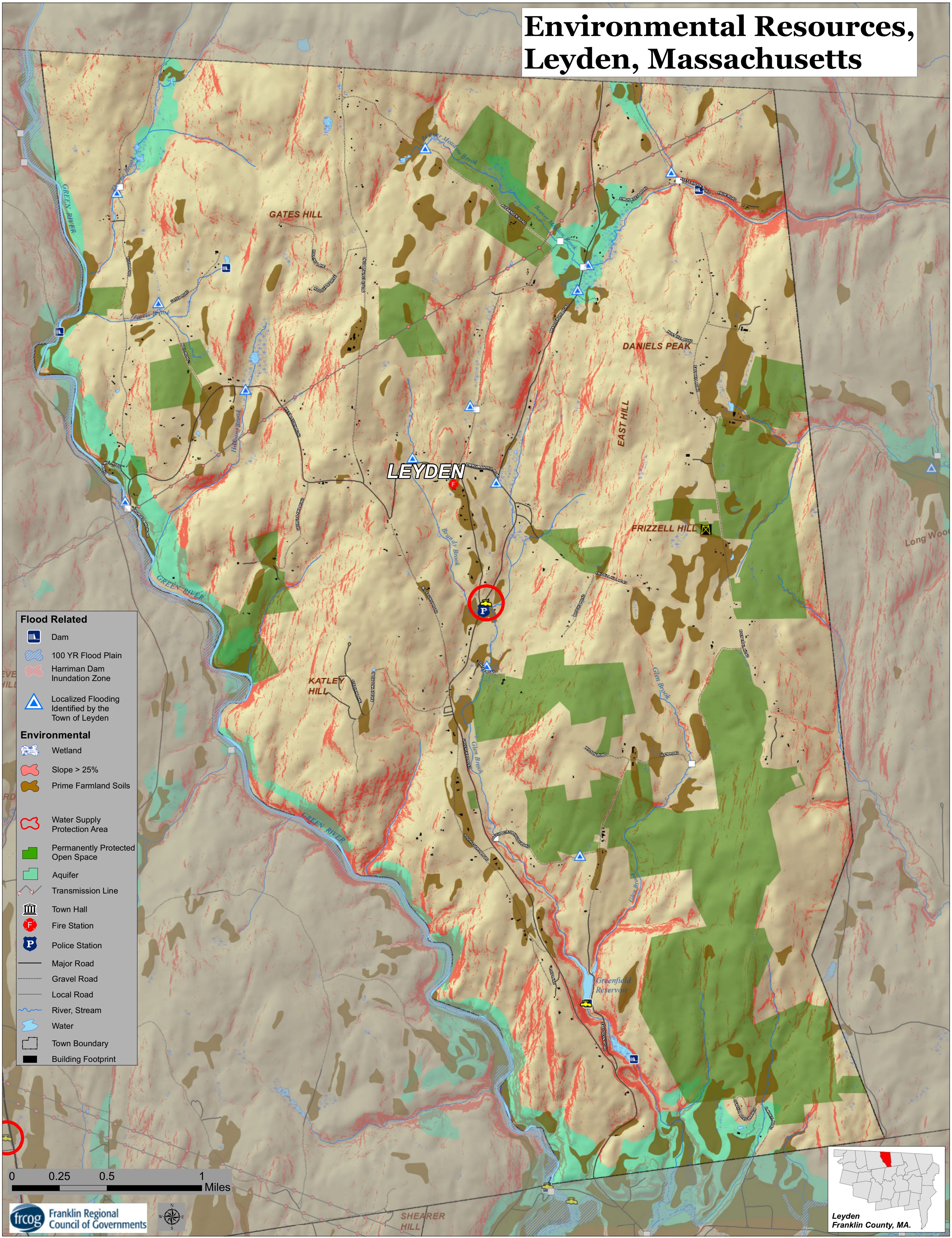
Table 2-5: Leyden Municipal Vulnerability Preparedness Planning Problem Statements	
Applicable Hazards	**Problem Statement**
	specialized medical needs and pet sheltering options.
Flooding, Hurricanes / Tropical Storms, Severe Thunderstorms / Wind / Microbursts, Landslides, Severe Winter Storms	Erosion is occurring on many roads and along the banks of the Green River.
Flooding	Beaver dams contribute to flooding, erosion, and sedimentation problems and could be part of a cascade of dam failures, as dam failures can release large, destructive volumes of water.
Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Tropical Storms, Severe Winter Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes	Existing communication infrastructure issues and vulnerabilities could be exacerbated by severe hazards.
Hurricanes / Tropical Storms, Severe Winter Storms, Tornadoes, Severe Thunderstorms / Wind / Microbursts, Earthquakes	An estimated 52% of homes in Leyden were built prior to the first State building code in 1975, potentially making them more vulnerable to damages from high winds or earthquakes.
Severe Winter Storms, Extreme Temperatures	Extreme cold temperatures combined with power outages, even short duration, can result in frozen and burst pipes for properties without back-up power.
Severe Winter Storms, Extreme Temperatures	Elderly, disabled, and low-income residents are more vulnerable to extreme temperatures and may lack A/C or adequate heating systems in their homes.
Extreme Temperatures	Extreme temperatures create a risk of "brown-outs" in the power grid, where electricity supply may dip due to excess demand on the system and can affect vulnerable populations and municipal operations dependent on a consistent and uninterrupted power supply.
Extreme Temperatures	Changing climate has resulted in an annual decrease in days below freezing, a trend that will progress over the next century. Fewer days below freezing and fewer deep frosts occurring later in the season are some of the contributing factors for larger tick and mosquito populations and longer seasons for both. This increases the risk of insect borne diseases.
Vector-borne Diseases, Extreme Temperatures	Residents may not be familiar with how to deal with or prevent diseases associated with increasing average temperatures (e.g., tick and mosquito borne diseases).
Vector-borne Diseases, Extreme	Climate change will increase the number of disease-carrying

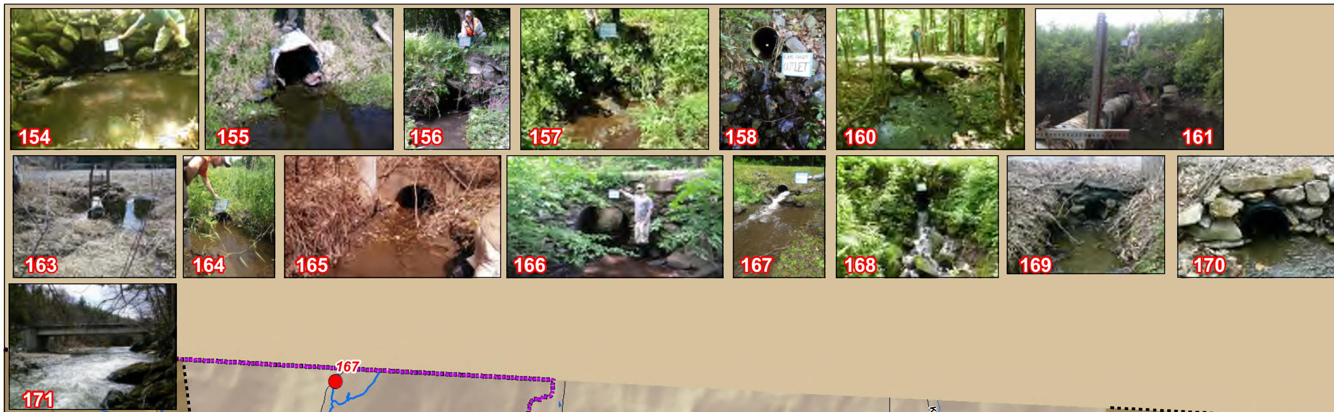
Table 2-5: Leyden Municipal Vulnerability Preparedness Planning Problem Statements	
Applicable Hazards	**Problem Statement**
Temperatures	vectors (ticks and mosquitoes) and thereby increase demands on our public health system for symptom management and care for infected people. There is a need for a cross-jurisdictional sharing program for local boards of health to share nursing staff, reduce costs, qualify for funding, and expand capacity to meet the demands of current and future public health crises.
Invasive Species	The health of Leyden's forests relies on biodiverse ecosystems. Leyden's forests are stressed by invasive pests and pathogens. The scope of successfully controlling invasives long-term is often beyond the reach of what foresters and landowners can manage on their own.
Flooding, Wildfire, Earthquakes, Landslides, Hurricanes / Tropical Storms, Severe Winter Storms, Severe Thunderstorms / Wind / Microbursts, Tornadoes	Zoning bylaws, general bylaws, and subdivision regulations need to be assessed and updated to ensure they include climate resiliency provisions.

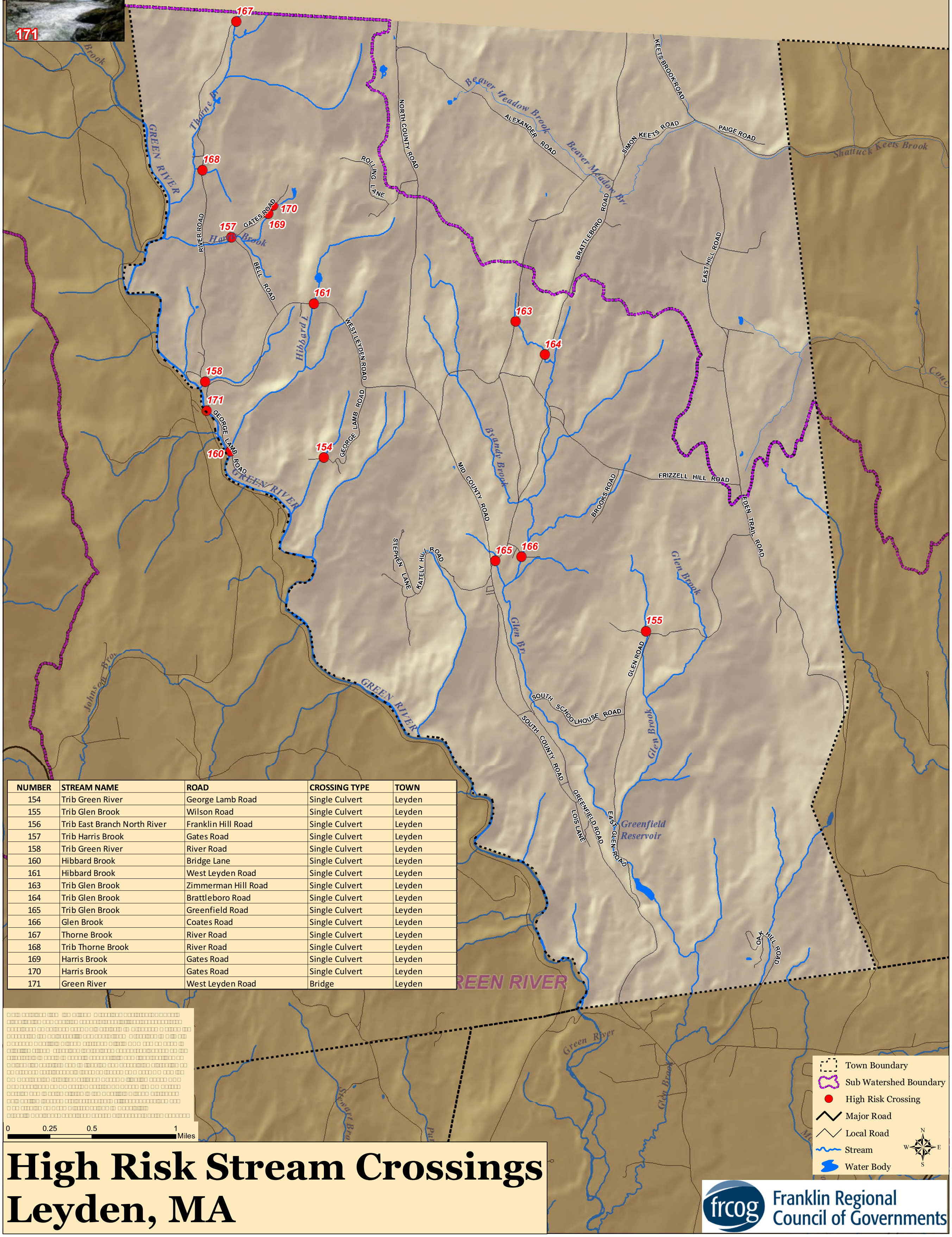
Hazards and Infrastructure, Leyden, Massachusetts



Environmental Resources, Leyden, Massachusetts







NUMBER	STREAM NAME	ROAD	CROSSING TYPE	TOWN
154	Trib Green River	George Lamb Road	Single Culvert	Leyden
155	Trib Glen Brook	Wilson Road	Single Culvert	Leyden
156	Trib East Branch North River	Franklin Hill Road	Single Culvert	Leyden
157	Trib Harris Brook	Gates Road	Single Culvert	Leyden
158	Trib Green River	River Road	Single Culvert	Leyden
160	Hibbard Brook	Bridge Lane	Single Culvert	Leyden
161	Hibbard Brook	West Leyden Road	Single Culvert	Leyden
163	Trib Glen Brook	Zimmerman Hill Road	Single Culvert	Leyden
164	Trib Glen Brook	Brattleboro Road	Single Culvert	Leyden
165	Trib Glen Brook	Greenfield Road	Single Culvert	Leyden
166	Glen Brook	Coates Road	Single Culvert	Leyden
167	Thorne Brook	River Road	Single Culvert	Leyden
168	Trib Thorne Brook	River Road	Single Culvert	Leyden
169	Harris Brook	Gates Road	Single Culvert	Leyden
170	Harris Brook	Gates Road	Single Culvert	Leyden
171	Green River	West Leyden Road	Bridge	Leyden

High Risk Stream Crossings
Leyden, MA

Franklin Regional Council of Governments

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

3.1 INTRODUCTION

The following section includes a summary of disasters that have affected or could affect Leyden. Historical research, conversations with local officials and emergency management personnel, available hazard mapping and other weather-related databases were used to develop this list.

The Hazard Mitigation Committee referred to the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (September 2018) as a starting point for determining the relevant hazards in Leyden. Table 3-1 identifies hazards that are relevant to Leyden.

Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, and the Leyden Hazard Mitigation Plan

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Town of Leyden Relevance	Leyden Community Resilience Building Workshop Top Priority Hazard
 Inland Flooding	YES	YES
 Drought	YES	NO
 Landslide	YES	NO
 Coastal Flooding	NO	NO

Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, and the Leyden Hazard Mitigation Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Leyden Relevance**	**Leyden Community Resilience Building Workshop Top Priority Hazard**
 Coastal Erosion	NO	NO
 Inland Flooding	YES	YES
 Tsunami	NO	NO
 Average/Extreme Temperatures	YES	YES
 Wildfires	YES	NO
 Invasive Species	YES	NO
 Hurricanes/Tropical Storms	YES	NO
 Severe Winter Storm	YES	YES

Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, and the Leyden Hazard Mitigation Plan

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Town of Leyden Relevance	Leyden Community Resilience Building Workshop Top Priority Hazard
 Tornadoes	YES	NO
 Other Severe Weather	YES	YES
 Earthquake	YES	NO

3.2 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

This chapter examines the hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* that have been identified as likely to affect Leyden. The analysis is organized into the following sections: Potential Effects of Climate Change, Hazard Description, Location, Extent, Previous Occurrences, Probability of Future Events, Impact, and Vulnerability. A description of each of these analysis categories is provided below.

Potential Effects of Climate Change
Climate change acts as a stressor and exacerbates natural hazards and a community's vulnerability to these hazards. The potential effects of climate change on each hazard, except earthquakes, are described to demonstrate the connections between traditional natural hazard analysis and climate change projections. This analysis aligns with three climate change categories (changes in precipitation, rising temperatures and extreme weather) included on the Commonwealth's Resilient MA Climate Change Clearinghouse website.[6]

Hazard Description
The natural hazards identified for Leyden are flooding, severe winter storms, hurricanes/tropical storms, severe thunderstorms/wind/microbursts, tornadoes, wildfire, earthquakes, drought, landslides, extreme temperatures, and invasive species, as well as vector-borne diseases and manmade hazards. Many of these hazards result in similar impacts to a community. For example, hurricanes, tornadoes and severe snowstorms may cause wind-related damage.

[6] http://www.resilientma.org/

Location

Location refers to the geographic areas within the town that are affected by the hazard. Some hazards affect the entire town universally, while others apply to a specific portion of the town, such as a floodplain or area that is susceptible to wild fires. Classifications are based on the area that would potentially be affected by the hazard, on the following scale:

Table 3-2: Location of Occurrence Rating Scale	
Classification	**Percentage of Town Impacted**
Large	More than 50% of the town affected
Medium	10 to 50% of the town affected
Isolated	Less than 10% of the town affected

Extent

Extent describes the strength or magnitude of a hazard. Where appropriate, extent is described using an established scientific scale or measurement system. Other descriptions of extent include water depth, wind speed, and duration.

Previous Occurrences

Previous hazard events that have occurred are described. Depending on the nature of the hazard, events listed may have occurred on a local, statewide, or regional level.

Probability of Future Events

The likelihood of a future event for each natural hazard was classified according to the following scale:

Table 3-3: Probability of Occurrence Rating Scale	
Classification	**Probability of Future Events**
Very High	Events that occur at least once each 1-2 years (50%-100% probability in the next year)
High	Events that occur from once in 2 years to once in 4 years (25%-50% probability in the next year)
Moderate	Events that occur from once in 5 years to once in 50 years (2%-25% probability in the next year)
Low	Events that occur from once in 50 years to once in 100 years (1-2% probability in the next year)
Very Low	Events that occur less frequently than once in 100 years (less than 1% probability in the next year)

Impact

Impact refers to the effect that a hazard may have on the people and property in the community, based on the assessment of extent described previously. Impacts are classified according to the following scale:

Table 3-4: Impacts Rating Scale	
Classification	**Magnitude of Multiple Impacts**
Catastrophic	Multiple deaths and injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of facilities for 30 days or more.
Critical	Multiple injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 week.
Limited	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 day.
Minor	Very few injuries, if any. Only minor property damage and minimal disruption of quality of life. Temporary shutdown of facilities.

Vulnerability
Based on the above metrics, a hazard vulnerability rating was determined for each hazard. The hazard vulnerability ratings are based on a scale of 1 through 3 as follows:

1 – High risk
2 – Medium risk
3 – Low risk

Table 3-5 summarizes the work of the Core Team to qualitatively categorize and determine the hazard vulnerability (risk to the town) of each hazard. The analysis and hazard vulnerability rating is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, including climate change projections developed by the Commonwealth for Franklin County (resilientMA), and the work of the Core Team during the development of the MVP Resiliency Plan and the update of this Hazard Mitigation Plan. The size and impacts of a natural hazard can be unpredictable. However, many of the mitigation strategies currently in place and many of those proposed for implementation can be applied to the expected natural hazards, regardless of their unpredictability.

Table 3-5: Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Flooding	Medium	Moderate	Limited	2 – Medium
Severe Winter Storms	Large	Very High	Critical	1 – High
Hurricanes / Tropical Storms	Large	High	Limited	2 – Medium
Severe Thunderstorms / Wind / Microbursts	Large	Very High	Limited	1 – High
Tornadoes	Isolated	Low	Critical	3 – Low
Wildfire	Large	Moderate	Critical	2 – Medium
Earthquakes	Large	Low	Critical	3 – Low
Dam Failure (other dams and beaver dams)	Isolated	Moderate	Critical	2 – Medium
Drought	Large	Very High	Critical	1 – High
Landslides	Isolated	Moderate	Limited	3 – Low
Extreme Temperatures	Large	Very High	Limited	1 – High
Invasive Species	Large	Very High	Critical	1 – High
Vector-Borne Diseases	Medium	Very High	Critical	1 – High
Manmade Hazards	Isolated	Low	Limited	3 – Low

3.3 FLOODING

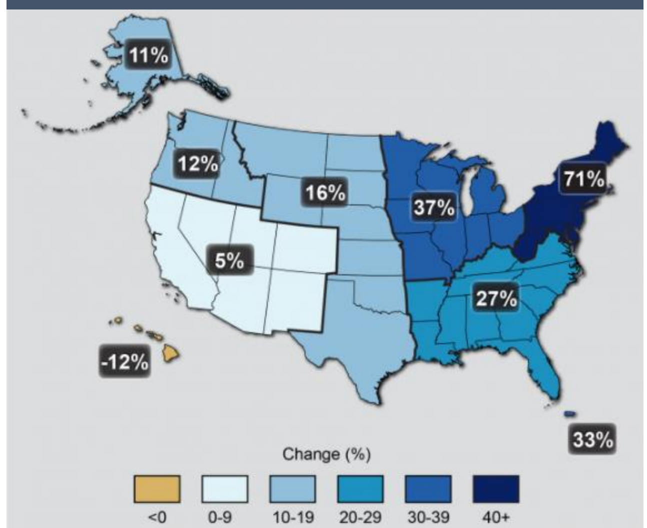
Potential Effects of Climate Change

In Massachusetts, annual precipitation amounts have increased at a rate of over 1 inch per decade since the late 1800s, and are projected to continue to increase largely due to more intense precipitation events. The Northeast has experienced a greater increase in extreme precipitation events than the rest of the U.S. in the past several decades (Figure 3-1). Although overall precipitation is expected to increase as the climate warms, it will occur more in heavy, short intervals, with a greater potential for dry, drought conditions in between.

Observed average annual precipitation in Massachusetts between 1971-2000 was 47 inches. Total annual precipitation in Massachusetts is expected to increase between 2% to 13% by 2050, or by roughly 1 to 6 inches.

The Climate Data Grapher tool on the Resilient MA website contains downscaled climate data for Franklin County (discussed in Section 2) and for the Connecticut River Watershed, which includes the Town of Leyden. Median observed annual precipitation over the last several decades (1970-2005) is approximately 45 inches. By 2050, the model predicts that nearly 41 inches per year would be the minimum annual precipitation; the mean (middle value of the model predictions) could be 48 inches/year with a maximum of 60 inches per year. In general, precipitation projections are more uncertain than temperature projections[7].

Figure 3-1: Observed Change in Very Heavy Precipitation



The northeast has seen a greater increase in heavy precipitation events than the rest of the country. *Source: updated from Karl et al. 2009, Global Climate Change Impacts in the United States.*

An increase in stronger storms leads to more flooding and erosion. A shift to winter rains instead of snow will lead to more runoff, flooding, and greater storm damage along with less spring groundwater recharge. More frequent heavy precipitation events also lead to an increased risk for people who live along rivers or in their floodplains. Furthermore, residents who live outside the current flood zone could find themselves within it as the century progresses. Figure 3-2 shows potential effects of climate change on flooding from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

[7] **https://resilientma.org/datagrapher/?c=Temp/basin/pcpn/ANN/Connecticut/**

Figure 3-2: Effects of Climate Change on Flooding

Potential Effects of Climate Change		
	CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT DOWNPOURS	More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and urban stormwater systems become overwhelmed. Flooding may occur as a result of heavy rainfall, snowmelt or coastal flooding associated with high wind and storm surge.
	EXTREME WEATHER ➔ MORE FREQUENT SEVERE STORMS	Climate change is expected to result in an increased frequency of severe storm events. This would directly increase the frequency of flooding events, and could increase the chance that subsequent precipitation will cause flooding if water stages are still elevated.
	CHANGES IN PRECIPITATION ➔ EPISODIC DROUGHTS	Vegetated ground cover has been shown to significantly reduce runoff. If drought causes vegetation to die off, this flood-mitigating capacity is diminished.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Nationally, inland flooding causes more damage annually than any other severe weather event (U.S. Climate Resilience Toolkit, 2017). Between 2007 and 2014, the average annual cost of flood damages in Massachusetts was more than $9.1 million (NOAA, 2014). Flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack (U.S. Climate Resilience Toolkit, 2017). Developed, impervious areas can contribute to and exacerbate flooding by concentrating and channeling stormwater runoff into nearby waterbodies. Increases in precipitation and extreme storm events from climate change are already resulting in increased flooding. Common types of flooding are described in the following subsections.

Riverine Flooding

Riverine flooding often occurs after heavy rain. Areas with high slopes and minimal soil cover (such as found in many areas of Leyden and Franklin County) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred because of strong nor'easters and tropical storms in which snowmelt was not a factor. Tropical storms can produce very high rainfall rates and volumes of rain that can generate high runoff when soil infiltration rates are exceeded. Inland flooding in Massachusetts is forecast and classified by the National Weather Service's (NWS) Northeast River Forecast Center as minor, moderate, or severe based upon the types of impacts that occur. Minor flooding is considered a "nuisance only" degree of flooding that causes impacts such as road closures and flooding of recreational areas and farmland. Moderate flooding can involve land with structures becoming inundated. Major flooding is a widespread, life-threatening event. River forecasts are made at many locations in the state where there are United States Geological Survey (USGS) river gauges that have established flood elevations and levels corresponding to each of the degrees of flooding.

- Overbank flooding occurs when water in rivers and streams flows into the surrounding floodplain or into "any area of land susceptible to being inundated by floodwaters from any source," according to FEMA.

- Flash floods are characterized by "rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level," according to FEMA.

Fluvial Erosion

Fluvial erosion is the process in which the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion can also include scouring and down cutting of the stream bottom, which can be a problem around bridge piers and abutments. In hillier terrain where streams may lack a floodplain, such as in many areas of Leyden, fluvial erosion may cause more property damage than inundation. Furthermore, fluvial erosion can often occur in areas that are not part of the 100- or 500-year floodplain.

Fluvial erosion hazard (FEH) zones are mapped areas along rivers and streams that are susceptible to bank erosion caused by flash flooding. Any area within a mapped FEH zone is considered susceptible to bank erosion during a single severe flood or after many years of slow channel migration. As noted above, while the areas of the FEH zones often overlap with areas mapped within the 100-year floodplain on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) or Flood Hazard Boundary Maps (FHBMs), the FIRMs or FHBMs only show areas that are likely to be inundated by floodwaters that overtop the riverbanks during a severe flood. However, much flood-related property damage and injuries are the result of bank erosion that can undermine roads, bridges, building foundations and other infrastructure. Consequently, FEH zones are sometimes outside of the 100-year floodplain shown on FIRMs or FHBMs. FEH zones can be mapped using fluvial geomorphic assessment data as well as historic data on past flood events. Both the FIRMs and FEH maps should be used in concert to understand and avoid both inundation and erosion hazards, respectively.[8] Leyden does not have mapped FEH zones.

Urban Drainage Flooding

Urban drainage flooding is caused by increased water runoff due to urban development and drainage systems that are not capable of conveying high flows. 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 a closed conveyance system that channels water away from an urban area 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 the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In urban areas, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

[8] Ammonoosuc River Fluvial Erosion Hazard Map for Littleton, NH. Field Geology Services, 2010.

Ground Failures

Flooding and flood-related erosion can result from various types of ground failures, which include mud floods and mudflows, and to a much lesser degree, subsidence, liquefaction, and fluvial erosion (discussed above).

Mud floods are floods that carry large amounts of sediment, which can at times exceed 50% of the mass of the flood, and often occur in drainage channels and adjacent to mountainous areas. Mudflows are a specific type of landslide that contains large amounts of water and can carry debris as large as boulders. Both mudflows and mud floods result from rain falling on exposed terrain, such as terrain impacted by wildfires or logging. Mud floods and mudflows can lead to large sediment deposits in drainage channels. In addition to causing damage, these events can exacerbate subsequent flooding by filling in rivers and streams.

Subsidence is the process where the ground surface is lowered from natural processes, such as consolidation of subsurface materials and movements in the Earth's crust, or from manmade activities, such as mining, inadequate fill after construction activity, and oil or water extraction. When ground subsides, it can lead to flooding by exposing low-lying areas to groundwater, tides, storm surges, and areas with a high likelihood of overbank flooding.

Liquefaction, or when water-laden sediment behaves like a liquid during an earthquake, can result in floods of saturated soil, debris, and water if it occurs on slopes. Floods from liquefaction are especially common near very steep slopes.

Ice Jam

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 winter to midwinter 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 as a result of the breakup of the ice cover at ice-out, causing large pieces of ice to 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 often 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. The Ice Jam Database, maintained by the Ice Engineering Group at the U.S. Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory currently consists of more than 18,000 records from across the U.S.

Dam Failure

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water. There are two primary types of dam failure:

catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs as a result of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34% of all dam failures in the U.S.

There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts—including shifts in seasonal and geographic rainfall patterns—could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as "design failures") can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures. Impacts and Leyden's vulnerability to dam failure is discussed in more detail in the Dam Failure section of this plan.

Additional Causes of Flooding

Additional causes of flooding include beaver dams or levee failure. Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break.

Floodplains

Floodplains by nature are vulnerable to inland flooding. Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic (land-shaping) and hydrologic (water flow) processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon. These areas form a complex physical and biological system that not only supports a variety of natural resources, but also provides natural flood storage and erosion control. When a river is separated from its floodplain by levees and other flood control facilities, these natural benefits are lost, altered, or significantly reduced. When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments known as alluvium (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater supplies.

Flooding is a natural and important part of wetland ecosystems that form along rivers and streams. Floodplains can support ecosystems that are rich in plant and animal species. Wetting the floodplain soil releases an immediate surge of nutrients from the rapid decomposition of organic matter that has accumulated over time. When this occurs, microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly fish or birds) often utilize the increased food supply. The production of nutrients peaks and falls away quickly, but the surge of new growth that results endures for some time. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and grow quickly in comparison to non-riparian trees.

Location

A floodplain is the relatively flat, lowland area adjacent to a river, lake or stream. Floodplains serve an important function, acting like large "sponges" to absorb and slowly release floodwaters back to surface waters and groundwater. Over time, sediments that are deposited in floodplains develop into fertile, productive farmland like that found in the Connecticut River valley. In the past, floodplain areas were also often seen as prime locations for development. Industries were located on the banks of rivers for access to hydropower. Residential and commercial development occurred in floodplains because of their scenic qualities and proximity to the water, and because these areas were easier to develop than the hilly, rocky terrain characteristic of many towns in the county. Although periodic flooding of a floodplain area is a natural occurrence, past and current development and alteration of these areas can result in flooding that is a costly and frequent hazard.

In Leyden, the FEMA-mapped 100-year floodplain covers about 165 acres, or approximately 1.44% of the town, including an estimated 3.9 acres of developed land serving three dwellings. Although no essential structures are within the floodplain, there are 629 buildings and public gathering spaces within 500 feet of the floodplain that are vulnerable to impacts of major floods.

In addition to the 100-year floodplain, areas upstream from major rivers play an important role in flood mitigation. Upland areas and the small tributary streams that drain them are particularly vulnerable to impacts from development, which can increase the amount of flooding downstream. These areas are critical for absorbing, infiltrating, and slowing the flow of stormwater. When these areas are left in a natural vegetated state (forested or forested floodplain), they act as "green infrastructure," providing flood storage and mitigation through natural processes.

Fragmentation and development in upland areas, including roads which commonly were built along stream and river corridors, can alter this natural process and result in increased amounts of stormwater runoff into streams. For example, the channels of many of these streams were altered centuries ago as a result of widespread deforestation for agriculture and lumber. The many small mills that used to dot the landscape built dams on the streams to generate power. Many of these streams are still unstable and flashy during storm events, generating high volumes of runoff and transporting sediment to the lower, flatter reaches of the watershed.

In addition, stressors to forests such as drought, extreme weather, and invasive species, can result in the loss of forest cover in upland areas. In particular, cold-water streams shaded by dense hemlock stands are particularly vulnerable due to the hemlock woolly adelgid that is causing widespread mortality of these trees in the region.

The following areas once had flooding problems but have improved as a result of road and infrastructure work:

- Keets Brook Road had bridgework done that improved flooding issues

There are a number of areas in Leyden that are still impacted by flooding, often caused by undersized stream crossing infrastructure. Key areas of concern include:

- Greenfield Road in the stretch north of South Schoolhouse Road.
- The intersection of Zimmerman Hill Road and Brattleboro Road.
- Brattleboro Road between West South Black Road and Greenfield Road.[9]
- Greenfield Road north of 910 Greenfield Road.
- West Leyden Road at the Brandy Brook stream crossing.
- West Leyden Road where beavers are damning the culvert in "The Bog".
- Three culverts along Gates Road.
- The mid to lower section of Alexander Road is susceptible to flash flooding of Keets Brook, in part due to new driveways having been built with undersized culverts.

A number of roads in Leyden are prone to erosion damage caused by flooding. Key areas of concern include:

- The wooden bridge on River Road where it crosses Thorne Brook is in critical condition.
- The bridge abutment on the Ten Mile Bridge and the riverbank in this area where the Green River changed course during Tropical Storm Irene.
- Paige Road, along a steep hillside with insufficient drainage.
- Keets Brook Road washes out occasionally due to water draining off a steep hillside adjacent to the road.
- George Lamb Road, along a steep hillside where culvert outlets are scouring out.
- Dirt roads in town tend to wash out periodically.
- Driveways entering onto roads can cause erosion and flooding problems as they direct water onto the roadway.

Culverts and Road Drainage

The Town of Leyden Culvert Assessment, conducted in fall of 2021, identified 800 culverts and drainage structures on Town-maintained roads.[10] Of the 800 structures, 18 were identified as being in Critical condition needing immediate repair, 75 were identified as being in Critical condition because they were 75-100% blocked and needed to be cleaned out. Of the 102 drop inlets or catch basins evaluated, one is in Critical condition and three in Poor condition. Of the 113 stream crossing structures, the majority had either of the two following issues:

- They may require repair to their headwalls and wingwalls to ensure that they remain functional; or
- The metal pipes have rusted out for large portions and need to be replaced.

---

[9] Brattleboro Road, though there are currently no problems, is very low in relation to adjacent wetlands; culverts are filling up and water may start to flow over the road when the culverts plug up.

[10] Franklin Regional Council of Governments. "Town of Leyden Culvert Assessment." 2021.

Replacement of these stream crossing structures will require that they be brought up to current stream crossings standards, which can greatly increase their size (and cost), but will ensure that they be more resilient to future storm events. Two of these structures are located on Coates Road and have already received a DER grant for replacement. The remaining top problem culverts were identified as:

- River Road (Culvert 381) – this stream crossing is a bridge with a span greater than 10 feet. The wingwalls are composed of fieldstone, while the bridge is supported by timber beams. The beams are rotting, particularly where they meet the wingwalls, ground, and on the edges.
- North County Road (Culvert 262) – this culvert allows the Beaver Meadow Brook to flow under North County Road. It is a round, 12 inch metal pipe. The inlet to the culvert is 100% blocked.
- George Lamb Road (Culvert 346o) – this metal, 16 inch culvert has a headwall made of fieldstone. The headwall has fallen over and completely blocked the outlet.
- Greenfield Road (Culvert 302) – this stream crossing is a 3 foot, metal round pipe. It has a headwall composed on concrete. The invert of the metal pipe is beginning to rust and the concrete is spalling and crumbling, particularly at the footing and around the outlet.
- Simon Keets Road (Culvert 53o) – this culvert is a 12 inch metal pipe. The bank under the outlet is experiencing severe erosion.
- Alexander Road (Culvert 242) – this stream crossing is a cast iron, 4 foot pipe. The inlet's wing wall is experiencing scour and the side of the inlet pipe is beginning to rust and become brittle. Parts of the outlet's headwall has fallen over and erosion is occurring above the outlet.
- West Leyden Road (Culvert 283o) – this 16 inch, metal pipe has a large scour hole under the outlet and the ground under the outlet is eroding.

Additionally, in 2018 the FRCOG prepared a report on high-risk road-stream crossings in Leyden.[11,12] The report provides a summary of the road-stream crossings that are considered to be at high risk of failure from precipitation events. Road-stream crossings were evaluated based on risk of failure in three categories: structural risk, geomorphic risk, and hydraulic risk. More information about each of these categories is included in the report linked below. Replacement of these stream crossing structures will require that they be brought up to current MA Stream Crossing Standards, which can greatly increase their size (and cost), but will ensure that they be more resilient to future storm events.

Beaver Dams

Areas in town where beaver dams are prevalent are identified on the Critical Facilities and Infrastructure Map. According to Leyden residents, a number of beaver ponds have expanded in recent years. Particular areas of concern include beaver dams adjacent to Brattleboro Road, just north of the intersection with Frizzell Hill Road. If these dams were to fail, Brattleboro Road could be washed out and the septic system at the Town Offices could be flooded. The Town regularly cleans out the Hibbard Brook culvert on West Leyden Road to prevent The Bog from flooding the area. In the past, beaver dam

---

[11] Road-stream crossings such as culverts and bridges were included in the assessment.

[12] High Risk Stream Crossings in Leyden, MA: A Resource for Assessing Risk and Improving Resiliency. Franklin Regional Council of Governments, October 2018. https://frcog.org/wp-content/uploads/2018/12/Leyden-High-Risk-Stream-Crossing-Report-Oct-2018.pdf

failures along Harris Brook have washed out Gates Road.

The Core Team determined that flooding has a medium area of occurrence, with 10% to 50% of the town affected.

Extent

The principal factors affecting the strength and magnitude of flood damage are flood depth and velocity. The deeper and faster that flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high-velocity flows and transporting debris and sediment.

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) will be equaled or exceeded in a given year.
Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge (discussed further in the following subsection) has a 1% chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

Floods can be classified as one of two types: flash floods and general floods.

Flash Floods

Flash floods are the product of heavy, localized precipitation in a short time period over a given location. Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam.

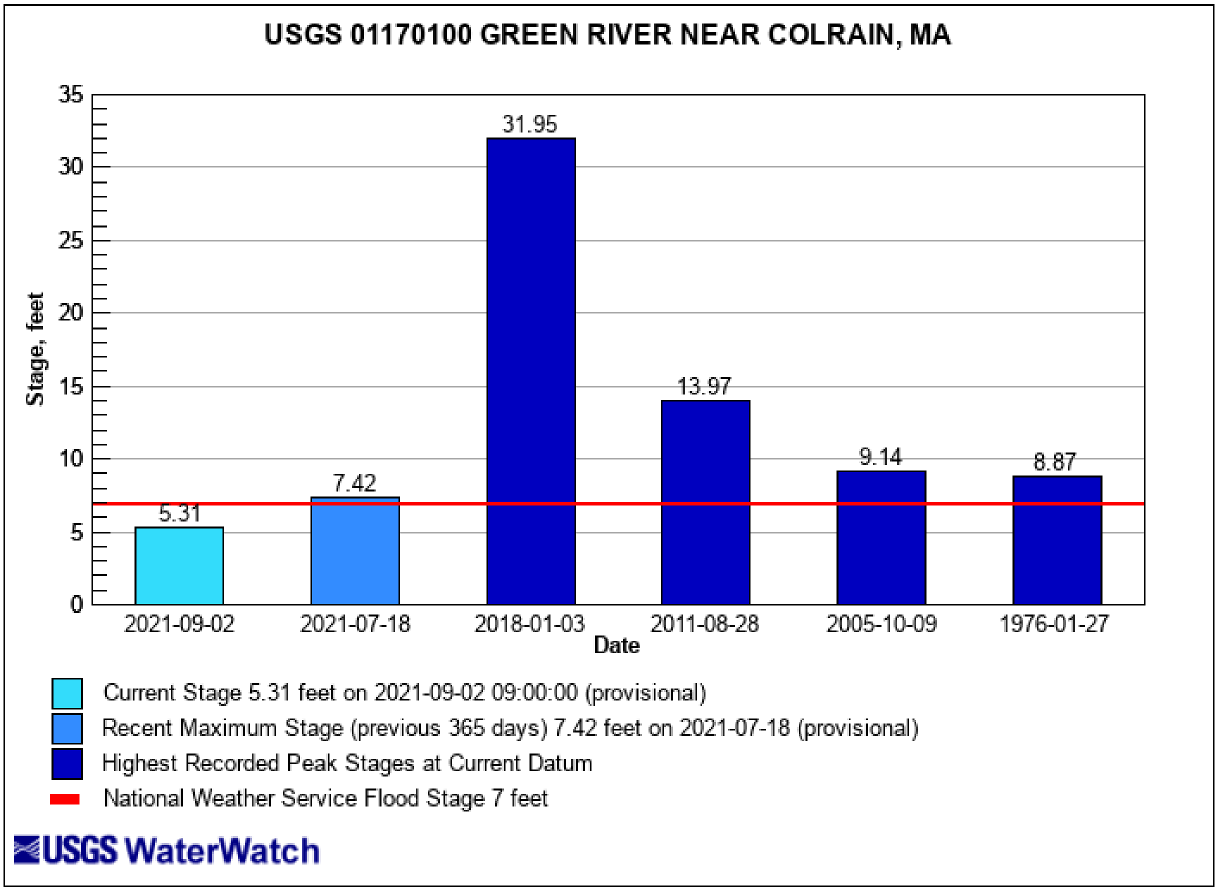
;Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface area (roadways, parking lots, rooftops).

General Floods

General flooding may last for several days or weeks and are caused by precipitation over a longer time period in a particular river basin. Excessive precipitation within a watershed of a stream or river can result in flooding particularly when development in the floodplain has obstructed the natural flow of the water and/or decreased the natural ability of the groundcover to absorb and retain surface water runoff (e.g., the loss of wetlands and the higher amounts of impervious surface area in urban areas).

Flood flows in Massachusetts are measured at numerous USGS stream gauges. The gauges operate routinely, but particular care is taken to measure flows during flood events to calibrate the stage-discharge relationships at each location and to document actual flood conditions. In the aftermath of a flood event, the USGS will typically determine the recurrence interval of the event using data from a gauge's period of historical record. Figure 3-3 shows the four highest recorded peak flooding events on the Green River, as well as the highest flow events in the last 365 days. A high flow event in July of 2021 reached 7.42 feet, surpassing the National Weather Service Flood Stage of 7 feet. The location of this river gage in the Green River is on the town boundary between Leyden and Colrain.

Figure 3-3: Highest Recorded Flood Events on the Green River on North Green River Road in Colrain, MA



Source: USGS WaterWatch https://waterwatch.usgs.gov/index.php?id=wwchart_ftc&site_no=01170100. Accessed on September 2, 2021.

<u>The 100-Year Flood</u>

The 100-year flood is the flood that has a 1% chance of being equaled or exceeded each year. The 100-year flood is the standard used by most federal and state agencies. For example, it is used by the National Flood Insurance Program (NFIP) to guide floodplain management and determine the need for flood insurance.

The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary can be used to assess vulnerability and risk in flood-prone communities.

Many communities have maps that show the extent and likely depth of flooding for the base flood. This extent generally includes both the stream channel and the flood fringe, which is the stream-adjacent area that will be inundated during a 100-year (or 1% annual chance) flood event but does not effectively convey floodwaters.

The 500-Year Flood

The term “500-year flood” is the flood that has a 0.2% chance of being equaled or exceeded each year. Flood insurance is not required by the NFIP in the 500-year floodplain, but could be required by individual lenders.

Secondary Hazards

The most problematic secondary hazards for flooding are fluvial erosion, river bank erosion, and landslides affecting infrastructure and other assets (e.g., agricultural fields) built within historic floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. For instance, fluvial erosion attributed to Hurricane Irene caused an excess of $23 million in damages along Route 2. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail.

These secondary hazards also affect infrastructure. Roadways and bridges are impacted when floods undermine or wash out supporting structures. Railroad tracks may be impacted, potentially causing a train derailment, which could result in the release of hazardous materials into the environment and nearby waterways. Dams may fail or be damaged, compounding the flood hazard for downstream communities. Failure of wastewater treatment plants from overflow or overtopping can occur during floods as well, releasing untreated wastewater or hazardous materials directly into storm sewers and rivers. Flooding can also impact public water supplies and the power grid.

Previous Occurrences

The average annual precipitation for Leyden and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2021, 19 flash floods have been reported in Franklin County (Table 3-6), resulting in $3,262,000 in property damages. Not all of these flash floods impacted Leyden.

Table 3-6: Previous Occurrences of Flash Floods in Franklin County			
Year	**# of Flash Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	4	$1,800,000	No Data
1998	1	$75,000	No Data
2000	1	No Data	No Data
2003	1	$10,000	No Data
2004	1	$10,000	No Data
2005	3	$1,235,000	No Data
2013	3	$65,000	No Data
2014	2	$50,000	No Data
2017	1	No Data	No Data
2021	2	$17,000	No Data
Total	**19**	**$3,262,000**	No Data

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed December 20, 2021

From 1996 to 2021, 48 flood events were reported in Franklin County, resulting in total property damages worth $25,593,000 (Table 3-7). The bulk of these damages ($22,275,000) were from Tropical Storm Irene in August 2011.

Leyden was spared from serious damage from Tropical Storm Irene in comparison to other Franklin County towns. A house next to the Green River on West Leyden Road was completely washed away. No one was injured during the incident. Other private homes in the town mostly suffered from nuisance flooding in basements simply because of saturated ground and a high water table. Bridge Lane, a private road, also washed out during the storm. The Town was concerned about a culvert on River Road and cleaned it out to avoid potential damage. Tropical Storm Irene did cause the Green River to change course, which resulted in the need to mitigate potential damage to a bridge abutment on the Ten Mile Bridge. The Leyden Highway Department worked with the Army Corps of Engineers on stabilizing the riverbank in this area. The Town was reimbursed $18,600 for damages from Irene.

Other storm events have caused flooding damage in Leyden. A microburst in July 2014 caused flash flooding along Keets Brook, washing out Alexander Road. As a result of heavy rain in August 2015, Keets Brook Road was flooded and impassable between Leyden and Bernardston, and $1,000 in property damage was incurred.

Table 3-7: Previous Occurrences of Floods in Franklin County			
Year	**# of Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	7	No Data	No Data
1998	3	No Data	No Data
2001	1	No Data	No Data
2004	1	No Data	No Data
2005	2	$2,600,000	No Data
2007	1	$250,000	No Data
2008	3	$38,000	No Data
2010	1	$150,000	No Data
2011	8	$22,375,000	No Data
2012	2	No Data	No Data
2015	10	$31,000	No Data
2017	1	$1,000	No Data
2018	4	$137,000	No Data
2020	1	No Data	No Data
2021	3	$11,000	No Data
Total	**48**	**$25,593,000**	**No Data**

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed December 20, 2021.

Table 3-8 displays flash flood and flooding events in Leyden since 1993 and reported damages. In total, two flood events were reported during this timeframe, including Tropical Storm Irene.

Table 3-8: Documented Flash Flood and Flooding Events in Leyden Since 1999			
Date	**Type**	**Recorded Property Damages**	**Storm Details**
8/28/2011	Flood	$22,000,000 (includes northwest Massachusetts, from Greenfield northwest through Colrain, Leyden, and vicinity.)	After receiving eight to ten inches of rain associated with Tropical Storm Irene, major flooding occurred to portions of northwest Massachusetts, from Greenfield northwest through Colrain, Leyden, and vicinity. There were evacuations- exact amount unknown- and there were homes that were condemned. A house on West Leyden Road was reported to have been washed away in Leyden on the Green River.
8/11/2015	Flood	$1,000	Keets Brook Road was flooded and

Table 3-8: Documented Flash Flood and Flooding Events in Leyden Since 1999			
Date	**Type**	**Recorded Property Damages**	**Storm Details**
			impassable between Leyden and Bernardston. The road was starting to wash out at the time of the report.

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed September 6, 2021.

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flooding events in Leyden is Moderate, with a 2% to 25% probability of occurring in any given year. Flooding frequencies for the various floodplains in Leyden are defined by FEMA as the following:

- 10-year floodplain – 10% chance of flooding in any given year
- 25-year floodplain – 2.5% chance of flooding in any given year
- 100-year floodplain – 1% chance of flooding in any given year
- 500-year floodplain – 0.2% chance of flooding in any given year

Of all the regions in the United States, the Northeast has seen the most dramatic increase in the intensity of rainfall events. The U.S. National Climate Assessment reports that between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events). Climate projections for Massachusetts, developed by the University of Massachusetts, suggest that the frequency of high-intensity rainfall events will continue to trend upward, and the result will be an increased risk of flooding. Specifically, the annual frequency of downpours releasing more than two inches of rain per day in Franklin County may climb from less than 1 day per year to 1.1 to 1.27 days per year by the 2090s. Events which release over one inch during a day could climb to as high as 9 to 11 days per year by the 2090s. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure.[13]

Impact

Flooding can cause a wide range of issues, from minor nuisance roadway flooding and basement flooding to major impacts such as roadway closures. Specific damages associated with flooding events include the following primary concerns:

- Blockages of roadways or bridges vital to travel and emergency response
- Breaching of dams
- Damaged or destroyed buildings and vehicles
- Uprooted trees causing power and utility outages

[13] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/changes-in-precipitation. Accessed December 20, 2021.

- Drowning, especially people trapped in cars
- Contamination of drinking water
- Dispersion of hazardous materials
- Interruption of communications and/or transportation systems, including train derailments

The impact of a flood event would be Limited in Leyden, with more than 10% of property in the affected area damaged or destroyed, and possible shutdown of facilities (roads, bridges, critical facilities) for more than one week.

Vulnerability

Society

The impact of flooding on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Populations living in or near floodplain areas may be impacted during a flood event. People traveling in flooded areas and those living in urban areas with poor stormwater drainage may be exposed to floodwater. People may also be impacted when transportation infrastructure is compromised from flooding.

Of Leyden's total acreage, 165 acres lie within the 100-year floodplain. According to 2016 MassGIS Land Use data there are 3 dwellings located in the floodplain (Table 3-9). Using this number and Leyden's estimated average household size, it is estimated that 7.5, or 0.01% of Leyden's total population, reside in the floodplain.

Table 3-9: Estimated Leyden Population Exposed to a 1% Flood Event				
Total Population	**# of Dwelling Units in Flood Hazard Area**	**Average # of People Per Household**	**Estimated Population in Flood Hazard Area**	**% of Total Population in Flood Hazard Area**
710	3	2.51	7.5	0.01%

Source: 2015-2019 American Community Survey Five-Year Estimates; 2016 MassGIS Land Use data.

<u>Vulnerable Populations</u>

Of the population exposed, the most vulnerable include people with low socioeconomic status, people over the age of 65, young children, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are more vulnerable because they are likely to consider the economic impacts of evacuation when deciding whether to evacuate. The population over the age of 65 is also more vulnerable because some of these individuals are more likely to seek or need medical attention because they may have more difficulty evacuating or the medical facility may be flooded. Those who have low English language fluency may not receive or understand the warnings to evacuate. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs.

Table 3-9 estimates the number of vulnerable people and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a flood event.

Table 3-10: Estimated Vulnerable Populations in Leyden		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event. The diesel fuel stored by the Highway Department is the only stored hazardous material located in Leyden.

<u>Health Impacts</u>
The total number of injuries and casualties resulting from typical riverine flooding is typically very limited thanks to advance weather forecasting, blockades, and warnings. The historical record from 1996 to 2018 indicates that there have been no fatalities or injuries associated with flooding or flash flooding events in Leyden. However, flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. For example, while 6 inches of moving water can cause adults to fall, 1 foot to 2 feet of water can sweep cars away. Downed power lines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone.

Events that cause loss of electricity and flooding in basements, where heating systems are typically located in Massachusetts homes, increase the risk of carbon monoxide poisoning. Carbon monoxide results from improper location and operation of cooking and heating devices (grills, stoves), damaged chimneys, or generators. According to the U.S. Environmental Protection Agency (EPA), floodwater often contains a wide range of infectious organisms from raw sewage. These organisms include intestinal bacteria, MRSA (methicillin-resistant staphylococcus aureus), strains of hepatitis, and agents of typhoid, paratyphoid, and tetanus (OSHA, 2005). Floodwaters may also contain agricultural or industrial chemicals and hazardous materials swept away from containment areas.

Individuals who evacuate and move to crowded shelters to escape the storm may face the additional risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals with pre-existing health conditions are also at risk if flood events (or related evacuations) render them unable to access medical support. Flooded streets and roadblocks can also make it difficult for emergency vehicles to respond to calls for service, particularly in rural areas.

Flood events can also have significant impacts after the initial event has passed. For example, flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual as a result of power outages or other flood-related conditions. Finally, the growth of mold inside buildings is often widespread after a flood.

Investigations following Hurricane Katrina and Superstorm Sandy found mold in the walls of many water-damaged homes and buildings. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2004). Property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events (Neria et al., 2008).

Economic Impacts

Economic losses due to a flood include, but are not limited to, damages to buildings (and their contents) and infrastructure, agricultural losses, business interruptions (including loss of wages), impacts on tourism, and impacts on the tax base. Flooding can also cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur, and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooding can shut down major roadways and disrupt public transit systems, making it difficult or impossible for people to get to work. Floodwaters can wash out sections of roadway and bridges, and the removal and disposal of debris can also be an enormous cost during the recovery phase of a flood event. Agricultural impacts range from crop and infrastructure damage to loss of livestock. Extreme precipitation events may result in crop failure, inability to harvest, rot, and increases in crop pests and disease. In addition to having a detrimental effect on water quality and soil health and stability, these impacts can result in increased reliance on crop insurance claims.

Damages to buildings can affect a community's economy and tax base; the following section includes an analysis of buildings in Leyden that are vulnerable to flooding and their associated value.

Infrastructure

Buildings, infrastructure, and other elements of the built environment are vulnerable to inland flooding. At the site scale, buildings that are not elevated or flood-proofed and those located within the floodplain are highly vulnerable to inland flooding. These buildings are likely to become increasingly vulnerable as riverine flooding increases due to climate change (Resilient MA, 2018). At a neighborhood to regional scale, highly developed areas and areas with high impervious surface coverage may be most vulnerable to flooding. Even moderate development that results in as little as 3% impervious cover can lead to flashier flows and river degradation, including channel deepening, widening, and instability (Vietz and Hawley, 2016).

Additionally, changes in precipitation will threaten key infrastructure assets with flood and water damage. Climate change has the potential to impact public and private services and business operations. Damage associated with flooding to business facilities, large manufacturing areas in river valleys, energy delivery and transmission, and transportation systems has economic implications for business owners as well as the state's economy in general (Resilient MA, 2018). Flooding can cause direct damage to Town-owned facilities and result in roadblocks and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service.

Table 3-11 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the floodplain. Less than one acre of commercial and 2.2 acres of public/institutional land uses lie within the floodplain. Though a small footprint, one hundred% of Leyden's commercial land use and 13% of public/institutional land use lies in the floodplain. There is no industrial land located in Leyden.

Table 3-11: Acres of Commercial, Industrial, and Public/Institutional Land Use Within the Flood Hazard Area in Leyden

Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Commercial	0.06	0.06	100%.
Industrial	0.00	0	0%
Public/Institutional	2.20	0.29	13%

Source: 2005 MassGIS Land Use data.

The average assessed values of the residential, commercial, and industrial land uses located within the floodplain are displayed in Table 3-12. The total average assessed value for these three land uses within the floodplain is $2,451,480. This is of concern because should a catastrophic flooding event befall Leyden, the assessed values of these structures and facilities would likely be significantly reduced, which in turn would impact the Town's tax revenues.

Table 3-12: Average Assessed Value of Land Use in Flood Hazard Area, 2021					
Land Use	**Total Acres in Town**	**Total Assessed Value**	**Average Assessed Value Per Acre**	**Acres in Flood Hazard Area**	**Average Assessed Value in Flood Hazard Area**
Residential	371.07	$92,101,538	$248,185	3.5	$868,648
Commercial	0.06	$1,582,832	$26,380,533	0.06	$1,582,832
Industrial	0	$239,600	$239,600	0	$0

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section 2021; 2016 MassGIS Land Use data.

NFIP data are useful for determining the location of areas vulnerable to flood and severe storm hazards. Table 3-13 summarizes the NFIP policies, claims, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties in Leyden associated with all flood events as of December 2018. A RL property is a property for which two or more flood insurance claims of more than $1,000 have been paid by the NFIP within any 10-year period since 1978. A SRL property is defined as one that "has incurred flood-related damage for which 4 or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property" (FEMA). Leyden currently has no policies in force. No losses have been paid and there are no repetitive loss properties in town.

Table 3-13: NFIP Policies, Claims, and Repetitive Loss Statistics for Leyden						
Number of Occupied Housing Units	**Number of Policies in Force**	**Percent of Housing Units**	**Total Insurance in Force**	**Number of Paid Losses**	**Total Losses Paid**	**Number of Repetitive Loss Properties**
283	0	0	$0	0	$0	0

Source: National Flood Insurance Program (NFIP), FEMA Region I; U.S. Census Bureau 2015-2019 American Community Survey Five-Year Estimates.

Many dams within the Commonwealth have aged past their design life. As a result, they are less resilient to hazards such as inland flooding and extreme precipitation, and may not provide adequate safety following these disasters. These structures, if impacted by disasters, can affect human health, safety, and economic activity due to increased flooding and loss of infrastructure functions. These dams require termination or restoration to improve their infrastructure and better equip them to withstand the hazards that the Commonwealth will face due to climate change.

As already stated, climate change impacts, including increased frequency of extreme weather events, are expected to raise the risk of damage to transportation systems, energy-related facilities, communication systems, a wide range of structures and buildings, solid and hazardous waste facilities, and water supply and wastewater management systems. A majority of the infrastructure in Massachusetts and throughout the country has been sited and designed based on historic weather and flooding patterns. As a result, infrastructure and facilities may lack the capacity to handle greater volumes of water or the required elevation to reduce vulnerability to flooding. Examples of climate change impacts to sectors of the built environment are summarized below.

<u>Agriculture</u>
Inland flooding is likely to affect the agricultural sector. Increased river flooding is likely to cause soil erosion, soil loss, and crop damage (Resilient MA, 2018). In addition, wetter springs may delay planting of crops, resulting in reduced yields.

<u>Energy</u>
Flooding can increase bank erosion and undermine buried energy infrastructure, such as underground power, gas, and cable infrastructure. Basement flooding can destroy electrical panels and furnaces. This can result in releases of oil and hazardous wastes to floodwaters. Inland flooding can also disrupt delivery of liquid fuels.

<u>Public Health</u>
The impacts to the built environment extend into other sectors. For example, flooding may increase the vulnerability of commercial and residential buildings to toxic mold buildup, leading to health risks, as described in the Populations section of the inland flooding hazard profile. Inland flooding may also lead to contamination of well water and contamination from septic systems (DPH, 2014).

<u>Public Safety</u>
Flash flooding can have a significant impact on public safety. Fast-moving water can sweep up debris, hazardous objects, and vehicles, and carry them toward people and property. Flooding can affect the ability of emergency response personnel to reach stranded or injured people. Drownings may also occur as people attempt to drive through flooded streets or escape to higher ground.

<u>Transportation</u>
Heavy precipitation events may damage roads, bridges, and energy facilities, leading to disruptions in transportation and utility services (Resilient MA, 2018). Roads may experience greater ponding, which will further impact transportation. If alternative routes are not available, damage to roads and bridges may dramatically affect commerce and public health and safety.

<u>Water Infrastructure</u>
Stormwater drainage systems and culverts that are not sized to accommodate larger storms are likely to

experience flood damage as extreme precipitation events increase (Resilient MA, 2018). Both culverts that are currently undersized and culverts that are appropriately sized may be overwhelmed by larger storms. Gravity-fed water and wastewater infrastructure that is located in low lying areas near rivers and reservoirs may experience increased risks. Combined sewer overflows may increase with climate change, resulting in water quality degradation and public health risks (Resilient MA, 2018).

Environment

Flooding is part of the natural cycle of a balanced environment. However, severe flood events can also result in substantial damage to the environment and natural resources, particularly in areas where human development has interfered with natural flood-related processes. As described earlier in this section, severe weather events are expected to become more frequent as a result of climate change; therefore, flooding that exceeds the adaptive capacity of natural systems may occur more often.

One common environmental effect of flooding is riverbank and soil erosion. Riverbank erosion occurs when high, fast water flows scour the edges of the river, transporting sediment downstream and reshaping the ecosystem. In addition to changing the habitat around the riverbank, this process also results in the deposition of sediment once water velocities slow. This deposition can clog riverbeds and streams, disrupting the water supply to downstream habitats. Soil erosion occurs whenever floodwaters loosen particles of topsoil and then transport them downstream, where they may be redeposited somewhere else or flushed into the ocean. Flooding can also influence soil conditions in areas where floodwaters pool for long periods of time, as continued soil submersion can cause oxygen depletion in the soil, reducing the soil quality and potentially limiting future crop production.

Flooding can also affect the health and well-being of wildlife. Animals can be directly swept away by flooding or lose their habitats to prolonged inundation. Floodwaters can also impact habitats nearby or downstream of agricultural operations by dispersing waste, pollutants, and nutrients from fertilizers. While some of these substances, particularly organic matter and nutrients, can actually increase the fertility of downstream soils, they can also result in severe impacts to aquatic habitats, such as eutrophication.

Debris Management

The Regional Debris Management Plan created by the Regional Emergency Planning Core Team (REPC) approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute a Memorandum of Understanding (MOU) with neighboring communities.

The Town may need to adopt and submit to MEMA/FEMA a Town-specific version of the Franklin County Regional Debris Management Plan (accepted by FEMA on 7-17-15), which contains information about Disaster Debris Management Sites pre-certified by MassDEP and identifies pre-qualified contractors for disaster debris management and monitoring services. Adoption of the plan would enable the Town to benefit from the increased cost share adjustments available under the FEMA Public Assistance

Alternative Procedures (PAAP) Pilot Program for Debris Removal. The Town could also build their own Disaster Debris Management Plan using a template that is available on the Western Region Homeland Security Advisory Council (WRHSAC) website.[14]

Vulnerability Summary

Based on the above analysis, Leyden has a Medium vulnerability to flooding.

[14] https://wrhsac.org/projects-and-initiatives/disaster-debris-management/

3.4 SEVERE SNOWSTORMS / ICE STORMS

Potential Effects of Climate Change

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change, including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers and lower spring river flows for aquatic ecosystems. Figure 3-4 show potential effects of climate change on severe winter storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-4: Effects of Climate Change on Severe Winter Storms

Potential Effects of Climate Change		
	EXTREME WEATHER AND RISING TEMPERATURES ➔ INCREASED SNOWFALL	Increased sea surface temperature in the Atlantic Ocean will cause air moving north over the ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts.
	RISING TEMPERATURES ➔ CHANGING CIRCULATION PATTERNS AND WARMING OCEANS	Research has found that increasing water temperatures and reduced sea ice extent in the Arctic are producing atmospheric circulation patterns that favor the development of winter storms in the eastern U.S. Global warming is increasing the severity of winter storms because warming ocean water allows additional moisture to flow into the storm, which fuels the storm to greater intensity.
	EXTREME WEATHER ➔ INCREASE IN FREQUENCY AND INTENSITY	There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated in the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Severe winter storms include blizzards, blowing snow, ice storms, nor'easters, heavy snow and other extreme forms of winter precipitation. A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile (NWS, 2018). These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20ºF. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero.

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 in the storm 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

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups of one-fourth of an inch or more. These can cause severe damage. An ice storm warning, which is now included in the criteria for a winter storm warning, is issued when a half inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees.

Ice pellets are another form of freezing precipitation, formed when snowflakes melt into raindrops as they pass through a thin layer of warmer air. The raindrops then refreeze into particles of ice when they fall into a layer of subfreezing air near the surface of the earth. Finally, sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm 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.). A nor'easter is characterized by a large counter-clockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, and rain. 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 are among winter's most ferocious storms. These winter weather events are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. These storms occur most often in late fall and early winter. The storm radius is often as much as 100 miles, and nor'easters often sit stationary for several days, affecting multiple tide cycles and causing extended heavy precipitation. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 mph. Nor'easters are commonly accompanied with a storm surge equal to or greater than 2.0 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 will then either move up the East Coast into New England and the Atlantic provinces of Canada, or out to sea. The level of damage in a strong hurricane is often more severe than a nor'easter, but historically Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (one or two per year). The comparison of hurricanes to nor'easters reveals that the duration of high surge and winds in a hurricane is 6 to 12 hours, while a nor'easter's duration can be from 12 hours to 3 days.

Severe winter storms can pose a significant risk to property and human life. The rain, freezing rain, ice, snow, cold temperatures and wind associated with these storms can cause the following hazards:

- Disrupted power and phone service
- Unsafe roadways and increased traffic accidents
- Infrastructure and other property are also at risk from severe winter storms and the associated flooding that can occur following heavy snow melt
- Tree damage and fallen branches that cause utility line damage and roadway blockages
- Damage to telecommunications structures
- Reduced ability of emergency officials to respond promptly to medical emergencies or fires

Location

Although the entire Commonwealth may be considered at risk to the hazard of severe winter storms, higher snow accumulations appear to be prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture. Ice storms occur most frequently in the higher-elevation portions of Western and Central Massachusetts. Inland areas, especially those in floodplains, are also at risk for flooding and wind damage.

The entire town of Leyden is susceptible to severe snowstorms and ice storms. Because these storms occur regionally, they impact the entire town. As a result, the location of occurrence is Large, with over 50% of land area affected.

Extent

Since 2005, the Regional Snowfall Index (RSI) has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5 as depicted in Table 3-14. The RSI is similar to 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 population.

The RSI is a regional index. Each of the six climate regions (identified by the NOAA National Centers for Environmental Information) in the eastern two-thirds of the nation has a separate index. The RSI incorporated region-specific parameters and thresholds for calculating the index. The RSI is important because, with it, a storm event and its societal impacts can be assessed within 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.

Table 3-14: Regional Snowfall Index Categories		
Category	**RSI Value**	**Description**
1	1—3	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Prior to the use of the RSI, the Northeast Snowfall Impact Scale (NESIS), developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service, was used to characterize and rank high-impact northeast snowstorms with large areas of 10-inch snowfall accumulations and greater. In contrast to the RSI, which is a regional index, NESIS is a quasi-national index that is calibrated to Northeast snowstorms. NESIS has five categories, as shown in Table 3-15.

Table 3-15: Northeast Snowfall Impact Scale Categories		
Category	**NESIS Value**	**Description**
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Previous Occurrences

New England generally experiences at least one or two severe winter storms each year with varying degrees of severity. Severe winter storms typically occur during January and February; however, they can occur from late September through late April. According to NOAA's National Climatic Data Center, as of December 2021, there have been 145 *heavy snow events* in Franklin County since 1996, resulting in $15,448,900 in damages; 53 *winter storm events* since 2002, resulting in $1,170,000 in damages; and five ice storms since 2002 that have resulted in damages of $6,300,000. In some cases, these events were the same storm recorded as different events (Eastern Franklin County and Western Franklin County).

In December 2008, a major ice storm impacted the Northeast. The hardest hit areas in southern New England were the Monadnock region of southwest New Hampshire, the Worcester Hills in central Massachusetts, and the east slopes of the Berkshires in western Massachusetts. Anywhere from half an inch to an inch of ice built up on many exposed surfaces. Combined with breezy conditions, the ice downed numerous trees, branches, and power lines, which resulted in widespread power outages. More than 300,000 customers were reportedly without power in Massachusetts and an additional 300,000 were without power in the state of New Hampshire.

Damage to the infrastructure in Massachusetts and New Hampshire amounted to roughly 80 million dollars. This amount does not include damage to private property. The extent of the damage and number of people affected prompted the governors of both Massachusetts and New Hampshire to request federal assistance. FEMA approved both requests. President Bush issued a Major Disaster Declaration for Public Assistance for seven Massachusetts counties and all of New Hampshire.

Based on data available from the National Oceanic and Atmospheric Administration, there are 214 winter storms since 1900 that have registered on the RSI scale. Of these, 31 storms with an RSI Value of 3 or greater have impacted the Northeast Region between 1900 and 2021. These storms are listed in Table 3-16, in order of their RSI severity.

Table 3-16: High-Impact Snowstorms in the Northeast, 1900 - 2021

Date	RSI Value	RSI Category	RSI Classification
1/6/1996	21.708	5	Extreme
3/12/1993	22.117	5	Extreme
2/4/1978	18.422	5	Extreme
2/22/1969	34.026	5	Extreme
3/12/2017	10.658	4	Crippling
1/22/2016	17.758	4	Crippling
2/21/2010	17.827	4	Crippling
2/14/2003	14.671	4	Crippling
2/26/1971	10.178	4	Crippling
12/25/1969	10.137	4	Crippling
1/28/1966	12.281	4	Crippling
11/22/1950	14.531	4	Crippling
2/27/1947	10.63	4	Crippling
3/3/1902	12.193	4	Crippling
2/26/1900	15.654	4	Crippling
1/30/2021	6.188	3	Major
1/25/2015	6.158	3	Major
2/8/2013	9.212	3	Major
2/4/2010	9.062	3	Major
2/11/2007	6.891	3	Major
12/4/2003	9.398	3	Major
2/10/1983	7.86	3	Major
2/1/1961	8.276	3	Major
2/29/1960	6.899	3	Major

Table 3-16: High-Impact Snowstorms in the Northeast, 1900 - 2021			
Date	**RSI Value**	**RSI Category**	**RSI Classification**
3/18/1958	7.144	3	Major
2/12/1958	7.866	3	Major
12/25/1947	8.108	3	Major
1/28/1925	7.383	3	Major
2/4/1920	6.028	3	Major
12/10/1915	6.133	3	Major
2/12/1914	9.875	3	Major

Source: https://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts. Accessed September 6, 2021.

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe snowstorm will hit Leyden in any given year is Very High, or a 70 to 100% probability in any given year.

Increased sea surface temperature in the Atlantic Ocean will cause air moving north over this ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts. Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers and lower spring river flows for aquatic ecosystems.

Impact

The phrase “severe winter storm” encapsulates several types of natural hazards, including snowfall, wind, ice, sleet, and freezing rain hazards. Additional natural hazards that can occur as a result of winter storms include sudden and severe drops in temperature. Winter storms can also result in flooding and the destabilization of hillsides as snow or ice melts and begins to run off. The storms can also result in significant structural damage from wind and snow load as well as human injuries and economic and infrastructure impacts.

The impact of an event could be Critical, with more than 25% of property in the affected area damaged and complete shutdown of facilities for more than 1 day possible.

Vulnerability

Society

According to the NOAA National Severe Storms Laboratory, every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds that create blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. These events are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. Injuries and deaths may occur due to traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold.

Heavy snow can immobilize a region and paralyze a community, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can cause buildings to collapse and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may perish. In the mountains, heavy snow can lead to avalanches.

The impact of a severe winter storm on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time was provided to residents. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. The entire population of Leyden is exposed to severe winter weather events.

Vulnerable Populations

Vulnerable populations include the elderly living alone, who are susceptible to winter hazards due to their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or injury and death related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. People with low socioeconomic status are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact on their families. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply).

The population over the age of 65, individuals with disabilities, and people with mobility limitations or who lack transportation are also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a winter storm event. These individuals are also more vulnerable because they may have more difficulty if evacuation becomes necessary. People with limited mobility risk becoming isolated or "snowbound" if they are unable to remove snow from their homes. Rural populations may become isolated by downed trees, blocked roadways, and power outages. Residents relying on private wells could lose access to fresh drinking water and indoor plumbing during a power outage.

Table 3-17 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a severe winter storm event.

Table 3-17: Estimated Vulnerable Populations in Leyden		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283

Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Health Impacts

Cold weather, which is a component of a severe winter storm, increases the risk of hypothermia and frostbite. Exposure to cold conditions can also exacerbate pre-existing respiratory and cardiovascular conditions. In addition to temperature-related dangers, however, severe winter storms also present other potential health impacts. For example, individuals may use generators in their homes if the power goes out or may use the heat system in their cars if they become trapped by snow. Without proper ventilation, both of these activities can result in carbon monoxide buildup that can be fatal. Loss of power can also lead to hypothermia. After Hurricane Sandy, the number of cases of cold exposure in New York City was three times greater than the same time period in previous years.[15] Driving during severe snow and ice conditions can also be very dangerous, as roads become slick and drivers can lose control of their vehicle. During and after winter storms, roads may be littered with debris, presenting a danger to drivers. Health impacts on people include the inability to travel to receive needed medical services and isolation in their homes. Additionally, natural gas-fueled furnaces, water heaters, and clothes dryers, and even automobile exhaust pipes may become blocked by snow and ice, which can lead to carbon monoxide poisoning.

Economic Impacts

The entire building stock inventory in Leyden is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content.

[15] Fink, Sheri. 2012. Hypothermia and Carbon Monoxide Poisoning Cases Soar in the City After Hurricane. New York Times. November 28.2012

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power networks can be disrupted for days while utility companies work to repair the extensive damage.

Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause both riverine and urban flooding. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms, including loss of utilities, interruption of transportation corridors, loss of business functions, and loss of income for many individuals during business closures, also impact the local economy.

Similar to hurricanes and tropical storms, nor'easter events can greatly impact the economy, with impacts that include the loss of business functions (e.g., tourism and recreation), damage to inventories or infrastructure (the supply of fuel), relocation costs, wage losses, and rental losses due to the repair or replacement of buildings.

Infrastructure

All infrastructure and other elements of the built environment in Leyden are exposed to the severe winter weather hazard. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common (Resilient MA, 2018). Table 3-18 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a severe winter storm.

Table 3-18: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

<u>Agriculture</u>

Severe winter weather can lead to flooding in low-lying agricultural areas. Ice that accumulates on branches in orchards and forests can cause branches to break, while the combination of ice and wind can fell trees. Storms that occur in spring can delay planting schedules. Frost that occurs after warmer periods in spring can cause cold weather dieback and damage new growth.

Energy

Severe weather can cause power outages from trees that fall during heavy snow and strong wind events. Severe ice events can take down transmission and distribution lines. The severe weather can impair a utility's ability to rapidly repair and recover the system.

Public Health

Severe winter weather presents many health hazards, as previously described in the discussion of the severe winter storm/nor'easter hazard profile. Severe winter storms and events with extended power outages may overburden hospitals and emergency shelters.

Public Safety

Public safety buildings may experience direct loss (damage) from downed trees, heavy snowfall, and high winds. Full functionality of critical facilities, such as police, fire and medical facilities, is essential for response during and after a winter storm event. Because power interruptions can occur, backup power is recommended for critical facilities and infrastructure. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees.

Transportation

Other infrastructure elements at risk for this hazard include roadways, which can be obstructed by snow and ice accumulation or by windblown debris. Additionally, over time, roadways can be damaged from the application of salt and the thermal expansion and contraction from alternating freezing and warming conditions. Other types of infrastructure, including rail, aviation, port, and waterway infrastructure (if temperatures are cold enough to cause widespread freezing), can be impacted by winter storm conditions.

Water Infrastructure

Water infrastructure that is exposed to winter conditions may freeze or be damaged by ice.

Environment

Although winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are well adapted to these events, changes in the frequency or severity of winter storms could increase their environmental impacts. Environmental impacts of severe winter storms can include direct mortality of individual plants and animals and felling of trees, which can damage the physical structure of the ecosystem. Similarly, if large numbers of plants or animals die as the result of a storm, their lack of availability can impact the food supply for animals in the same food web. If many trees fall or die within a small area, they can release large amounts of carbon as they decay. This unexpected release can cause further imbalance in the local ecosystem. The flooding that results when snow and ice melt can also cause extensive environmental impacts. Nor'easters can cause impacts that are similar to those of hurricanes and tropical storms and flooding. These impacts can include direct damage to species and ecosystems, habitat destruction, and the distribution of contaminants and hazardous materials throughout the environment.

Vulnerability Summary

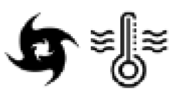
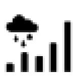
Based on the above assessment, Leyden faces a High vulnerability from severe winter storms. High-impact snow and ice storms occur frequently in Leyden and due to climate change, these storms will be occurring more frequently.

3.5 HURRICANES / TROPICAL STORMS

Potential Effects of Climate Change

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land. When extreme storms like Tropical Storm Irene travel over inland areas, they may release large quantities of precipitation and cause rivers to overtop their banks. Irene dumped more than 10 inches of rain in western Massachusetts. Buildings floated downriver in Shelburne Falls, flooded highways were closed, and 400,000 utility customers lost power (Resilient MA, 2018). Figure 3-5 displays the potential effects of climate change on hurricanes and tropical storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-5: Effects of Climate Change on Hurricanes and Tropical Storms

Potential Effects of Climate Change		
	EXTREME WEATHER AND RISING TEMPERATURES ➔ LARGER, STRONGER STORMS	As warmer oceans provide more energy for storms, both past events and models of future conditions suggest that the intensity of tropical storms and hurricanes will increase.
	CHANGES IN PRECIPITATION ➔ INCREASED RAINFALL RATES	Warmer air can hold more water vapor, which means the rate of rainfall will increase. One study found that hurricane rainfall rates were projected to rise 7 percent for every degree Celsius increase in tropical sea surface temperature.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Hurricanes

Hurricanes can range from as small as 50 miles across to as much as 500 miles across; Hurricane Allen in 1980 took up the entire Gulf of Mexico. There are generally two source regions for storms that have the potential to strike New England: (1) off the Cape Verde Islands near the west coast of Africa, and (2) in the Bahamas. The Cape Verde storms tend to be very large in diameter, since they have a week or more to traverse the Atlantic Ocean and grow. The Bahamas storms tend to be smaller, but they can also be just as powerful, and their effects can reach New England in only a day or two.

Tropical systems customarily come from a southerly direction and when they accelerate up the East Coast of the U.S., most take on a distinct appearance that is different from a typical hurricane. Instead of having a perfectly concentric storm with heavy rain blowing from one direction, then the calm eye, then the heavy rain blowing from the opposite direction, our storms (as viewed from satellite and radar) take on an almost winter-storm-like appearance. Although rain is often limited in the areas south and east of the track of the storm, these areas can experience the worst winds and storm surge.

Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation. Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall.

The official hurricane season runs from June 1 to November 30. In New England, these storms are most likely to occur in August, September, and the first half of October. This is due in large part to the fact that it takes a considerable amount of time for the waters south of Long Island to warm to the temperature necessary to sustain the storms this far north. Also, as the region progresses into the fall months, the upper-level jet stream has more dips, meaning that the steering winds might flow from the Great Lakes southward to the Gulf States and then back northward up the eastern seaboard. This pattern would be conducive for capturing a tropical system over the Bahamas and accelerating it northward.

Tropical Storms

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They 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.

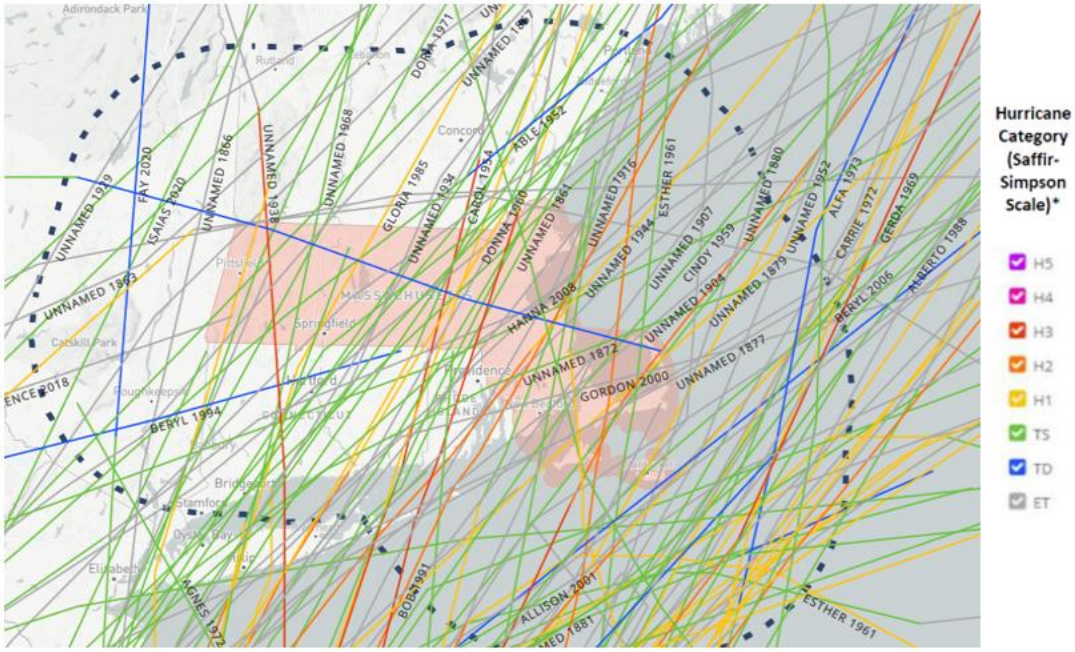
The term "tropical" refers both to the geographical origin of these systems, which usually form in tropical regions of the globe, and to their formation in maritime tropical air masses. The term "cyclone" refers to such storms' cyclonic nature, with counterclockwise wind flow in the Northern Hemisphere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

Location

Because of the hazard's regional nature, all of Leyden is at risk from hurricanes and tropical storms, with a Large location of occurrence with over 50% of land area affected. Ridge tops are more susceptible to wind damage. Inland areas, especially those in floodplains, are also at risk for flooding from heavy rain and wind damage. The majority of the damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms.

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2020. According to this resource, over the time frame tracked, 70 events categorized as an extra-tropical storm or higher occurred within 65 nautical miles of Massachusetts. The tracks of these storms are shown in Figure 3-6. As this figure shows, the paths of these storms vary across the Commonwealth, but are more likely to occur toward the coast.

Figure 3-6: Historical Hurricane Paths within 65 Miles of Massachusetts



Source: NOAA, Figure Generated March 2022. * TS=Tropical Storm, TD=Tropical Depression

Extent

Hurricanes are measured according to the Saffir-Simpson scale, which categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected from a hurricane landfall. Wind speed is the determining factor in the scale. All winds are assessed using the U.S. 1-minute average, meaning the highest wind that is sustained for 1 minute. The Saffir-Simpson Scale described in Table 3-19 gives an overview of the wind speeds and range of damage caused by different hurricane categories.

Table 3-19: Saffir-Simpson Scale		
Scale No. (Category)	**Winds (mph)**	**Potential Damage**
1	74 – 95	Minimal: Damage is primarily to shrubbery and trees, mobile homes, and some signs. No real damage is done to structures.
2	96 – 110	Moderate: Some trees topple; some roof coverings are damaged; and major damage is done to mobile homes.
3	111 – 130	Extensive: Large trees topple; some structural damage is done to roofs; mobile homes are destroyed; and structural damage is done to small homes and utility buildings.
4	131 – 155	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	Catastrophic: Roof damage is considerable and widespread; window and door damage is severe; there are extensive glass failures; and entire buildings could fail.
Additional Classifications		
Tropical Storm	39-73	NA
Tropical Depression	< 38	NA

Source: NOAA, n.d. Note: mph = miles per hour, NA = not applicable

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. 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 5 days.

While tropical storms can produce extremely powerful winds and torrential rain, they are also able to produce high waves, damaging storm surge, and tornadoes. They develop over large bodies of warm water and lose their strength if they move over land due to increased surface friction and loss of the warm ocean as an energy source. Heavy rains associated with a tropical storm, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 25 miles from the coastline.

One measure of the size of a tropical cyclone is determined by measuring the distance from its center of circulation to its outermost closed isobar. If the radius is less than 2 degrees of latitude, or 138 miles, then the cyclone is “very small.” A radius between 3 and 6 degrees of latitude, or 207 to 420 miles, is considered “average-sized.” “Very large” tropical cyclones have a radius of greater than 8 degrees, or 552 miles.

Previous Occurrences

According to NOAA's Historical Hurricane Tracker tool, 70 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2020. Therefore, there is an average of one storm every two to three years, or 0.4 storms per year. Storms severe enough to receive FEMA disaster declarations, however, are far rarer, occurring every 9 years on average. The Commonwealth has not been impacted by any Category 4 or 5 hurricanes; however, Category 3 storms have historically caused widespread flooding. Winds have caused sufficient damage to impair the ability of individuals to remain in their homes.

In Massachusetts, major hurricanes occurred in 1904, 1938, 1954, 1955, 1960 and 1976, 1985, 1991 and 2010. The Great New England Hurricane of 1938, a Category 3 hurricane which occurred on September 21, 1938, was one of the most destructive and powerful storms ever to strike Southern New England. Sustained hurricane force winds occurred throughout most of Southern New England. Extensive damage occurred to roofs, trees and crops. Widespread power outages occurred, which in some areas lasted several weeks. Rainfall from this hurricane resulted in severe river flooding across sections of Massachusetts and Connecticut. The combined effects from a frontal system several days earlier and the hurricane produced rainfall of 10 to 17 inches across most of the Connecticut River Valley. This resulted in some of the worst flooding ever recorded in this area. The most recent hurricane to make landfall in Franklin County was Hurricane Bob, a weak Category 2 hurricane, which made landfall in New England in August 1991. In Franklin County, Hurricane Bob caused roughly $5,555,556 in property and crop damages. Tropical Storm Doria in 1971 and an unnmed hurricane in 1867 have tracked directly through Leyden.

Historic data for hurricane and tropical storm events indicate one hurricane and 17 tropical storms have been recorded in Franklin County. Hurricane Bob in 1991 caused over $5.5 million in property damage in the county, and over $500,000 in crop damage. In 2011, Tropical Storm Irene caused over $26 million in property damage in Franklin County, mostly from flooding impacts.

Probability of Future Events

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land.[16]

Leyden's location in western Massachusetts reduces the risk of extremely high winds that are associated with hurricanes, although it can experience some high wind events. Based upon past occurrences, Leyden has a High probability, or a 25% to 50% chance, of experiencing a hurricane or tropical storm event in a given year.

---

[16] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 11, 2019.

Impact

While historically there have been no Hurricane events that have impacted Leyden, the Vulnerability Assessment revealed an occurrence would probably have a Limited impact the Town, with potential multiple injuries or deaths of citizens possible and with a potential of more than 10% of property damaged or destroyed.

Vulnerability

The entire town would be vulnerable to the impact of a hurricane or tropical storm. Areas prone to flooding are particularly vulnerable. Additionally, high winds could impact the town's communication and energy infrastructure.

Society

Vulnerable Populations

Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are likely to consider the economic impacts of evacuation when deciding whether or not to evacuate. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. During and after an event, rescue workers and utility workers are vulnerable to impacts from high water, swift currents, rescues, and submerged debris. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs or to relocate from a damaged neighborhood.

Table 3-20 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a hurricane or tropical storm event.

Table 3-20: Estimated Vulnerable Populations in Leyden

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%

Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Health Impacts

The health impacts from hurricanes and tropical storms can generally be separated into impacts from flooding and impacts from wind. The potential health impacts of flooding are extensive and are discussed in detail in the Flooding section. In general, some of the most serious flooding-related health threats include floodwaters sweeping away individuals or cars, downed power lines, and exposure to hazards in the water, including dangerous animals or infectious organisms. Contact with contaminated floodwaters can cause gastrointestinal illness.

Wind-related health threats associated with hurricanes are most commonly caused by projectiles propelled by the storm's winds. Wind- and water-caused damage to residential structures can also increase the risk of threat impacts by leaving residents more exposed to the elements. Hurricanes that occur later in the year also increase the risk of hypothermia.

Economic Impacts

In addition to the human costs that extreme storms deliver when they permanently or temporarily displace people, the repair and reconstruction costs after storm damage can be enormous for homeowners and businesses. When bridges and culverts have been washed away and roads damaged, municipal and state agencies must secure the resources for expensive recovery projects in limited municipal budgets and from Federal disaster grant programs that are increasingly over-subscribed. Electrical grid, power plants and wastewater infrastructure repair costs are all expected to increase in the future.[17]

Infrastructure

Hurricanes and tropical storms could catastrophically affect the town, with a potential of more than 50% of property in affected area damaged or destroyed. Residential and commercial buildings built along rivers may be vulnerable to severe damage. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Table 3-21 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a hurricane or tropical storm. Leyden is a member of the Franklin County Cooperative Inspection Program (FCCIP), which works to ensure that new buildings are designed and constructed to reduce the risk of

[17] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 29, 2019.

damage from high winds.

Table 3-21: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2021**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

Energy

Hurricanes and tropical storms often result in power outages and contact with damaged power lines during and after a storm, which may result in electrocution.

Public Health

Combined sewer overflows associated with heavy rainfall can release contaminants, chemicals, and pathogens directly into the environment and into water systems. If a mass outbreak of waterborne illness were to occur, hospitals and medical providers may lack the capacity to treat patients. Leyden does not have any combined sewer overflows.

Public Safety

Critical infrastructure, including local and state-owned police and fire stations, other public safety buildings, and facilities that serve as emergency operation centers may experience direct loss (damage) during a hurricane or tropical storm. Emergency responders may also be exposed to hazardous situations when responding to calls. Road blockages caused by downed trees may impair travel.

Transportation

Some roads and bridges are also considered critical infrastructure, particularly those providing ingress and egress and allowing emergency vehicles access to those in need. Costly damage to roads, bridges, and rail networks may occur as a result of hurricanes.[18]

Water and Wastewater Infrastructure

Wastewater treatment centers may face elevated risks of damage and destruction from hurricanes (Resilient MA, 2018). Heavy rains can lead to contamination of well water and can release contaminants

[18] Resilient MA 2018.

from septic systems (DPH, 2014). Heavy rainfall can also overburden stormwater systems, drinking water supplies, and sewage systems.

Environment

The environmental impacts of hurricanes and tropical storms are similar to those described for other hazards, including flooding, severe winter storms and other severe weather events. As described for human health, environmental impacts can generally be divided into short-term direct impacts and long-term impacts. As the storm is occurring, flooding may disrupt normal ecosystem function and wind may fell trees and other vegetation. Additionally, wind-borne or waterborne detritus can cause mortality to animals if they are struck or transported to a non-suitable habitat.

In the longer term, impacts to natural resources and the environment as a result of hurricanes and tropical storms are generally related to changes in the physical structure of ecosystems. For example, flooding may cause scour in riverbeds and erode riverbanks, modifying the river ecosystem and depositing the scoured sediment in another location. Similarly, trees that fall during the storm may represent lost habitat for local species, or they may decompose and provide nutrients for the growth of new vegetation. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

Vulnerability Summary

Based on the above analysis, Leyden faces a Medium vulnerability from hurricanes and tropical storms.

3.6 SEVERE THUNDERSTORMS / WIND / MICROBURSTS

Potential Effects of Climate Change

Climate change is expected to increase extreme weather events across the globe and in Massachusetts. Climate change leads to extreme weather because of warmer air and ocean temperatures and changing air currents. Warmer air leads to more evaporation from large water bodies and holds more moisture, so when clouds release their precipitation, there is more of it. In addition, changes in atmospheric air currents like jet streams and ocean currents can cause changes in the intensity and duration of stormy weather. While it is difficult to connect one storm to a changing climate, scientists point to the northeastern United States as one of the regions that is most vulnerable to an increase in extreme weather driven by climate change.[19]

Figure 3-7: Effects of Climate Change on Severe Thunderstorms, Wind, and Microbursts

Potential Effects of Climate Change		
	EXTREME WEATHER AND CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT THUNDERSTORMS AND DOWNPOURS	The Northeast has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, and this trend is expected to continue.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size.

Tornadoes can also be generated during these events. According to the National Weather Service, a thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado.

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage that is 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 "macro-burst." An organized, fast-moving line of microbursts traveling across large areas is known as a "derecho." These occasionally occur in Massachusetts. Winds exceeding 100 mph have been measured from downbursts in Massachusetts.

[19] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 29, 2019.

Wind is air in motion relative to surface of the earth. For non-tropical events over land, the NWS issues a Wind Advisory (sustained winds of 31 to 39 mph for at least 1 hour or any gusts 46 to 57 mph) or a High Wind Warning (sustained winds 40+ mph or any gusts 58+ mph). For non-tropical events over water, the NWS issues a small craft advisory (sustained winds 25-33 knots), a gale warning (sustained winds 34-47 knots), a storm warning (sustained winds 48 to 63 knots), or a hurricane force wind warning (sustained winds 64+ knots). For tropical systems, the NWS issues a tropical storm warning for any areas (inland or coastal) that are expecting sustained winds from 39 to 73 mph. A hurricane warning is issued for any areas (inland or coastal) that are expecting sustained winds of 74 mph. Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, and other structural components. High winds can cause scattered power outages. High winds are also a hazard for aircraft.

Location

Leyden has a Large location of occurance, with the entire town of Leyden at risk for severe thunderstorms, wind and microbursts.

Extent

An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. The severity of thunderstorms can vary widely, from commonplace and short-term events to large-scale storms that result in direct damage and flooding. Thunderstorms can cause hail, wind, and flooding, with widespread flooding the most common characteristic that leads to a storm being declared a disaster. The severity of flooding varies widely based both on characteristics of the storm itself and the region in which it occurs. Lightning can occasionally also present a severe hazard. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms.

Microbursts are typically less than three miles across. They can last anywhere from a few seconds to several minutes. Microbursts cause damaging winds up to 170 miles per hour in strength and can be accompanied by precipitation.

Leyden is susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Wind speeds in a hurricane are measured using the Saffir-Simpson scale. Another scale developed for measuring wind is the Beaufort wind scale (see Figure 3-8).

Figure 3-8: Beaufort Wind Scale				
Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Source: Developed in 1805 by Sir Francis Beaufort

Previous Occurrences

Since 1996, a total of 23 high wind events occurred in Franklin County (Table 3-22), causing a total of $307,000 in property damages. In some cases, these events were the same storm recorded as different events (Eastern Franklin County and Western Franklin County). High winds are defined by the National Weather Service as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration. The probability of future high wind events is expected to increase as a result of climate projections for the state that suggest a greater occurrence of severe weather events in the future.

Table 3-22: High Wind Events in Franklin County			
Year	**# of High Wind Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	4	$0	$0
1999	1	$0	$0
2003	4	$130,000	$0
2004	1	$30,000	$0
2005	1	$10,000	$0
2006	5	$68,000	$0
2011	2	$15,000	$0
2013	2	$35,000	$0
2018	1	$3,000	$0
2019	1	$12,000	$0
2020	1	$4,000	$0
Total	**23**	**$307,000**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed September, 6, 2021.

Thunderstorm winds are defined by the National Weather Service as winds arising from convection (occurring within 30 minutes of lightning being observed or detected) with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Leyden has experienced 13 thunderstorm wind events since 1996 (Table 3-23). These storms resulted in downed trees and wires and caused $203,000 in property damage.

Table 3-23: Thunderstorm Wind Events in Leyden				
Year	**# of Thunderstorm Wind Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
1998	1	$0	$0	Trees were blown down in Leyden.
2008	2	$5,000	$0	In June, severe thunderstorms produced winds that broke limbs off trees, including one that struck an 81 year old woman hard enough that she subsequently died. Thunderstorms in July produced damaging wind and lots of lightning which struck people and ignited fires elsewhere in Massachusetts and New Hampshire and caused $5,000 in damages..
2010	2	$25,000	$0	Trees and wires on West Leyden Road and Brattleboro Roads were downed

Table 3-23: Thunderstorm Wind Events in Leyden				
				by thunderstorm winds. This resulted in numerous road closures and power outages.
2012	1	$10,000	$0	A tree on East Hill Road was downed on wires.
2013	2	$100,000	$0	In August, a microburst occurred in the northwestern part of Greenfield and the southeastern portions of Leyden and Colrain, downing numerous trees and wires, and causing $100,000 in damages. In October, A tree and wires on Greenfield Road were downed by thunderstorm winds.
2014	2	$55,000	$0	In July, a large tree was downed onto wires on Alexander Road causing $5,000 in damages. In September, a microburst occurred in Leyden and Bernardston resulting in straight-line wind damage along a broken five and a half mile path. In Leyden, several large trees and wires were downed along Mid-County Road, South County Road, Greenfield Road, and Eden Road, and $50,000 in damages was reported.
2017	1	$1,000	$0	A tree was downed on Mid County Road in Leyden..
2018	1	$6,000	$0	Trees were reported down on wires on Kately Road, Mid County Road and Greenfield Road in Leyden.
2021	1	$1,000	$0	A large tree was down on Eden Trail.
Total	**13**	**$203,000**	**$0**	

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed on September 6, 2021.

Secondary hazards of thunderstorms and severe weather include lightning and hail. In Franklin County, 23 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-23). On September 6, 2014, lightning struck a house on Alexander Road in Leyden, setting it on fire and causing $15,000 in property damage.

Table 3-24: Lightning Events in Franklin County			
Year	**# of Lightning Events**	**Annual Property Damage**	**Annual Crop Damage**
1997	1	$3,000	$0
2001	1	$20,000	$0
2002	1	$15,000	$0
2004	1	$35,000	$0
2005	1	$50,000	$0
2008	1	$10,000	$0
2010	2	$25,000	$0
2012	1	$500,000	$0
2013	4	$49,000	$0
2014	3	$93,000	$0
2018	6	$35,500	$0
2019	1	$0	$0
Total	**23**	**$835,500**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed September 6, 2021.

A total of 45 hail events have been reported in Franklin County since 1998 (Table 3-25). Property damage was only recorded for one event, in the amount of $5,000. One hail event in 2008 resulted in $50,000 in crop damages. Pea- to marble-size hail fell in a swath from Colrain to Shelburne damaging apple and peach orchards. An estimated 45 acres of apples and two to three acres of peaches were damaged by the hail.

Table 3-25: Hail Events in Franklin County			
Year	**# of Hail Events**	**Annual Property Damage**	**Annual Crop Damage**
1998	4	$0	$0
2000	1	$0	$0
2001	1	$0	$0
2003	1	$0	$0
2004	2	$0	$0
2005	3	$5,000	$0
2007	5	$0	$0
2008	7	$0	$50,000
2009	2	$0	$0
2010	4	$0	$0
2011	4	$0	$0
2012	1	$0	$0
2013	3	$0	$0
2017	3	$0	$0
2018	1	$0	$0
2020	3	$0	$0
Total	**45**	**$5,000**	**$50,000**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed on September 6, 2021.

Probability of Future Events

According to the National Weather Service, Massachusetts experiences between 20 to 30 thunderstorm days each year. Based on past occurrences, there is a Very High probability (50% to 100% chance) of a severe thunderstorm or winds affecting the town in a given year. Climate change is expected to increase the frequency and intensity of thunderstorms and other severe weather.

Impact

The entire town of Leyden is vulnerable to high winds that can cause extensive damage. The U.S. is divided into four wind zones. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes. The Commonwealth is located within Wind Zone II, which includes wind speeds up to 180 mph. The entire Commonwealth is also located within the hurricane-susceptible region, and the western portion of the Commonwealth is located within the special wind region, in which wind-speed anomalies are present and additional consideration of the wind hazard is warranted. The entire town of Leyden can experience the effect and impact from severe thunderstorms, microbursts, and hail. The magnitude of impact of a severe thunderstorm event is likely Limited, with more than 10% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire population of Leyden is considered exposed to high-wind and thunderstorm events. Downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Populations located outdoors are considered at risk and more vulnerable to many storm impacts, particularly lightning strikes, compared to those who are located inside. Moving to a lower risk location will decrease a person's vulnerability.

Vulnerable Populations

Socially vulnerable populations are most susceptible to severe weather based on a number of factors, including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing. In general, vulnerable populations include people over the age of 65, the elderly living alone, people with low socioeconomic status, people with low English language fluency, people with limited mobility or a life-threatening illness, and people who lack transportation or are living in areas that are isolated from major roads. The isolation of these populations is a significant concern.

Table 3-26 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a severe weather event.

Table 3-26: Estimated Vulnerable Populations in Leyden

Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283

Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Power outages can be life-threatening to those dependent on electricity for life support. Power outages may also result in inappropriate use of combustion heaters, cooking appliances and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning. People who work or engage in recreation outdoors are also vulnerable to severe weather.

<u>Health Impacts</u>

Both high winds and thunderstorms present potential safety impacts for individuals without access to shelter during these events. Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal illness. Additionally, research has found that thunderstorms may cause the rate of emergency room visits for asthma to increase to 5 to 10 times the normal rate.[20] Much of this phenomenon is attributed to the stress and anxiety that many individuals, particularly children, experience during severe thunderstorms. The combination of wind, rain, and lightning from thunderstorms with pollen and mold spores can exacerbate asthma. The rapidly falling air temperatures characteristic of a thunderstorm as well as the production of nitrogen oxide gas during lightning strikes have also both been correlated with asthma.

<u>Economic Impacts</u>

Windstorms and severe thunderstorms events may impact the economy, including direct building losses and the cost of repairing or replacing the damage caused to the building. Additional economic impacts may include loss of business functions, water supply system damage, inventory damage, relocation costs, wage losses, and rental losses due to the repair/replacement of buildings. Agricultural losses due to lightning and the resulting fires can be extensive. Lightning can be responsible for damage to buildings; can cause electrical, forest and/or wildfires; and can damage infrastructure, such as power transmission lines and communication towers.

Recovery and clean-up costs can also be costly, resulting in further economic impacts. Prolonged obstruction of major routes due to secondary hazards such as landslides, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts on an entire region.

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside. There are no mobile homes in Leyden.[21]

Infrastructure

---

[20] Andrews, L.W. 2012. How Thunderstorms Affect Health. Psychology Today. June 2, 2012. Https://www.psychologytoday.com/blog/minding-the-body/201206/how-thunderstorms-affect-health

[21] U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. According to the Hazus wind model,[22] direct wind-induced damage (wind pressures and windborne debris) to buildings is dependent upon the performance of components and cladding, including the roof covering (shingles, tiles, membrane), roof sheathing (typically wood-frame construction only), windows, and doors, and is modeled as such. Structural wall failures can occur for masonry and wood-frame walls, and uplift of whole roof systems can occur due to failures at the roof/wall connections. Foundation failures (i.e., sliding, overturning, and uplift) can potentially take place in manufactured homes.

Massachusetts is divided into three design wind speeds for four risk categories, the limits of which are defined by the Massachusetts State Building Code (9th Edition). National wind data prepared by the American Society of Civil Engineers serve as the basis of these wind design requirements ("Minimum Design Loads for Buildings and Other Structures," American Society of Civil Engineers ASCE-7). Generally speaking, structures should be designed to withstand the total wind load of their location. Leyden falls within the 90 mph wind load zone. Refer to the State Building Code (9th Edition [780 CMR] Chapter 16 Structural Design, as amended by Massachusetts) for appropriate reference wind pressures, wind forces on roofs, and similar data.

All elements of the built environment are exposed to severe weather events such as high winds and thunderstorms. Table 3-27 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of high winds or a severe thunderstorm.

Table 3-27Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

Agriculture

Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by high winds. Trees are also vulnerable to lightning strikes.

[22] https://www.fema.gov/hazus-mh-hurricane-wind-model

Energy

The most common problem associated with severe weather is loss of utilities. Severe windstorms causing downed trees can create serious impacts on power and aboveground communication lines. Downed power lines can cause blackouts, leaving large areas isolated. Loss of electricity and phone connections would leave certain populations isolated because residents would be unable to call for assistance. Additionally, the loss of power can affect heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage, and impacts can result in the loss of power, which can affect business operations. After an event, there is a risk of fire, electrocution, or an explosion.

Public Safety

Public safety facilities and equipment may experience a direct loss (damage) from high winds.

Transportation

Roads may become impassable due to flash or urban flooding, downed trees and power lines, or due to landslides caused by heavy, prolonged rains. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

Water & Wastewater Infrastructure

The hail, wind, and flash flooding associated with thunderstorms and high winds can cause damage to water infrastructure. Flooding can overburden stormwater, drinking water, and wastewater systems. Water and sewer systems may not function if power is lost.

Environment

As described under other hazards, such as hurricanes and severe winter storms, high winds can defoliate forest canopies and cause structural changes within an ecosystem that can destabilize food webs and cause widespread repercussions. Direct damage to plant species can include uprooting or total destruction of trees and an increased threat of wildfire in areas of tree debris. High winds can also erode soils, which can damage both the ecosystem from which soil is removed as well as the system on which the sediment is ultimately deposited.

Environmental impacts of extreme precipitation events are discussed in depth in the Flooding section, and often include soil erosion, the growth of excess fungus or bacteria, and direct impacts to wildlife. For example, research by the Butterfly Conservation Foundation shows that above average rainfall events have prevented butterflies from successfully completing their mating rituals, causing population numbers to decline. Harmful algal blooms and associated neurotoxins can also be a secondary hazard of extreme precipitation events in addition to heat. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Vulnerability Summary

Based on the above assessment, Leyden has a High vulnerability to severe thunderstorms and wind events. Thunderstorms are common in New England, and can impact property, crops, utilities and the population of Leyden. Microbursts are less common, but can cause significant damage when they do occur. The cascade effects of severe storms include utility losses and transportation accidents and flooding. Particular areas of vulnerability include low-income and elderly populations, trailer homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding.

3.7 TORNADOES

Potential Impacts of Climate Change

Climate change is expected to increase the frequency and intensity of severe weather, which can include tornadoes. However, tornadoes are too small to be simulated well by climate models. Therefore, specific predictions about how this hazard will change are not possible, given current technical limitations. As discussed in other sections in this Plan, the conditions that are conducive to tornadoes (which are also conducive to other weather phenomena, such as hurricanes and tropical storms) are expected to become more severe under global warming.

Figure 3-9: Impacts of Climate Change on Tornadoes

Potential Effects of Climate Change		
	EXTREME WEATHER ➔ INCREASE IN FREQUENCY AND INTENSITY OF SEVERE THUNDERSTORMS	Future environmental changes may result in an increase in the frequency and intensity of severe thunderstorms, which can include tornadoes. However, the resolution of current climate models is too coarse to accurately simulate tornado formation and the confidence on model details associated with this potential increase is low.

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 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground, with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

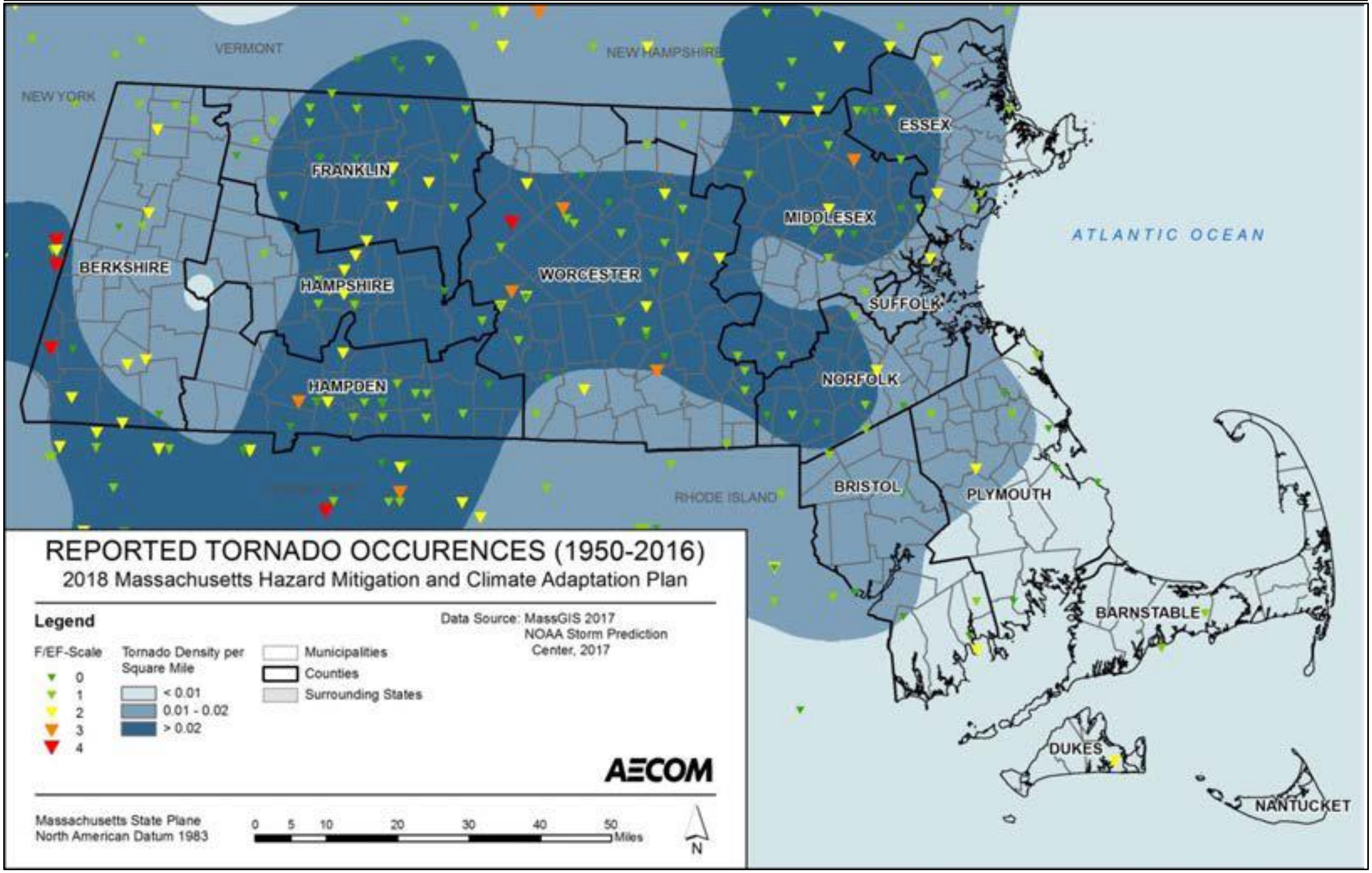
Tornadoes can form from individual cells within severe thunderstorm squall lines. They can also form from an isolated supercell thunderstorm. They can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even occur from little more than a rain shower if air is converging and spinning upward. Most tornadoes occur in the late afternoon and evening hours, when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Conway, Massachusetts, tornado (2017) occurred in February.

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, or can form on a clear day with the right amount of instability and wind shear. Tornadic waterspouts can have wind speeds of 60 to 100 mph, but since they do not move very far, they can often be navigated around. They can become a threat to land if they drift onshore.

Location
Figure 3-9 illustrates the reported tornado occurrences, based on all-time initial touchdown locations across the Commonwealth as documented in the NOAA NCDC Storm Events Database. ArcGIS was used to calculate an average score per square mile. The analysis indicated that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts, and includes Leyden and much of Franklin County. Tornadoes are rated as having an Isolated area of occurance due to the concentrated nature of the storm. If a tornado were to occur in Leyden, it may impact less than 10% of the town.

Extent
The NWS 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 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity. Figure 3-10 provides guidance from NOAA about the impacts of a storm with each rating.

Figure 3-10: Density of Reported Tornadoes per Square Mile



Source: NOAA Storm Prediction Center (SPC), as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-11: Enhanced Fujita Scale & Guide to Tornado Severity

Scale	Wind Speed Estimate		Potential damage	Example of Damage
	mph	km/h		
EF0	65–85	105–137	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–177	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	178–217	Considerable damage. Roofs torn off from well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	218–266	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.	
EF4	166–200	267–322	Devastating damage. Well-constructed and whole frame houses completely leveled; some frame homes may be swept away; cars and other large objects thrown and small missiles generated.	
EF5	>200	>322	Incredible damage. Strong-framed, well-built houses leveled off foundations and swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; cars, trucks, and trains can be thrown approximately 1 mile (1.6 km).	

Source: Wikipedia: https://en.wikipedia.org/wiki/Enhanced_Fujita_scale

Previous Occurrences

On June 1, 2011, thunderstorms forming ahead of a cold front across southern New England organized into discrete supercells in an environment highly favorable for tornado formation. A tornado evaluated to be an EF-3 tornado entered Hampden County from the Berkshires, touched down in Westfield, and continued on a 38 mile long trek through West Springfield, Springfield, Wilbraham, Monson, Brimfield, and Sturbridge. This tornado was on the ground for an estimated 70 minutes. About two hours later, another supercell tracked just to the north of the storm track of the EF3 tornado. While its rotation was not as strong, it produced brief tornadoes in Wilbraham (EF1), North Brimfield (EF1), and Sturbridge (EF0). While the focus was on the tornadoes and their damage, damaging winds, large hail up to two inches in diameter, and some flash flooding also occurred across southern New England.

Since the 1950s, there have been 25 tornadoes in Franklin County. Since 1997, five tornadoes have been reported in Franklin County, in the towns of Heath, Charlemont, Wendell, New Salem, and Conway causing a total of $700,000 in property damages (Table 3-28). The February 2017 tornado in the center of Conway was the most destructive, impacting forests and causing major property damage to several homes, barns, and a church that subsequently had to be torn down. Miraculously, no deaths or serious injuries were reported.

Table 3-28: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
7/3/1997	F1	$50,000	$0	A tornado touched down just west of Number Nine Road in Heath and then skipped along a path which ended about a mile into northwest Colrain. Many large trees were uprooted or snapped at their mid levels. A silo was destroyed and part of the roof of an attached barn was peeled back. A hay tractor was flipped over with its wheels in the air. Doors to a garage were blown in and the roof was partially ripped off. The tornado affected mostly wooded terrain and did extensive tree damage when it passed through a state forest. The path width was up to 100 yards. There were no injuries.
7/3/1997	F1	$50,000	$0	A tornado touched down in the eastern part of Charlemont and travelled east causing damage to a campground. Fifteen trailers were damaged from falling trees and flying debris. Two of the trailers were severely damaged and one was destroyed with seven trees falling on top of it. Eyewitnesses reported rotation in the clouds and debris. The tornado then moved through the higher terrain of the Catamount State Forest. The path was discontinuous and ranged in width from 50 to 100 yards. The tornado path ended in the Copeland Hills section of

Table 3-28: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
				Colrain. There were no direct injuries reported.
7/11/2006	F2	$200,000	$0	Brief F2 touchdown in Wendell
9/1/2013	EF0	$0	$0	A Massachusetts Department of Conservation and Recreation employee observed a waterspout on Quabbin Reservoir in New Salem, MA. He was able to snap two pictures of the storm, one showing a funnel and another showing the funnel extended down to the water. The waterspout was very short lived, never hit land, and did no damage and injured no people. Winds aloft were not conducive for tornadic development, but the environment was unstable and a surface front was moving through the region.
2/25/2017	EF1	$400,000	$0	This tornado touched down at 7:23 pm on Main Poland Road in western Conway, Massachusetts. The path width started at 50 yards, with a sharp gradient evident of damage versus no damage. Large sections of forest had thick pine trees snapped at mid-tree. Numerous power lines were downed along the path into downtown Conway. The path width grew, reaching a maximum width of 200 yards near the town hall. Several houses were severely damaged on Whately Road, southeast of the town hall. Roofs were blown off, and in one case the side walls of a house were missing with the interior of the house exposed. On Hill View Road a large barn collapsed. One injury occurred when a tree landed on a house on South Deerfield Road east of town. That was where the visible damage path ended.
Total	**5**	**$700,000**	**$0**	

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/. Accessed September 6, 2021.

Probability of Future Events

As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last 2 decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase. The Core Team determined that there is a Low (1-2%) probability of a tornado affecting the town in a given year.

Impact

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike in the populated areas of Leyden, damage could be widespread. Fatalities could be high; many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses could be forced to close for an extended period of time or even permanently; and routine services, such as telephone or power, could be disrupted. The severity of impact of a tornado event is likely Critical, with more than 50% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire town of Leyden has the potential for tornado formation, and is located in the area within Massachusetts described above as having higher-than-average tornado frequency. Residents of impacted areas may be displaced or require temporary to long-term shelter due to severe weather events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

<u>Vulnerable Populations</u>

In general, vulnerable populations include people over the age of 65, people with low socioeconomic status, people with low English language fluency, people with compromised immune systems, and residents living in areas that are isolated from major roads. Power outages can be life-threatening to those who are dependent on electricity for life support and can result in increased risk of carbon monoxide poisoning. Individuals with limited communication capacity, such as those with limited internet or phone access, may not be aware of impending tornado warnings. The isolation of these populations is also a significant concern, as is the potential insufficiency of older or less stable housing to offer adequate shelter from tornadoes. Residents living in mobile homes are at increased risk to tornadoes.

An estimated 172 housing units in Leyden, or 52% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. There are currently no mobile homes in Leyden.[23] Table 3-29 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a tornado event.

[23] U.S. Census Bureau 2015-2019 American Community Survey five-year estimates.

Table 3-29: Estimated Vulnerable Populations in Leyden		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Health Impacts

The primary health hazard associated with tornadoes is the threat of direct injury from flying debris or structural collapse as well as the potential for an individual to be lifted and dropped by the tornado's winds. After the storm has subsided, tornadoes can present unique challenges to search and rescue efforts because of the extensive and widespread distribution of debris. The distribution of hazardous materials, including asbestos-containing building materials, can present an acute health risk for personnel cleaning up after a tornado disaster and for residents in the area. The duration of exposure to contaminated material may be far longer if drinking water reservoir or groundwater aquifers are contaminated. According to the EPA, properly designed storage facilities for hazardous materials can reduce the risk of those materials being spread during a tornado. Many of the health impacts described for other types of storms, including lack of access to a hospital, carbon monoxide poisoning from generators, and mental health impacts from storm-related trauma, could also occur as a result of tornado activity.

Economic Impacts

Tornado events are typically localized; however, in those areas, economic impacts can be significant. Types of impacts may include loss of business functions, water supply system damage, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. Recovery and clean-up costs can also be costly. The damage inflicted by historical tornadoes in Massachusetts varies widely, but the average damage per event is approximately $3.9 million.

Because of differences in building construction, residential structures are generally more susceptible to tornado damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Infrastructure

All critical facilities and infrastructure in Leyden are exposed to tornado events. Table 3-30 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a tornado.

Table 3-30: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2021**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

<u>Agriculture</u>

Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by tornadoes.

<u>Energy</u>

High winds could down power lines and poles adjacent to roads. Damage to above-ground transmission infrastructure can result in extended power outages.

<u>Public Safety</u>

Public safety facilities and equipment may experience direct loss (damage) from tornadoes. Shelters and other critical facilities that provide services for people whose property is uninhabitable following a tornado may experience overcrowding and inadequate capacity to provide shelter space and services.

<u>Transportation</u>

Incapacity and loss of roads and bridges are the primary transportation failures resulting from tornadoes, and these failures are primarily associated with secondary hazards, such as landslide events. Tornadoes can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of particular concern are bridges and roads providing access to isolated areas and to the elderly. Prolonged obstruction of major routes due to secondary hazards, such as landslides, debris, or floodwaters, can disrupt the shipment of goods and other commerce. If the tornado is strong enough to transport large debris or knock out infrastructure, it can create serious impacts on power and aboveground communication lines.

Water & Wastewater Infrastructure

The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, residential pumping fixtures, and distribution systems. Water and wastewater utilities are also vulnerable to potential contamination due to chemical leaks from ruptured containers. Ruptured service lines in damaged buildings and broken hydrants can lead to loss of water and pressure.

Environment

Direct impacts may occur to flora and fauna small enough to be uprooted and transported by the tornado. Even if the winds are not sufficient to transport trees and other large plants, they may still uproot them, causing significant damage to the surrounding habitat. As felled trees decompose, the increased dry matter may increase the threat of wildfire in vegetated areas. Additionally, the loss of root systems increases the potential for soil erosion.

Disturbances created by blowdown events may also impact the biodiversity and composition of the forest ecosystem. Invasive plant species are often able to quickly capitalize on the resources (such as sunlight) available in disturbed and damaged ecosystems. This enables them to gain a foothold and establish quickly with less competition from native species. In addition to damaging existing ecosystems, material transported by tornadoes can also cause environmental havoc in surrounding areas. Particular challenges are presented by the possibility of asbestos-contaminated building materials or other hazardous waste being transported to natural areas or bodies of water, which could then become contaminated. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Vulnerability Summary

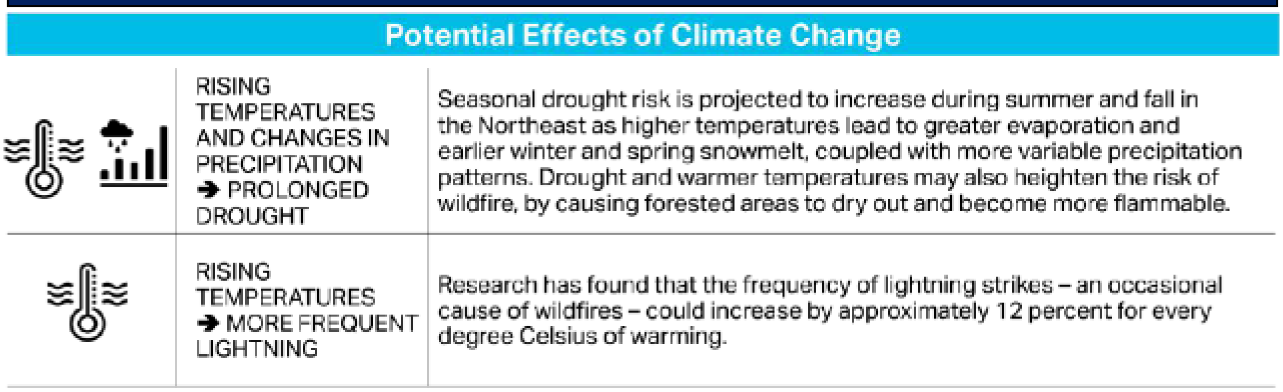
Overall, Leyden has a Low vulnerability to tornadoes. Tornadoes are not common occurrences in Leyden, but can cause significant damage when they do occur. The cascade effects of tornadoes include utility losses and transportation accidents and flooding. Losses associated with the flood hazard are discussed earlier in this section. Particular areas of vulnerability include low-income and elderly populations, mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding.

3.8 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Periods of hot, dry weather create the highest fire risk. Therefore, the predicted increase in average and extreme temperatures in the Commonwealth may intensify wildfire danger by warming and drying out vegetation. A recent study published in *the Proceedings of the National Academy of Sciences* found that climate change has likely been a significant contributor to the expansion of wildfires in the western U.S., which have nearly doubled in extent in the past three decades.[24] Another study found that the frequency of lightning strikes—an occasional cause of wildfires—could increase by approximately 12% for every degree Celsius of warming.[25] Finally, the year-round increase in temperatures is likely to expand the duration of the fire season. Climate change is also interacting with existing stressors to forests, making them more vulnerable to wildfire. Drought, invasive species, and extreme weather events, all can lead to more dead, downed, or dying trees, increasing the fire load in a forest.

Figure 3-12: Impacts of Climate Change on Wildfires



Potential Effects of Climate Change		
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	Seasonal drought risk is projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, coupled with more variable precipitation patterns. Drought and warmer temperatures may also heighten the risk of wildfire, by causing forested areas to dry out and become more flammable.
	RISING TEMPERATURES ➔ MORE FREQUENT LIGHTNING	Research has found that the frequency of lightning strikes – an occasional cause of wildfires – could increase by approximately 12 percent for every degree Celsius of warming.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes. The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. Drought, snowpack level, and local

[24] Abatzoglou, J.T. and Williams, A.P. 2016. Impact of anthropogenic climate change on wildfire across western US forests 2016 113 (42) 11770-11775; published ahead of print October 10, 2016, doi:10.1073/pnas.1607171113
[25] Romps, D.M. et al. 2014. Projected increase in lightning strikes in the United States due to global warming. Science. November 14, 2014. http://science.sciencemag.org/content/346/6211/851

weather conditions can impact the length of the fire season.

Fire Ecology and Wildfire Behavior

The "wildfire behavior triangle" reflects how three primary factors influence wildfire behavior: fuel, topography, and weather. Each point of the triangle represents one of the three factors, and arrows along the sides represent the interplay between the factors. For example, drier and warmer weather with low relative humidity combined with dense fuel loads and steeper slopes can result in dangerous to extreme fire behavior.

How a fire behaves primarily depends on the characteristics of available fuel, weather conditions, and terrain, as described below.

- Fuel:
  - Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite.
  - Snags and hazard trees, especially those that are diseased or dying, become receptive to ignition when influenced by environmental factors such as drought, low humidity, and warm temperatures.
- Weather:
- Strong winds, especially wind events that persist for long periods or ones with significant sustained wind speeds, can exacerbate extreme fire conditions or accelerate the spread of wildfire.
  - Dry spring and summer conditions, or drought at any point of the year, increases fire risk. Similarly, the passage of a dry, cold front through the region can result in sudden wind speed increases and changes in wind direction.
  - Thunderstorms in Massachusetts are usually accompanied by rainfall; however, during periods of drought, lightning from thunderstorm cells can result in fire ignition. Thunderstorms with little or no rainfall are rare in New England but have occurred.
- Terrain:
  - Topography of a region or a local area influences the amount and moisture of fuel.
  - Barriers such as highways and lakes can affect the spread of fire.
  - Elevation and slope of landforms can influence fire behavior because fire spreads more easily uphill compared to downhill.

The wildland-urban interface is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. There are a number of reasons that the wildland-urban interface experiences an increased risk of wildfire damage. Access and fire suppression issues on private property in the wildland-urban interface can make protecting structures from wildfires difficult. This zone also faces increased risk because structures are built in densely wooded areas, so fires started on someone's property are more easily spread to the surrounding forest.

Fire is also used extensively as a land management tool to replicate natural fire cycles, and it has been used to accomplish both fire-dependent ecosystem restoration and hazard fuel mitigation objectives on federal, state, municipal, and private lands in Massachusetts since the 1980s. for example, over the past 16 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire in the Montague Plains Wildlife Management Area, a rare pitch pine-scrub oak forest in Montague. Approximately 880 acres have been treated since 2004 to restore woodland and shrubland habitats. MassWildlife has cooperative agreements with the Department of Conservation and Recreation and the Town of Montague Conservation Commission to restore sandplain habitats on their inholdings within the plains, and works closely with local fire departments and the DCR Bureau of Fire Control to ensure that firefighters have adequate access in the event of a wildfire and are familiar with the changes in vegetation and fuels resulting from habitat management activities.[26]

In Massachusetts, the DCR Bureau of Forest Fire Control is the state agency responsible for protecting 3.5 million acres of state, public, and private wooded land and for providing aid, assistance, and advice to the Commonwealth's cities and towns. The Bureau coordinates efforts with a number of entities, including fire departments, local law enforcement agencies, the Commonwealth's county and statewide civil defense agencies, and mutual aid assistance organizations.

Bureau units respond to all fires that occur on state-owned forestland and are available to municipal fire departments for mutual assistance. Bureau firefighters are trained in the use of forestry tools, water pumps, brush breakers, and other motorized equipment, as well as in fire behavior and fire safety. Massachusetts also benefits from mutual aid agreements with other state and federal agencies. The Bureau is a member of the Northeastern Forest Fire Protection Commission, a commission organized in 1949 by the New England states, New York, and four eastern Canadian Provinces to provide resources and assistance in the event of large wildfires. Massachusetts DCR also has a long-standing cooperative agreement with the U.S. Department of Agriculture's Forest Service both for providing qualified wildfire-fighters for assistance throughout the U.S. and for receiving federal assistance within the Commonwealth. Improved coordination and management efforts seem to be reducing the average damage from wildfire events. According to the Bureau's website, in 1911, more than 34 acres were burned on average during each wildfire. As of 2017, that figure has been reduced to 1.17 acres.

Location

The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "interface" or "intermix." Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50% vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface communities are

---

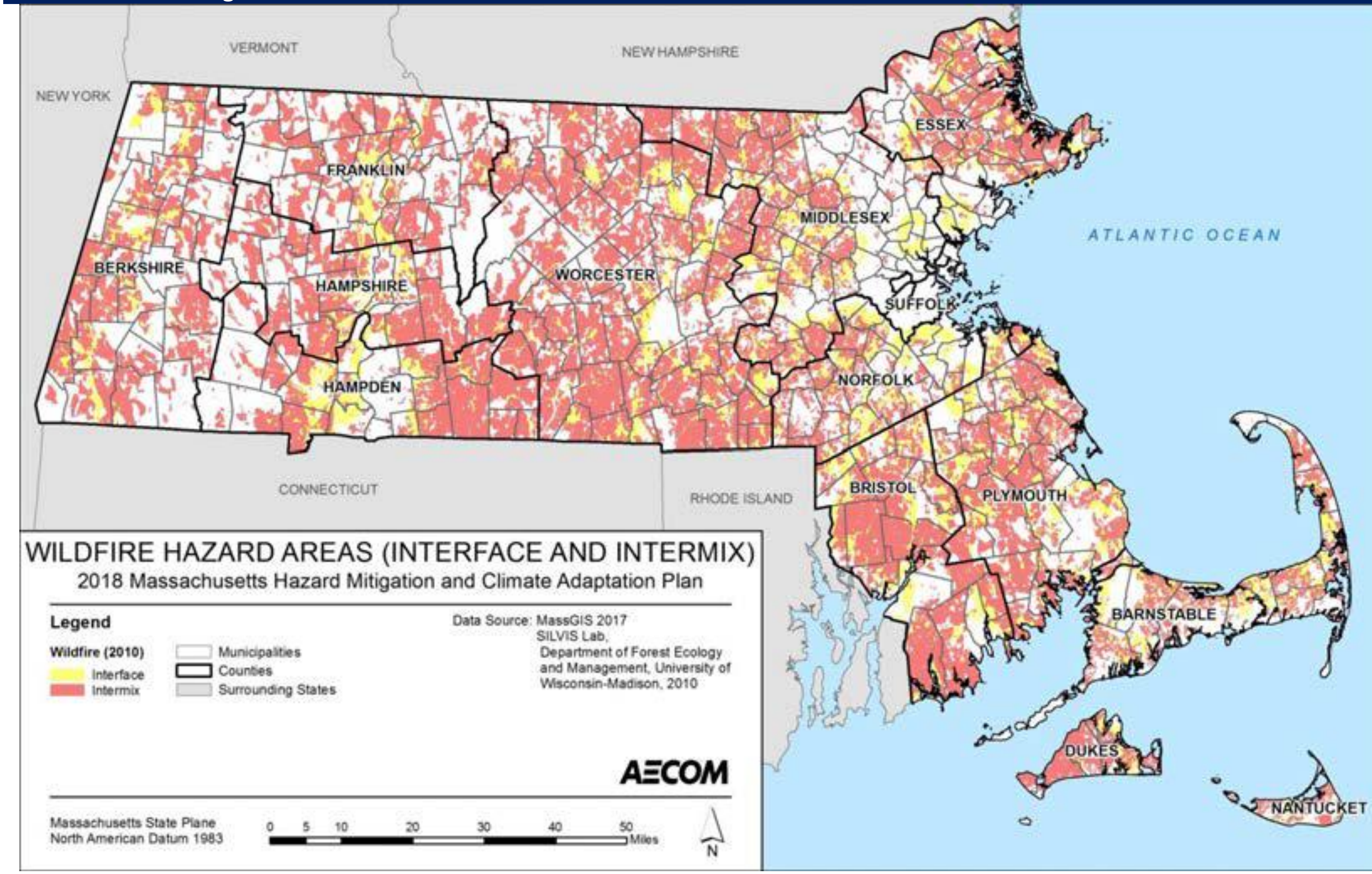
[26] "Background information on Montague Plains Wildlife Management Area," MA Division of Fisheries and Wildlife, as published in the *2018 Montague Open Space and Recreation Plan*.

defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50% vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75% vegetated. These areas are shown in Figure 3-13. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Leyden has several areas of “intermix” zones within town.

The Northeast Wildfire Risk Assessment Geospatial Work Group completed a geospatial analysis of fire risk in the 20-state U.S. Forest Service Northeastern Area. The assessment is comprised of three components—fuels, wildland-urban interface, and topography (slope and aspect)—that are combined using a weighted overlay to identify wildfire-prone areas where hazard mitigation practices would be most effective. Figure 3-14 illustrates the areas identified for the Commonwealth. Much of Leyden, which is 82% forested, is at risk of wildfire, making the risk area Large.

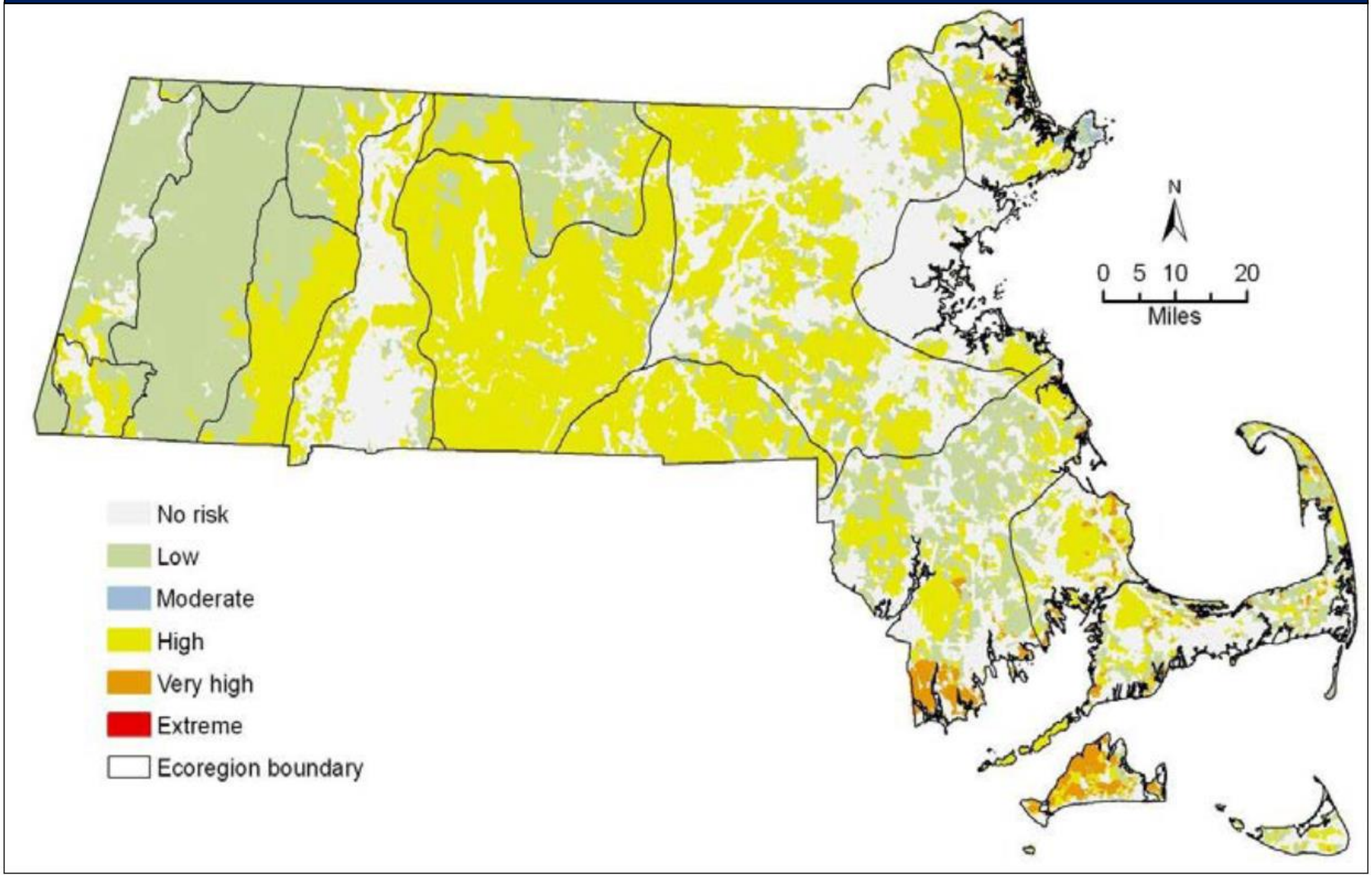
Early detection of wildfires is a key part of the Bureau’s overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. Figure 3-15 displays the Bureau’s fire control districts and fire towers in Massachusetts.

Figure 3-13: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



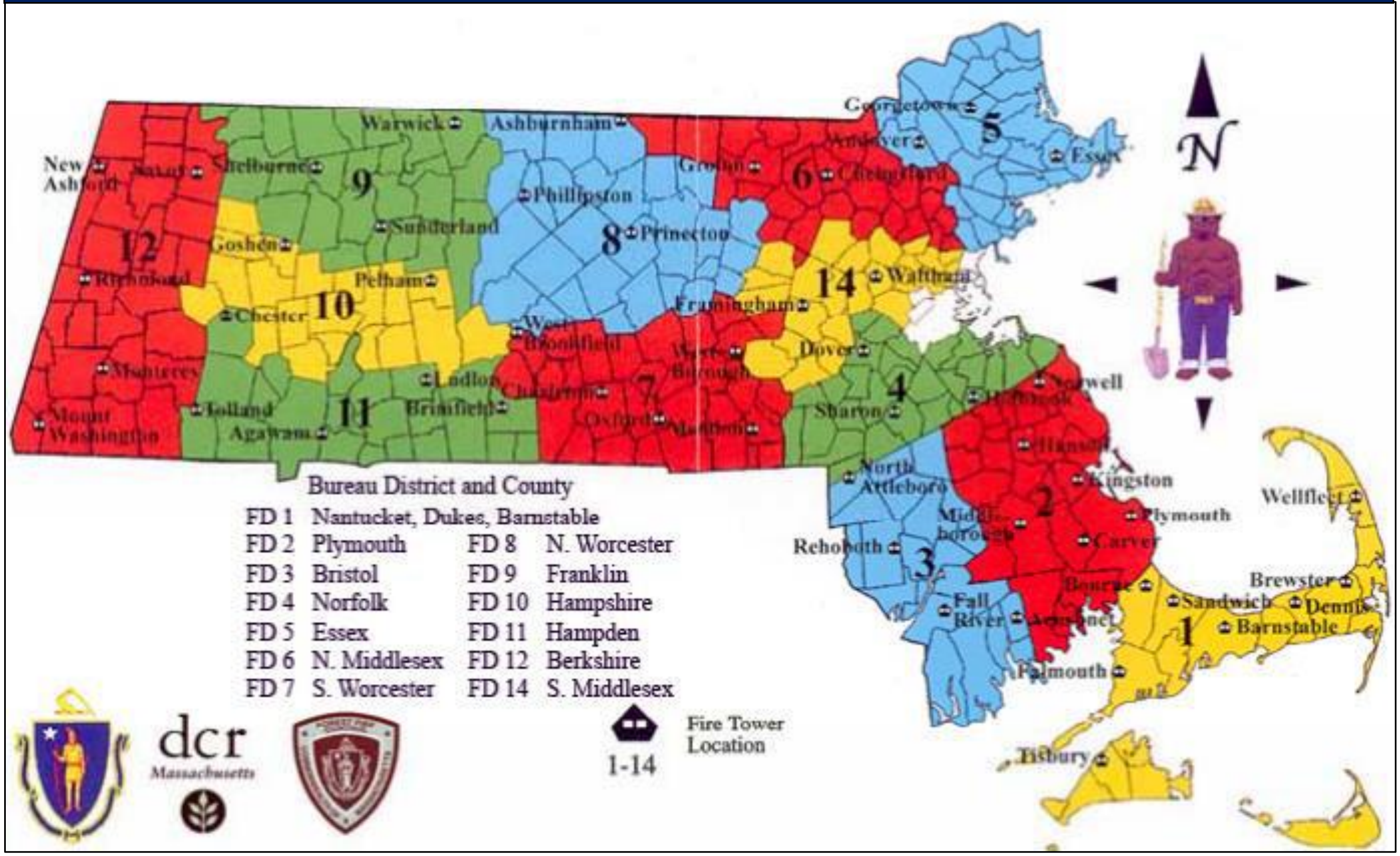
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Figure 3-14: Wildfire Risk Areas for the Commonwealth of Massachusetts



Source: Northeast Wildfire Risk Assessment Geospatial Work Group, 2009, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-15: Massachusetts Bureau of Forest Fire Control Districts and Tower Network



Source: Massachusetts Department of Conservation and Recreation, Bureau of Forest Fire Control, 2018, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Extent
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 acres
- Class G: 5,000 acres or more.

Unfragmented and heavily forested areas of the state are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. Fires can be classified by physical parameters such as their fireline intensity, or Byram's intensity, which is the rate of energy per unit length of the fire front (BTU [British thermal unit] per foot of fireline per second). Wildfires are also measured by their behavior, including total heat release during burnout of fuels (BTU per square foot) and whether they are crown-, ground-, or surface-burning fires. Following a fire event, the severity of the fire can be measured by the extent of mortality and survival of plant and animal life aboveground and belowground and by the loss of organic matter.[27]

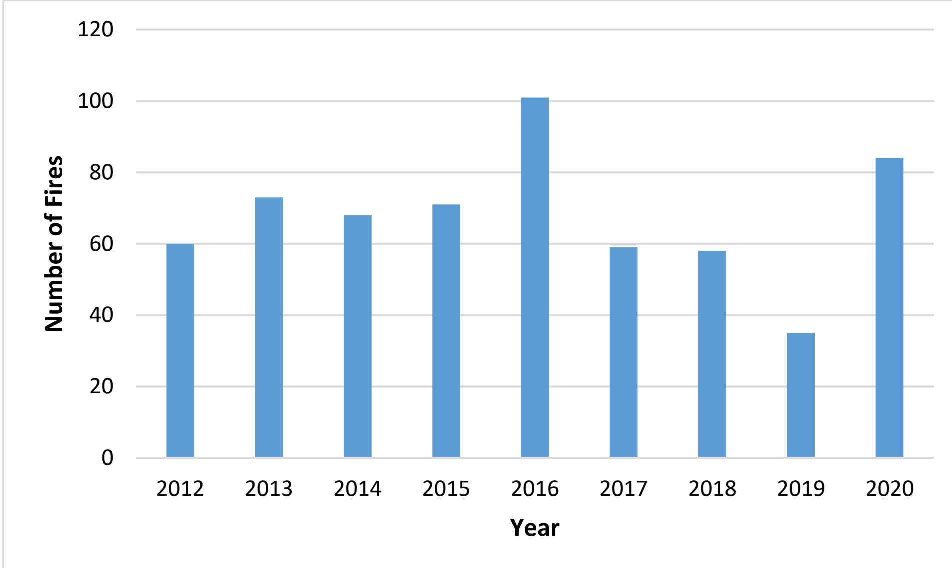
If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

Previous Occurrences
In the six years from 2014 to 2019, Franklin County has averaged 65.3 brush, tree, or lawn fires a year, with the highest reported number of fires occurring in 2016 (Figure 3-16). During 2016, Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

---

[27]National Parks Service (NPS), compiled by George Wooten. n.d. Fire and fuels management: Definitions, ambiguous terminology and references. https://www.nps.gov/olym/learn/management/upload/fire-wildfire-definitions-2.pdf

Figure 3-16: Outdoor Vegetation Fires in Franklin County 2012 - 2020



Source: Massachusetts Fire Incident Reporting System County Profiles.

Leyden is heavily forested and therefore vulnerable to wildfires. Additionally, the town has many west to south facing slopes, which are at the greatest risk of experiencing rapidly spreading fires.

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. However, the Core Team felt that due to climate change and the impacts of invasive species on trees and drought, there will be more fire load in the forests. Therefore, Leyden has a Moderate probability (2% to 25% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Leyden are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. The greatest impact in Leyden from a wildfire is to the natural environment, which faces a Critical impact from wildfires, with more than 50% of property in the affected area damaged or destroyed.

Vulnerability

Society

As demonstrated by historical wildfire events, potential losses from wildfire include human health and the lives of residents and responders. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment.

Vulnerable Populations

All individuals whose homes or workplaces are located in wildfire hazard zones are exposed to this hazard, as wildfire behavior can be unpredictable and dynamic. However, the most vulnerable members of this population are those who would be unable to evacuate quickly, including those over the age of 65, households with young children under the age of 5, people with mobility limitations, and people with low socioeconomic status. Landowners with pets or livestock may face additional challenges in evacuating if they cannot easily transport their animals. Outside of the area of immediate impact, sensitive populations, such as those with compromised immune systems or cardiovascular or respiratory diseases, can suffer health impacts from smoke inhalation. Individuals with asthma are more vulnerable to the poor air quality associated with wildfire. Finally, firefighters and first responders are vulnerable to this hazard if they are deployed to fight a fire in an area they would not otherwise be in.

Table 3-31 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during a wildfire event.

Table 3-31: Estimated Vulnerable Populations in Leyden

Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283

Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Health Impacts

Smoke and air pollution from wildfires can be a severe health hazard. Smoke generated by wildfire consists of visible and invisible emissions containing particulate matter (soot, tar, and minerals), gases (water vapor, carbon monoxide, carbon dioxide (CO_2), and nitrogen oxides), and toxics (formaldehyde and benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Other public health impacts associated with wildfire include difficulty in breathing, reactions to odor, and reduction in visibility. Due to the high prevalence of asthma in Massachusetts, there is a high incidence of emergency department visits when respiratory irritants like smoke envelop an area. Wildfires may also threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and the aftereffects of smoke inhalation and heat-related illness.

Economic Impacts

Wildfire events can have major economic impacts on a community, both from the initial loss of structures and the subsequent loss of revenue from destroyed businesses and a decrease in tourism. Individuals and families also face economic risk if their home is impacted by wildfire. The exposure of homes to this hazard is widespread. Additionally, wildfires can require thousands of taxpayer dollars in fire response efforts and can involve hundreds of operating hours on fire apparatus and thousands of man-hours from volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from work to fight these fires.

Infrastructure

For the purposes of this planning effort, all elements of the built environment located in the wildland interface and intermix areas are considered exposed to the wildfire hazard. Table 3-32 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a wildfire.

Table 3-32: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

Agriculture

While Massachusetts does not experience wildfires at the same magnitude as those in western states, wildfires do occur and are a threat to the agriculture sector. The forestry industry is especially vulnerable to wildfires. Barns, other wooden structures, and animals and equipment in these facilities are also susceptible to wildfires.

Energy

Distribution lines are subject to wildfire risk because most poles are made of wood and susceptible to burning. Transmission lines are at risk of faulting during wildfires, which can result in a broad area outage. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Public Health

As discussed in the Populations section of the wildfire hazard profile, wildfires impact air quality and public health. Widespread air quality impairment can lead to overburdened hospitals.

Public Safety

Wildfire is a threat to emergency responders and all infrastructure within the vicinity of a wildfire.

Transportation

Most road and railroads would be without damage except in the worst scenarios. However, fires can create conditions that block or prevent access, and they can isolate residents and emergency service providers. The wildfire hazard typically does not have a major direct impact on bridges, but wildfires can create conditions in which bridges are obstructed.

Water Infrastructure

In addition to potential direct losses to water infrastructure, wildfires may result in significant withdrawal of water supplies. Coupled with the increased likelihood that drought and wildfire will coincide under the future warmer temperatures associated with climate change, this withdrawal may result in regional water shortages and the need to identify new water sources.

Environment

Fire is a natural part of many ecosystems and serves important ecological purposes, including facilitating the nutrient cycling from dead and decaying matter, removing diseased plants and pests, and regenerating seeds or stimulating germination of certain plants. However, many wildfires, particularly man-made wildfires, can also have significant negative impacts on the environment. In addition to direct mortality, wildfires and the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported.

Frequent wildfires can eradicate native plant species and encourage the growth of fire-resistant invasive species. Some of these invasive species are highly flammable; therefore, their establishment in an area increases the risk of future wildfires. There are other possible feedback loops associated with this hazard. For example, every wildfire contributes to atmospheric CO_2 accumulation, thereby contributing to global warming and increasing the probability of future wildfires (as well as other hazards). There are also risks related to hazardous material releases during a wildfire. During wildfires, containers storing hazardous materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading of the wildfire and escalating it to unmanageable levels. In addition, these materials could leak into surrounding areas, saturating soils and seeping into surface waters to cause severe and lasting environmental damage.

Vulnerability Summary

Based on the above assessment, Leyden faces a Medium risk from wildfire and brushfires. While wildfires have caused minimal damage, injury and loss of life to date in Leyden, their potential to destroy property and cause injury or death exists. Existing and future mitigation efforts should continue to be developed and employed that will enable Leyden to be prepared for these events when they occur. Wildfires can also cause utility disruption and air-quality problems. Particular areas of vulnerability include low-income and elderly populations, and residents living in the interface area adjacent to large areas of unfragmented forests.

3.9 EARTHQUAKES

Potential Impacts of Climate Change

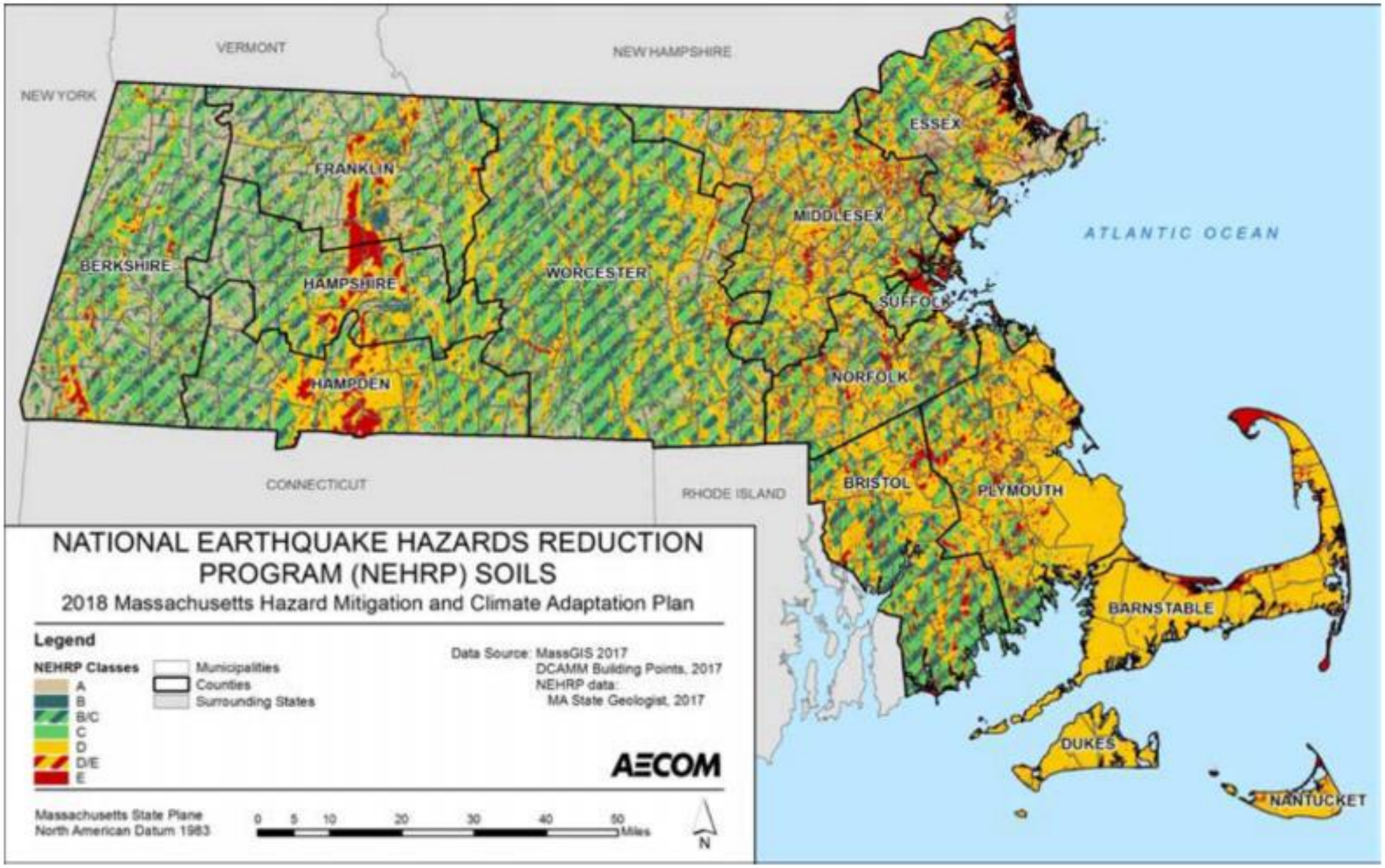
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

Hazard Description

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. These earthquakes often occur along fault boundaries. As a result, areas that lie along fault boundaries—such as California, Alaska, and Japan—experience earthquakes more often than areas located within the interior portions of these plates. New England, on the other hand, experiences intraplate earthquakes because it is located deep within the interior of the North American plate. Scientists are still exploring the cause of intraplate earthquakes, and many believe these events occur along geological features that were created during ancient times and are now weaker than the surrounding areas.

Ground shaking is the primary cause of earthquake damage to man-made structures. This damage can be increased due to the fact that soft soils amplify ground shaking. A contributor to site amplification is the velocity at which the rock or soil transmits shear waves (S waves). The National Earthquake Hazards Reduction Program (NEHRP) developed five soil classifications, which are defined by their S-wave velocity, that impact the severity of an earthquake. 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 damage and losses. These soil types are shown in Figure 3-17.

Figure 3-17: National Earthquake Hazards Reduction Program Soil Types in Massachusetts



Note: This map should be viewed as a first-order approximation of the NEHRP soil classifications. They are not intended for site-specific engineering design or construction. The map is provided only as a guide for use in estimating potential damage from earthquakes. The maps do not guarantee or predict seismic risk or damage. However, the maps certainly provide a first step by highlighting areas that may warrant additional, site-specific investigation if high seismic risk coincides with critical facilities, utilities, or roadways. Sources: Mabee and Duncan, 2017; Preliminary NEHRP Soil Classification Map of Massachusetts, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Location
New England is located in the middle of the North American Plate. One edge of the North American Plate is along the West Coast where the plate is pushing against the Pacific Ocean Plate. The eastern edge of the North American Plate is located at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African Plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular 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. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered.

In addition to earthquakes occurring within the Commonwealth, earthquakes in other parts of New England can impact widespread areas. This is due in part to the fact that earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. The difference between seismic shaking in the East versus the West is primarily due to the geologic structure and rock properties that allow seismic waves to travel farther without weakening.[28]

Because of the regional nature of the hazard, the entire town is susceptible to earthquakes, and the location of occurrence is Large, with over 50% of the town affected.

Extent
The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). 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. The focus of most earthquakes is concentrated in the upper 20 miles of the Earth's crust. 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 or extent of an earthquake is a measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale for measuring earthquake magnitude. It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can

[28] U.S. Geological Survey (USGS). 2012. New Evidence Shows Power of East Coast Earthquakes. Accessed May 6, 2013. http://www.usgs.gov/newsroom/article.asp?ID=3447

have the same magnitude as an earthquake in a remote area that causes no damage.

The perceived severity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and severity varies with location. Intensity is expressed by the Modified Mercalli Scale, which describes how strongly an earthquake was felt at a particular location. The Modified Mercalli Scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Seismic hazards are also expressed in terms of PGA, which is defined by USGS as "what is experienced by a particle on the ground" in terms of% of acceleration force of gravity. More precisely, seismic hazards are described in terms of Spectral Acceleration, which is 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% of acceleration force of gravity (percent g). Tables 3-33 and 3-34 summarize the Richter scale magnitudes, Modified Mercali Intensity scale, and associated damage.

Table 3-33: Richter Scale Magnitudes and Effects

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

Source: US Federal Emergency Management Agency

Table 3-34: Modified Mercalli Intensity Scale for and Effects

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

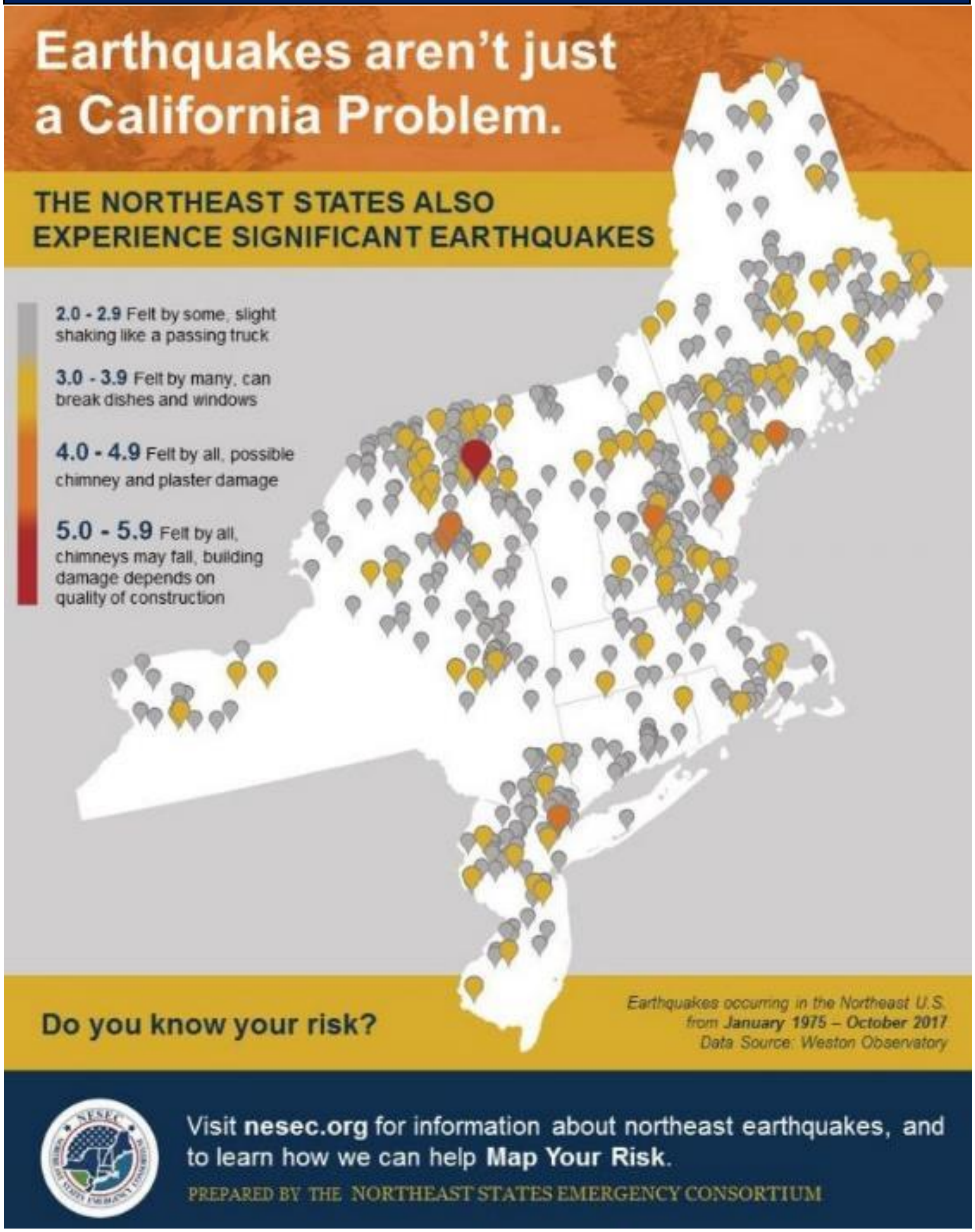
Table 3-34: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves.	< 5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged.	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open.	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: US Federal Emergency Management Agency

Previous Occurrences

Although it is well documented that the zone of greatest seismic activity in the U.S. is along the Pacific Coast in Alaska and California, in the New England area, an average of six earthquakes are felt each year (Figure 3-15). Damaging earthquakes have taken place historically in New England (Table 3-35). According to the Weston Observatory Earthquake Catalog, 6,470 earthquakes have occurred in New England and adjacent areas. However, only 35 of these events were considered significant. The most recent earthquakes in the region that could have affected Leyden are shown in Figure 3-18. There is no record of any damage to the Town of Leyden as a result of these earthquakes.

Figure 3-18: Earthquakes Occurring in the Northeast from 1975 - 2017



Source: Northeast States Emergency Consortium (NESEC) http://nesec.org/earthquakes-hazards/.

Table 3-35: Northeast States Record of Historic Earthquakes			
State	**Years of Record**	**Number of Earthquakes**	**Years with Damaging Earthquakes**
Connecticut	1678 - 2016	115	1791
Maine	1766 - 2016	454	1973, 1904
Massachusetts	1668 - 2016	408	1727, 1755
New Hampshire	1638 - 2016	320	1638, 1940
Rhode Island	1766 - 2016	34	
Vermont	1843 - 2016	50	
New York	1737 - 2016	551	1737, 1929, 1944, 1983, 2002
Total Number of Earthquakes felt: 1,932			

Source: Northeast States Emergency Consortium website, http://nesec.org/earthquakes-hazards/

Probability of Future Events

Earthquakes cannot be predicted and may occur at any time. However, a 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. Earthquakes above magnitude 5.0 have the potential for causing damage near their epicenters, and larger magnitude earthquakes have the potential for causing 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%. This probability rises to about 41% to 56% for a 50-year period. The last earthquake with a magnitude above 5.0 that was centered in New England took place in the Ossipee Mountains of New Hampshire in 1940. Based on past events, Leyden has Low probability, or a 1% to 2% chance in a given year, of being impacted by an earthquake.

Impact

Ground shaking from earthquakes can rupture gas mains and disrupt other utility service, damage buildings, bridges and roads, and trigger other hazardous events such as avalanches, flash floods (dam failure) and fires. Un-reinforced masonry buildings, buildings with foundations that rest on filled land or unconsolidated, unstable soil, and mobile homes not tied to their foundations are at risk during an earthquake. Massachusetts introduced earthquake design requirements into the building code in 1975 and improved building code for seismic reasons in the 1980s. However, these specifications apply only to new buildings or to extensively modified existing buildings. Buildings, bridges, water supply lines, electrical power lines and facilities built before the 1980s may not have been designed to withstand the forces of an earthquake. The seismic standards have also been upgraded with the 1997 revision of the State Building Code. Liquefaction of the land near water could also lead to extensive destruction.

Leyden faces potentially Critical impacts from earthquakes, with more than 25% of property damaged in the affected area.

Vulnerability

Society

The entire population of Leyden is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure depends on many factors, including the age and construction type of the structures where people live, work, and go to school; the soil type these buildings are constructed on; and the proximity of these building to the fault location. In addition, the time of day also exposes different sectors of the community to the hazard. There are many ways in which earthquakes could impact the lives of residents. Business interruptions could keep people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event itself. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction.

<u>Vulnerable Populations</u>

The populations most vulnerable to an earthquake event include people over the age of 65 (21% of Leyden's population) and those living below the poverty level (14% of Leyden's population). These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies. Residents living in homes built prior to the 1970s when the State building code first went into effect, and residents living in mobile homes, are also more vulnerable to earthquakes. An estimated 172 housing units in Leyden, or 52% of all housing units in town, were built prior to the 1970s. There are currently no mobile homes in Leyden[29]

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. In the rare event that an earthquake would trigger a dam failure upstream, the Town of Leyden could be impacted; the risk of such failure is discussed in more detail in the Dam Failure section.

<u>Health Impacts</u>

The most immediate health risk presented by the earthquake hazard is trauma-related injuries and fatalities, either from structural collapse, impacts from nonstructural items such as furniture, or the secondary effects of earthquakes, such as landslides and fires. Following a severe earthquake, health impacts related to transportation impediments and lack of access to hospitals may occur, as described for other hazards. If ground movement causes hazardous material (in storage areas or in pipelines) to enter the environment, additional health impacts could result, particularly if surface water, groundwater, or agricultural areas are contaminated.

<u>Economic Impacts</u>

Earthquakes also have impacts on the economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of

[29] U.S. Census Bureau 2013-2017 American Community Survey five-year estimates.

buildings. Lifeline-related losses include the direct repair cost for transportation and utility systems. Additionally, economic losses include the business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced.

Infrastructure

All elements of the built environment in Leyden are exposed to the earthquake hazard. Table 3-36 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of an earthquake.

Table 3-36: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$92,101,538	$921,015	$4,605,075	$9,210,150
Open Space	$0	$0	$0	$0
Commercial	$1,582,832	$15,828	$79,140	$158,280
Industrial	$239,600	$2,396	$11,980	$23,960
Total	**93,923,970**	**939,239**	**4,696,198**	**9,392,397**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

In addition to these direct impacts, there is increased risk associated with hazardous materials releases, which have the potential to occur during an earthquake from fixed facilities, transportation-related incidents (vehicle transportation), and pipeline distribution. These failures can lead to the release of materials to the surrounding environment, including potentially catastrophic discharges into the atmosphere or nearby waterways, and can disrupt services well beyond the primary area of impact.

Agriculture

Earthquakes can result in loss of crop yields, loss of livestock, and damage to barns, processing facilities, greenhouses, equipment, and other agricultural infrastructure. Earthquakes can be especially damaging to farms and forestry if they trigger a landslide.

Energy

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utility poles, solar and wind infrastructure, and other elements of the energy sector. Damage to any components of the grid can result in widespread power outages.

Public Health

A significant earthquake may result in numerous injuries that could overburden hospitals.

Public Safety

Police stations, fire stations, and other public safety infrastructure can experience direct losses (damage) from earthquakes. The capability of the public safety sector is also vulnerable to damage caused by earthquakes to roads and the transportation sector.

Transportation

Earthquakes can impact many aspects of the transportation sector, including causing damage to roads, bridges, vehicles, and storage facilities and sheds. Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response.

Water and Wastewater Infrastructure

Due to their extensive networks of aboveground and belowground infrastructure—including pipelines, pump stations, tanks, administrative and laboratory buildings, reservoirs, chemical storage facilities, and treatment facilities—water and wastewater utilities are vulnerable to earthquakes. Additionally, sewer and water treatment facilities are often built on ground that is subject to liquefaction, increasing their vulnerability. Earthquakes can cause ruptures in storage and process tanks, breaks in pipelines, and building collapse, resulting in loss of water and loss of pressure, and contamination and disruption of drinking water services. Damage to wastewater infrastructure can lead to sewage backups and releases of untreated sewage into the environment.

Environment

Earthquakes can impact natural resources and the environment in a number of ways, both directly and through secondary impacts. For example, damage to gas pipes may cause explosions or leaks, which can discharge hazardous materials into the local environment or the watershed if rivers are contaminated. Fires that break out as a result of earthquakes can cause extensive damage to ecosystems, as described in the Wildfire section. Primary impacts of an earthquake vary widely based on strength and location. For example, if strong shaking occurs in a forest, trees may fall, resulting not only in environmental impacts but also potential economic impacts to the landowner or forestry businesses relying on that forest. If shaking occurs in a mountainous environment, cliffs may crumble and caves may collapse. Disrupting the physical foundation of the ecosystem can modify the species balance in that ecosystem and leave the area more vulnerable to the spread of invasive species.

Vulnerability Summary

Based on this analysis, Leyden has a Low vulnerability to earthquakes.

3.10 DAM FAILURE

Potential Impacts of Climate Change

The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the dam failure hazard in Massachusetts.

Hazard Description

Dams and levees and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control. However, they also pose a potential risk to lives and property. Dam or levee failure is not a common occurrence, but dams do represent a potentially disastrous hazard. When a dam or levee fails, the potential energy of the stored water behind the dam is released rapidly. Most dam or levee failures occur when floodwaters above overtop and erode the material components of the dam. Often dam or levee breeches lead to catastrophic consequences as the water rushes in a torrent downstream, flooding an area engineers refer to as an "inundation area." The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Many dams in Massachusetts were built during the 19th Century without the benefit of modern engineering design and construction oversight. Dams of this age can fail because of structural problems due to age and/or lack of proper maintenance, as well as from structural damage caused by an earthquake or flooding.

The Massachusetts Department of Conservation and Recreation Office of Dam Safety is the agency responsible for regulating dams in the state (M.G.L. Chapter 253, Section 44 and the implementing regulations 302 CMR 10.00). The regulations apply to dams that are in excess of 6 feet in height (regardless of storage capacity) or have more than 15 acre-feet of storage capacity (regardless of height). Dam safety regulations enacted in 2005 transferred significant responsibilities for dams from the State of Massachusetts to dam owners, including the responsibility to conduct dam inspections.

Location

Table 3-37: Locations and Hazard Rating of Dams in Leyden

Dam Name	Location	Owner	Condition	Hazard Rating
Upper Glen Reservoir Dam	Glen Brook	Town of Greenfield	Good	Significant Hazard
Lower Glen Reservoir Dam	Glen Brook	Town of Greenfield	Unknown	Not rated*
C.A. Denison Dam	Green River	Private	Unknown	Not rated*

Table 3-37: Locations and Hazard Rating of Dams in Leyden				
Farm Pond Dam	Harris Brook near Gates Road	Private	Unknown	Not rated*
Perry Pond Dam	Shattuck Brook	Private	Unknown	Not rated.* However, it was identified in the 2021 Bernardston Multi-Hazard Mitigation Plan as a potential threat to properties downstream in Bernardston.

*This dam does not fall under the jurisdiction of the Office of Dam Safety, likely because of size, and therefore is not assigned a hazard potential.

As described in the Flooding section, there are some beaver dams in Leyden. Beaver dams can impound a significant amount of water, which can raise the risk of flooding. The Core Team noted that the beaver dams in the following locations are of concern:

- Brattleboro Hill Road/Frizzell Hill Road
- Hibbard Brook/West Leyden Road
- Harris Brook/Gates Road

Because riverine areas and beaver ponds are confined to very specific locations, dam failure has an Isolated area of occurance in Leyden.

Extent

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

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

- *High Hazard*: Dams located where failure or improper operation will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads.
- *Significant Hazard*: Dams located where failure or improper operation may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads or cause interruption of use or service of relatively important facilities.
- *Low Hazard*: Dams located where failure or improper operation may cause minimal property

damage to others. Loss of life is not expected.

Owners of dams are required to hire a qualified engineer to inspect and report results using the following inspection schedule:

- Low Hazard Potential dams – 10 years
- Significant Hazard Potential dams – 5 years
- High Hazard Potential dams – 2 years

The time intervals represent the maximum time between inspections. More frequent inspections may be performed at the discretion of the state. As noted previously, dams and reservoirs licensed and subject to inspection by the Federal Energy Regulatory Commission (FERC) are excluded from the provisions of the state regulations provided that all FERC-approved periodic inspection reports are provided to the DCR. FERC inspections of high and significant hazard projects are conducted on a yearly basis. All other dams are subject to the regulations unless exempted in writing by DCR.

Previous Occurrences
To date, there have been no known dam or levee failures in Leyden.

Probability of Future Events
Currently the frequency of dam failures is Moderate with a less than 2% to 25%% chance of a dam failing in any given year.

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Throughout the western United States, communities downstream of dams are already seeing increases in stream flows from earlier releases from dams. Dams are constructed with safety features known as "spillways." Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

Impact
A dam failure impacting Leyden is likely to have a Critical impact, depending on the location of the dam failure. This may impact more than 25% of property in the affected area.

Vulnerability

Dam failures, while rare, can destroy roads, bridges, structures, facilities, utilities, and impact the population of Leyden. Existing and future mitigation efforts should continue to be developed and employed that will enable Leyden to be prepared for these events when they occur. Particular areas of vulnerability include low-income and elderly populations, buildings in the floodplain or inundation areas, and infrastructure such as roadways and utilities that can be damaged by such events.

Society

<u>Vulnerable Populations</u>
The most vulnerable members of the population are those living or working within the floodplain or dam inundation areas, and in particular, those who would be unable to evacuate quickly. This includes people over the age of 65, households with young children under the age of 5, people with mobility limitations, people with low socioeconomic status, and people with low English fluency who may not understand emergency instructions provided in English.

<u>Economic Impacts</u>
Economic impacts are not limited to assets in the inundation area, but may extend to infrastructure and resources that serve a much broader area. In addition to direct damage from dam failure, economic impacts include the amount of time required to repair or replace and reopen businesses, governmental and nonprofit agencies, and industrial facilities damaged by the dam failure.[30]

Infrastructure
Structures that lie in the inundation area of each of the dams in Leyden are vulnerable to a dam failure. Buildings located within the floodplain are also vulnerable to dam failure.

Environment
Examples of environmental impacts from a dam failure include:

- Pollution resulting from septic system failure, back-up of sewage systems, petroleum products, pesticides, herbicides, or solvents
- Pollution of the potable water supply or soils
- Exposure to mold or bacteria during cleanup
- Changes in land development patterns
- Changes in the configuration of streams or the floodplain
- Erosion, scour, and sedimentation
- Changes in downstream hydro-geomorphology
- Loss of wildlife habitat or biodiversity

---

[30] *Assessing the Consequences of Dam Failure: A How-To Guide*. Federal Emergency Management Agency (FEMA). March 2012.
https://damsafety.org/sites/default/files/files/FEMA%20TM%20AssessingtheConsequencesofDamFailure%20March2012.pdf

- Degradation to wetlands
- Loss of topsoil or vegetative cover
- Loss of indigenous plants or animals[31]

Vulnerability Summary

Overall, the Town determined that it has a Medium vulnerability from dam or levee failure.

[31] *Assessing the Consequences of Dam Failure: A How-To Guide*. Federal Emergency Management Agency (FEMA). March 2012. https://damsafety.org/sites/default/files/files/FEMA%20TM%20AssessingtheConsequencesofDamFailure%20March2012.pdf

3.11 DROUGHT

Potential Impacts of Climate Change

Although total annual precipitation is anticipated to increase over the next century, seasonal precipitation is predicted to include more severe and unpredictable dry spells. More rain falling over shorter time periods will reduce groundwater recharge, even in undeveloped areas, as the ground becomes saturated and unable to absorb the same amount of water if rainfall were spread out. The effects of this trend will be exacerbated by the projected reduction in snowpack, which can serve as a significant water source during the spring melt to buffer against sporadic precipitation. Also, the snowpack melt is occurring faster than normal, resulting not only in increased flooding but a reduced period in which the melt can recharge groundwater and the amount of water naturally available during the spring growing period.

Reduced recharge can in turn affect base flow in streams that are critical to sustain ecosystems during dry periods and groundwater-based water supply systems. Reservoir-based water supply systems will also need to be assessed to determine whether they can continue to meet projected demand by adjusting their operating rules to accommodate the projected changes in precipitation patterns and associated changes in hydrology. Finally, rising temperatures will also increase evaporation, exacerbating drought conditions.

Figure 3-19: Impacts of Climate Change on Drought

Potential Effects of Climate Change		
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	The frequency and intensity of droughts are projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, and precipitation patterns become more variable and extreme.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ REDUCED SNOWPACK	Due to climate change, the proportion of precipitation falling as snow and the extent of time snowpack remains are both expected to decrease. This reduces the period during which snowmelt can recharge groundwater Supplies, bolster streamflow, and provide water for the growing period.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Droughts can vary widely in duration, severity, and local impact. They may have widespread social and economic significance that requires the response of numerous parties, including water suppliers, firefighters, farmers, and residents. Droughts are often defined as periods of deficient precipitation. How this deficiency is experienced can depend on factors such as land use change, the existence of dams, and water supply withdrawals or diversions. For example, impervious surfaces associated with development can exacerbate the effects of drought due to decreased groundwater recharge.

Drought is a natural phenomenon, but its impacts are exacerbated by the volume and rate of water withdrawn from these natural systems over time as well as the reduction in infiltration from precipitation that is available to recharge these systems. Groundwater withdrawals for drinking water can reduce groundwater levels, impacting water supplies as well as base flow (flow of groundwater) in streams. A reduction in base flow is significant, especially in times of drought, as this is often the only source of water to the stream. In extreme situations, groundwater levels can fall below stream channel bottom, and groundwater becomes disconnected from the stream, resulting in a dry channel.

Natural infiltration is reduced by impervious cover (pavement, buildings) on the land surface and by the interruption of natural small-scale drainage patterns in the landscape caused by development and drainage infrastructure. Sewer collection systems can also reduce groundwater levels when groundwater infiltrates into them. This is a common problem for wastewater collection systems in Franklin County, where many of the existing pipes were put in place over 100 years ago. Also, when drains are connected to the sanitary system, groundwater and precipitation are transported to wastewater treatment plants where effluent is typically discharged to surface water bodies and not returned to the groundwater.

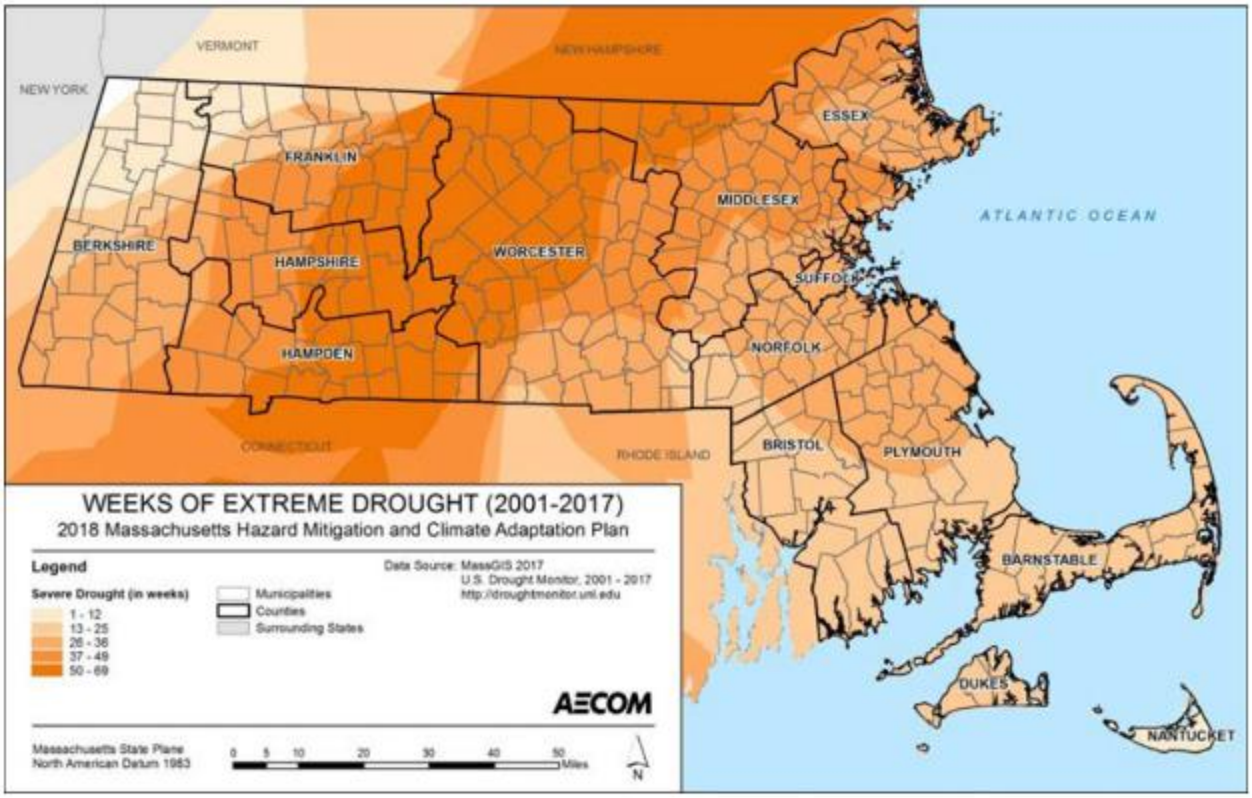
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[32] The importance of increasing infiltration is widely recognized, and the implementation of nature-based solutions to help address this problem is discussed further in later portions of this plan.

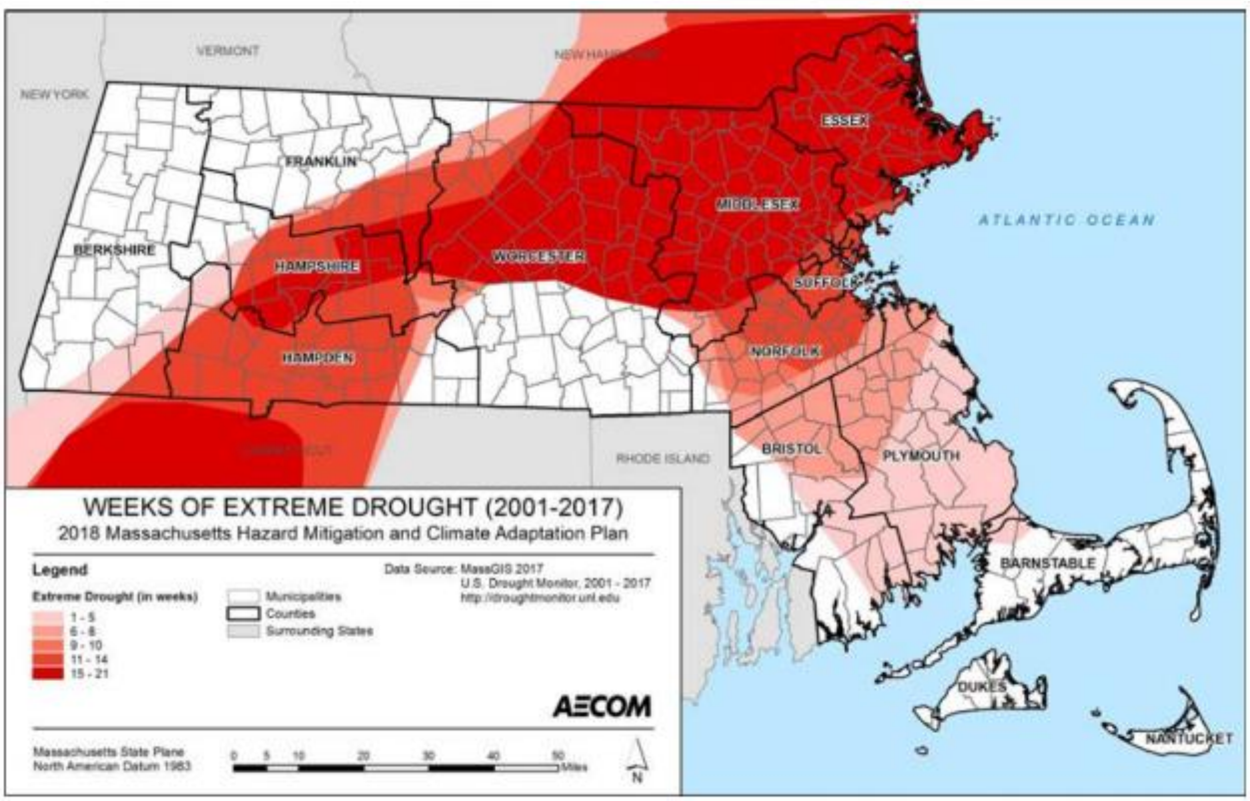
Location

Leyden falls on the edge of a region in Massachusetts that is more prone to severe and extreme drought based on the number of weeks these areas experienced drought conditions from 2001-2017 (Figure 3-20). Because of this hazard's regional nature, a drought would impact the entire town, resulting in a Large location of occurrence, or more than 50% of total land area affected.

[32] ERG and Horsley Witten Group. 2017. Using Green Infrastructure to Improve Resilience in the Commonwealth of Massachusetts: Final Project Report.

Figure 3-20: Areas Experiencing Severe or Extreme Drought, 2001 - 2017





Source: U.S. Drought Monitor, 2017, from the 2018 MA Hazard Mitigation and Climate Adaptation Plan.

Extent
The severity of a drought would determine the scale of the event and would vary among town residents depending on whether the residents' water supply is derived from a private well or the public water system. All Leyden residents rely on private wells for water. The only public water supply (PWS) serves the Town Offices (formerly the Pearl E. Rhodes Elementary School). Massachusetts' wells are permitted according to their ability to meet demand for 180 days at maximum capacity with no recharge; if these conditions extended beyond the thresholds that determine supply capacity the damage from a drought could be widespread due to depleted groundwater supplies.

The U.S. Drought Monitor categorizes drought on a D0-D4 scale (Table 3-38).

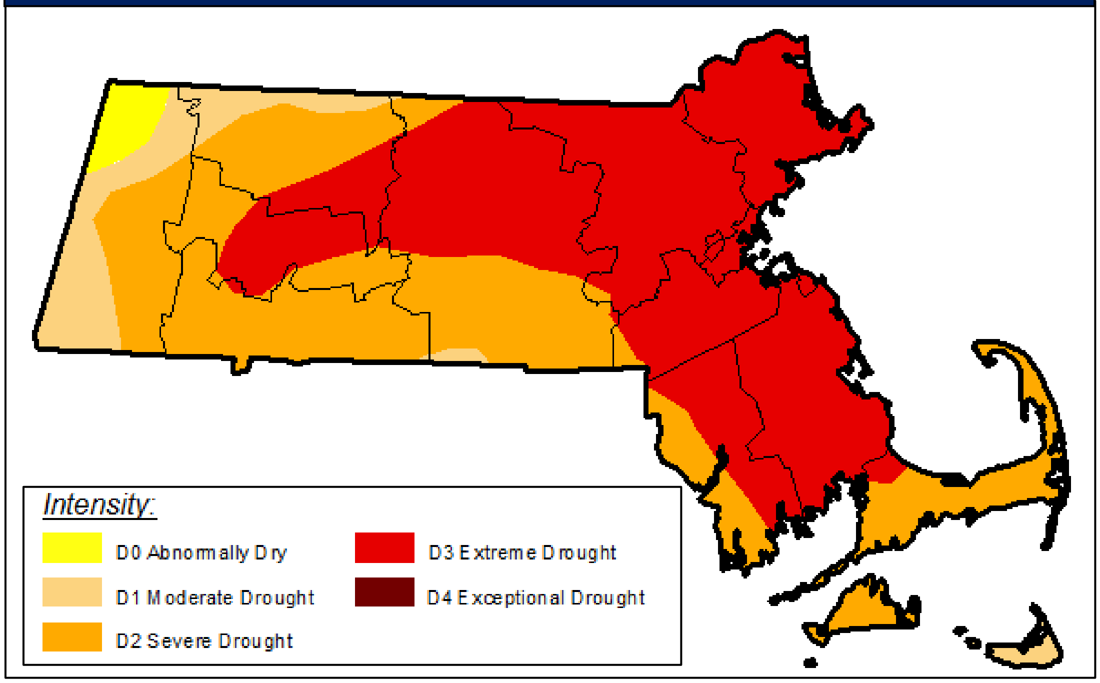
Table 3-38: U.S. Drought Monitor		
Classification	**Category**	**Description**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies

Previous Occurrences
In Massachusetts, six major droughts have occurred statewide since 1930. They range in severity and length, from three to eight years. In many of these droughts, water-supply systems were found to be inadequate.

Beginning in 1960 in western Massachusetts and in 1962 in eastern Massachusetts through 1969, Massachusetts experienced the most significant drought on record, according to the United States Geological Survey. The severity and duration of the drought caused significant impacts on both water supplies and agriculture. Although short or relatively minor droughts occurred over the next 50 years, the next long-term event began in March 2015, when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of EOEEA declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years.

By September 2016, 78% of Franklin County was categorized as "severe drought" (D2) or higher, and 26% of the County was categorized as "extreme drought" (D3) (Figure 3-21).[33] By May 2017, the entire Commonwealth had returned to "normal" due to wetter-than-normal conditions in the spring of 2017.

Figure 3-21: Drought Conditions in Massachusetts on September 20, 2016



Source: U.S. Drought Monitor. https://droughtmonitor.unl.edu/

Probability of Future Events

According to the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, on a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level. As noted previously, rising temperatures and changes in precipitation due to climate change could increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016. In Leyden, the Core Team determined that drought has a Very High probability of future occurrence.

Impact

Due to the water richness of western Massachusetts, Leyden is unlikely to be adversely affected by anything other than a major, extended drought. Droughty periods are already causing a lot of dust to be kicked up on roads, which can be bad for public health. The major impact to residents in the case of a major drought would be private wells running dry or being contaminated due to low water levels. Farmers could be impacted economically by the extended lack of water. Drought may increase the

---

[33] U.S. Drought Monitor, accessed February 13, 2019. https://droughtmonitor.unl.edu/Data/DataTables.aspx?state,MA

probability of a wildfire occurring. The prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly prone to ignition as long as the drought persists. As a result, the impact of a drought would be Critical, with more than 50% property damage or disruption on quality of life.

Vulnerability

The number and type of impacts increase with the persistence of a drought as the effect of the precipitation deficit cascades down parts of the watershed and associated natural and socioeconomic assets. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that may be discernible relatively quickly to farmers. The impact of this same precipitation deficit may not affect hydroelectric power production, drinking water supply availability, or recreational uses for many months.

Society

The entire population of Leyden is vulnerable to drought events. However, the vulnerability of populations to this hazard can vary significantly based on water supply sources and municipal water use policies.

<u>Vulnerable Populations</u>

Drought conditions can cause a shortage of water for human consumption. The PWS at the Town Offices/former Pearl E. Rhodes Elementary School could struggle to meet system demands. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan.

All Leyden residents are served by private wells. Residential well owners are as vulnerable as their ability to find an alternate short- or long-term water supply (i.e. install a new well) or temporarily relocate in the event their well runs dry.

<u>Health Impacts</u>

With declining groundwater levels, residential well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the aquifer and to raise water from a deeper depth. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals (including uranium) depending on local geology. The loss of clean water for consumption and for sanitation may be a significant impact depending on the affected population’s ability to quickly drill a deeper or a new well or to relocate to unaffected areas.

During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts, but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma. Lowered water levels can also result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present. Stagnant water bodies may develop and increase the prevalence of mosquito breeding, thus increasing the risk for vector-borne illnesses.

Economic Impacts
The economic impacts of drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors.

Infrastructure

Agriculture
Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests. Insufficient irrigation will impact the availability of produce, which may result in higher demand than supply. This can drive up the price of local food. Farmers with wells that are dry are advised to contact the Massachusetts Department of Agricultural Resources to explore microloans through the Massachusetts Drought Emergency Loan Fund or to seek federal Economic Injury Disaster Loans.

Water and Wastewater Infrastructure
As noted already, drought affects both groundwater sources and smaller surface water reservoir supplies. Water supplies for drinking, agriculture, and water-dependent industries may be depleted by smaller winter snow packs and drier summers anticipated due to climate change. Reduced precipitation during a drought means that water supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Suppliers may struggle to meet system demands while maintaining adequate water supply pressure for fire suppression requirements. Private well supplies may dry up and need to either be deepened or supplemented with water from outside sources.

Environment
Drought has a wide-ranging impact on a variety of natural systems. Some of those impacts can include the following:[34]

- Reduced water availability, specifically, but not limited to, habitat for aquatic species
- Decreased plant growth and productivity
- Increased wildfires
- Greater insect outbreaks
- Increased local species extinctions
- Lower stream flows and freshwater delivery to downstream estuarine habitats
- Increased potential for hypoxia (low oxygen) events
- Reduced forest productivity

[34] Clark, J.S. et al. 2016. The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States. Global Change Biology, 22, 2329–2352. Doi: 10.1111/gcb.13160.

- Direct and indirect effects on goods and services provided by habitats (such as timber, carbon sequestration, recreation, and water quality from forests)
- Limited fish migration or breeding due to dry streambeds or fish mortality caused by dry streambeds

In addition to these direct natural resource impacts, a wildfire exacerbated by drought conditions could cause significant damage to Leyden’s environment as well as economic damage related to the loss of valuable natural resources.

Vulnerability Summary

Based on the above assessment and the discussion of the Core Team, Leyden has a High vulnerability to drought. While such a drought would require water saving measures to be implemented, there would be no foreseeable damage to structures or loss of life resulting from the hazard.

3.12 LANDSLIDES

Potential Impacts of Climate Change

According to the 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*, slope saturation by water is already a primary cause of landslides in the Commonwealth. Regional climate change models suggest that New England will likely experience warmer, wetter winters in the future as well as more frequent and intense storms throughout the year. This increase in the frequency and severity of storm events could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides. Additionally, an overall warming trend is likely to increase the frequency and duration of droughts and wildfire, both of which could reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Figure 3-22: Impacts of Climate Change on Landslides

Potential Effects of Climate Change		
	CHANGES IN PRECIPITATION AND EXTREME WEATHER ➔ SLOPE SATURATION	Regional climate change models suggest that Massachusetts will likely experience more frequent and intense storms throughout the year. This change could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides.
	RISING TEMPERATURES ➔ REDUCED VEGETATION EXTENT	An increased frequency of drought events is likely to reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. 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 wetness leading to excess pore pressures in the subsurface. Historical landslide data for the Commonwealth suggests 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.[35] This precipitation can cause slopes to become saturated.

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by

[35] Mabee, S.B., Duncan, C.C. 2013. Slope Stability Map of Massachusetts. Prepared for the Massachusetts Emergency Management Agency, the Federal Emergency Management Agency and the Massachusetts Department of Conservation and Recreation. http://www.geo.umass.edu/stategeologist/Products/Landslide_Map/Slope_Stability_Map_MA_Report.pdf

glacial till or bedrock. Bedrock is relatively 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, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur.

Landslides are created by human activities as well, including deforestation, cultivation and construction, which destabilize already fragile slopes. Some human activities that could cause landslides include:

- vibrations from machinery or traffic;
- blasting;
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope;
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock; and
- construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

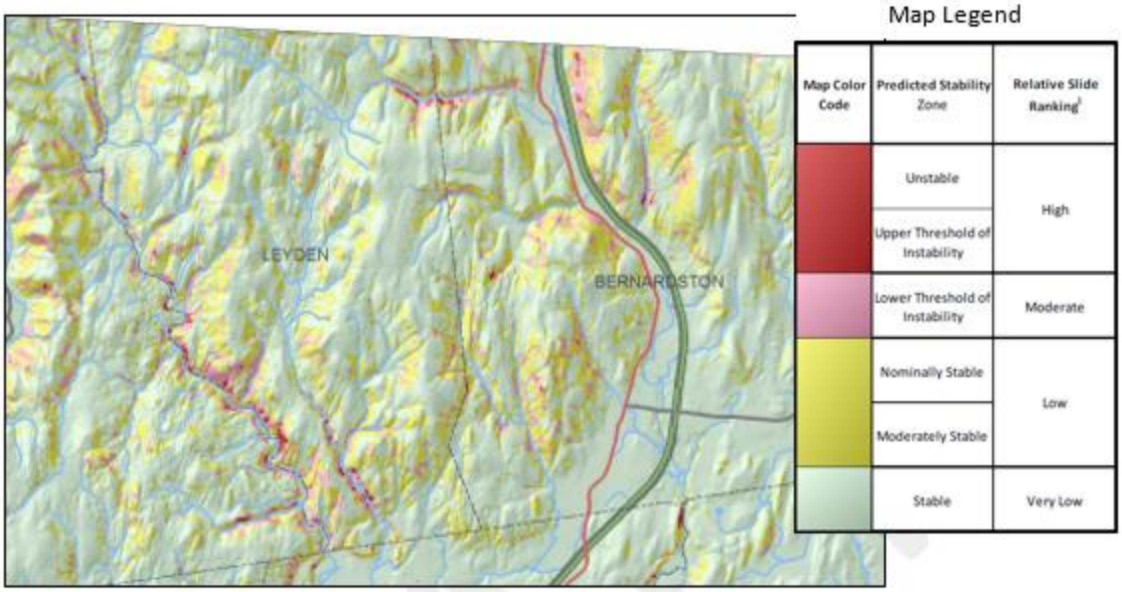
Location

In 2013, the Massachusetts Geological Survey prepared an updated map of potential landslide hazards for the Commonwealth (funded by FEMA's Hazard Mitigation Grant Program) to provide the public, local governments, and emergency management agencies with the location of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall. This project was designed to provide statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high-risk areas for mitigation.

Leyden has areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-23 and are mostly located along the steep ridges in town that run north-south along the Green River and Glen Brook, and east-west on Keets Brook Road. Steep banks along roads in Town may be more susceptible to landslides. The following roads were identified as areas of concern for landslides in Leyden's 2016 Multi-Hazard Mitigation Plan:

- Eden Trail Rd. (entire length; main access road to the Town of Bernardston)
- Keets Brook Rd. (from Bernardston Town Line to Simon Keets Rd.)
- Mid-County Rd. (southern portion)
- West Leyden Rd. (sections from Mid-County Rd. to Town Hall and from Bell Rd. to the 10-Mile Bridge; the first section provides critical access to Town Hall and emergency services, while the second section provides the main access to Town of Colrain

Figure 3-23: Slope Stability Map, Leyden and Surrounding Towns



Source: Massachusetts Geologic Survey and UMass Amherst, 2013

The risk area for landslides is considered to be Isolated.

Extent

Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult. As a result, estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides can provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. The distribution of susceptibility in Leyden is depicted on the Slope Stability Map, with areas of higher slope instability considered to also be more susceptible to the landslide hazard.

Previous Occurrences

No significant landslide events have been observed in Leyden. However, the Core Team feels the potential for landslides exist in the areas of town with steep slopes.

Probability of Future Events

In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for a significant landslide to occur. Increasing heavy precipitation events will increase the risk of landslides in Leyden. Due to climate change, the Core Team determined that there is a Moderate probability of a landslide happening in the next year (2% to 10% probability in the next year).

Impact

Homes located on lots with significant slopes (i.e., 10% or greater), or that are located at the bottom of steep slopes, are at greater risk of impacts from landslides. The impact of a landslide in Leyden would be Limited, depending on where it occurs.

Vulnerability

Society

<u>Vulnerable Populations</u>

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. In Leyden, some residents may be vulnerable to landslides due to the fact that there are homes are built on property below steep slopes. Key evacuation routes also may become blocked in the event of a major landslide.

<u>Health Impacts</u>

People in landslide hazard zones are exposed to the risk of dying during a large-scale landslide; however, damage to infrastructure that impedes emergency access and access to health care is the largest health impact associated with this hazard. Mass movement events in the vicinity of major roads could deposit many tons of sediment and debris on top of the road. Restoring vehicular access is often a lengthy and expensive process.

<u>Economic Impacts</u>

A landslide's impact on the economy and estimated dollar losses are difficult to measure. Landslides can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines.

Infrastructure

Landslides can result in direct losses as well as indirect socioeconomic losses related to damaged infrastructure. Infrastructure located within areas shown as unstable on the Slope Stability Map should be considered to be exposed to the landslide hazard.

<u>Agriculture</u>

Landslides that affect farmland can result in significant loss of livelihood and long-term loss of productivity. Forests can also be significantly impacted by landslides.

<u>Energy</u>

The energy sector is vulnerable to damaged infrastructure associated with landslides. Transmission lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide may cause a tower to collapse, bringing down the lines and causing a transmission fault.

Transmission faults can cause extended and broad area outages.

Public Health

Landslides can result in injury and loss of life. Landslides can impact access to power and clean water and also increase exposure to vector-borne diseases.

Public Safety

Access to major roads is crucial to life safety after a disaster event and to response and recovery operations. The ability of emergency responders to reach people and property impacted by landslides can be impaired by roads that have been buried or washed out by landslides. The instability of areas where landslides have occurred can also limit the ability of emergency responders to reach survivors.

Transportation

Landslides can significantly impact roads and bridges. Landslides can block egress and ingress on roads, isolating neighborhoods and causing traffic problems and delays for public and private transportation. These impacts can result in economic losses for businesses. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.

The possibility of a landslide in the vicinity of a highway or major road represents a significant economic vulnerability for the Town and State. For example, the damage to a 6-mile stretch of Route 2 caused by Tropical Storm Irene (2011), which included debris flows, four landslides, and fluvial erosion and undercutting of infrastructure, cost $23 million for initial repairs.

Water and Wastewater Infrastructure

Surface water bodies may become directly or indirectly contaminated by landslides. Landslides can block river and stream channels, which can result in upstream flooding and reduced downstream flow. This may impact the availability of drinking water. Water and wastewater infrastructure may be physically damaged by mass movements.

Environment

Landslides can affect a number of different facets of the environment, including the landscape itself, water quality, and habitat health. Following a landslide, soil and organic materials may enter streams, reducing the potability of the water and the quality of the aquatic habitat. Additionally, mass movements of sediment may result in the stripping of forest trees and soils, which in turn impacts the habitat quality of the animals that live in those forests. Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Vulnerability Summary

Based on the above assessment, Leyden has an overall Low hazard vulnerability for landslides.

3.13 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Leyden will experience increasing days of extreme heat in the future. Generally, extreme heat is considered to be over 90 degrees Fahrenheit (°F), because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase. The average summer across the Commonwealth during the years between 1971 and 2000 included 4 days over 90°F. Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with between 10-28 days over 90°F. By the end of the century, extreme heat could occur between 13-56 days during summer, depending on how successful we are in reducing greenhouse gas emissions.[36]

Figure 3-24: Impacts of Climate Change on Extreme Temperatures

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ HIGHER EXTREME TEMPERATURES	The average summer across the Massachusetts during the years between 1971 and 2000 included 4 days over 90°F (i.e. extreme heat days). Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with an additional 10-28 days over 90°F during summer. By the end of the century, extreme heat could occur between 13-56 days during summer.
	RISING TEMPERATURES ➔ HIGHER AVERAGE TEMPERATURES	Compared to an annual 1971-2000 average temperature baseline of 47.6°F, annual average temperatures in Massachusetts are projected to increase by 3.8 to 10.8 degrees (likely range) by the end of the 21st century; slightly higher in western Massachusetts.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

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

Massachusetts has four seasons with several defining factors, and temperature is one of the most significant. Extreme temperatures can be defined as those that are far outside the normal ranges. The average highs and lows of the hottest and coolest months in Franklin County (using Greenfield data as a proxy) are provided in Table 3-39.

[36] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/rising-temperatures. Accessed March 1, 2019.

Table 3-39: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	January (Coldest Month)
Average High (°F)	**81°**	**33°**
Average Low (°F)	**57°**	**12°**

Note: Average temperatures are for the years 1981-2010.
Source: U.S. Climate Data.

Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal, as shown in Figure 3-25. Average annual temperatures vary slightly over the divisions, with annual average temperatures of around 46°F in the Western division (area labeled "1" in the figure), 49°F in the Central division (area labeled "2" in the figure) and 50°F in the Coastal division (area labeled "3" in the figure). Leyden falls within the Central climate division.

Figure 3-25: Climate Divisions in Massachusetts

Source: NOAA, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Extreme temperature events occur more frequently and vary more in the inland regions of the State where temperatures are not moderated by the Atlantic Ocean. The severity of extreme heat impacts, however, is greater in densely developed urban areas like Boston than in suburban and rural areas, due to the urban "heat island" effect, described in more detail in the Impacts sub-section.

The risk area for extreme temperatures in Leyden is Large.

Extent

The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The National Weather Service (NWS) issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to –24°F for at least three hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least three hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index designed to more accurately calculate how cold air feels on human skin. Figure 3-26 shows the Wind Chill Temperature Index.

Figure 3-26: National Weather Service 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

Source: National Weather Service: https://www.weather.gov/safety/cold-wind-chill-chart

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for two or more hours. The NWS Heat Index is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 3-27. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. In addition, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Figure 3-27: National Weather Service Heat Index:

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

According to the NOAA's Storm Events Database, there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995 in Massachusetts. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database. Information on excessive heat was not available for Leyden or Franklin County prior to 2018.

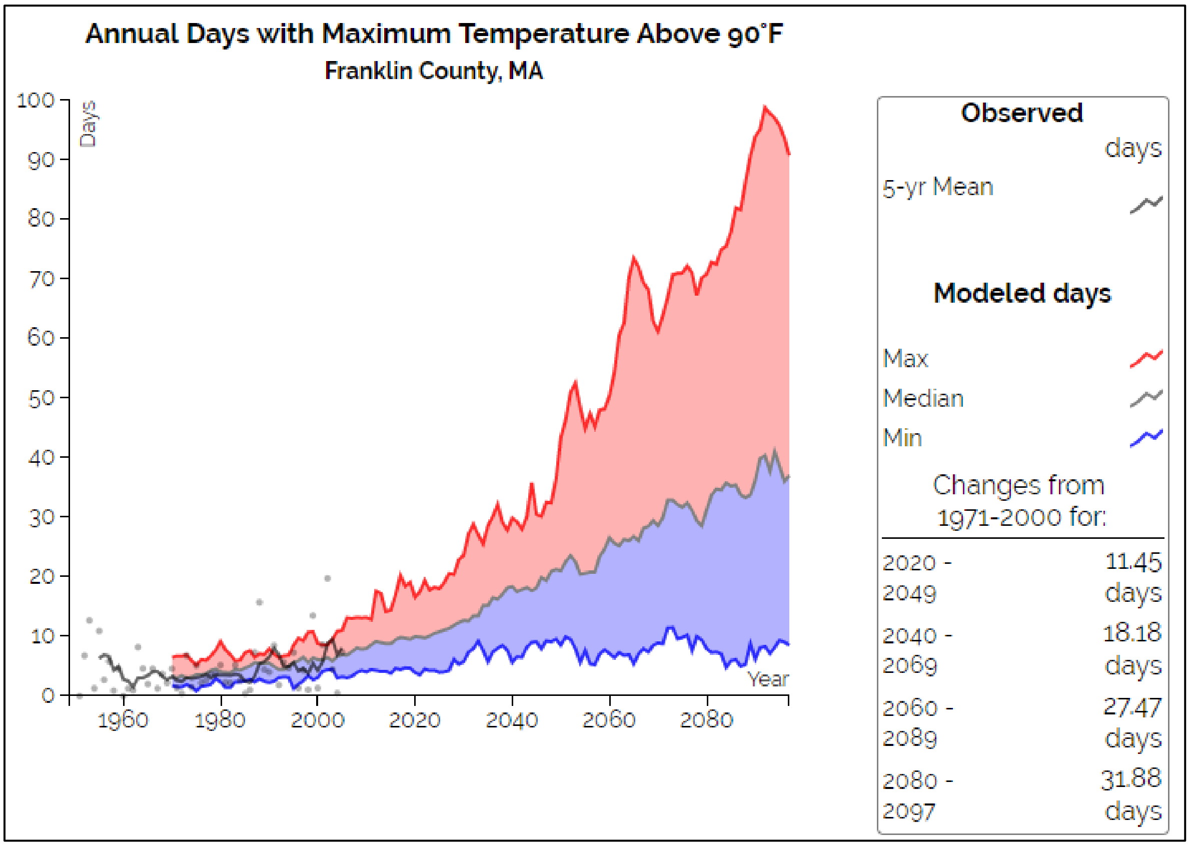
In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F. In Franklin County, excessive heat was recorded for July 1, 2018, when a heat index of 107°F was observed at the Orange Municipal Airport from 1:00 PM to 5:00 PM.

Probability of Future Events

There are a number of climatic phenomena that determine the number of extreme weather events in a specific year. However, there are significant long-term trends in the frequency of extreme hot and cold events. In the last decade, U.S. daily record high temperatures have occurred twice as often as record lows (as compared to a nearly 1:1 ratio in the 1950s). Models suggest that this ratio could climb to 20:1 by midcentury, if GHG emissions are not significantly reduced. The data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events.

The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (Resilient MA, 2018). This gradual change will put long-term stress on a variety of social and natural systems, and will exacerbate the influence of discrete events. Significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 3-28 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 3-28: Projected Annual Days with a Maximum Temperature Above 90°F



Source: www.resilientma.org

The probably of future extreme temperature events was determined to be Very High in Leyden.

Impact

Extreme Cold

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. Extreme cold events are events when temperatures drop well below normal in an area. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0°F or below.

When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures often accompany a winter storm, which may also cause power failures and icy roads. During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively, and temperature inversions can trap the resulting pollutants closer to the ground.

Staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, but cold weather also can present hazards indoors. Many homes may be too cold, either due to a power failure or because the heating system is not adequate for the weather. Exposure to cold temperatures, whether indoors or outside, can cause other serious or life-threatening health problems. Power outages may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fire.

Extreme Heat

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined.

Heat impacts can be particularly significant in urban areas. Buildings, roads, and other infrastructure replace open land and vegetation. Dark-colored asphalt and roofs also absorb more of the sun's energy. These changes cause urban areas to become warmer than the surrounding areas. This forms "islands" of higher temperatures, often referred to as "heat islands." The term "heat island" describes built-up areas that are hotter than nearby rural or shaded areas. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50°F to 90°F hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and GHG emissions, heat-related illness and death, and water quality degradation.

Extreme heat events can also have impacts on air quality. Many conditions associated with heat waves or more severe events—including high temperatures, low precipitation, strong sunlight and low wind speeds—contribute to a worsening of air quality in several ways. High temperatures can increase the production of ozone from volatile organic compounds and other aerosols. Weather patterns that bring high temperatures can also transport particulate matter air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds allow polluted air to remain in one location for a prolonged period of time. The Core Team determined that the impacts from extreme temperatures is Limited.

Vulnerability
The entire town of Leyden is vulnerable to extreme temperatures.

Society

<u>Vulnerable Populations</u>
According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include: (1) people over the age of 65, who are less able to withstand temperature extremes due to their age, health conditions, and limited mobility to access shelters; (2) infants and children under 5 years of age; (3) individuals with pre-existing medical conditions that impair heat tolerance (e.g., heart disease or kidney disease); (4) low-income individuals who cannot afford proper heating and cooling; (5) people with respiratory conditions, such as asthma or chronic obstructive pulmonary disease; and (6) the general public who may overexert themselves when working or exercising during extreme heat events or who may experience hypothermia during extreme cold events. Additionally, people who live alone—particularly the elderly and individuals with disabilities—are at higher risk of heat-related illness due to their isolation and potential reluctance to relocate to cooler environments.

An additional element of vulnerability to extreme temperature events is homelessness, as homeless individuals have a limited capacity to shelter from dangerous temperatures. Two homeless people died from exposure to extreme cold in January 2019 in Greenfield.

Table 3-40 estimates the number of vulnerable populations and households in Leyden. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Leyden residents during an extreme temperature event.

Table 3-40: Estimated Vulnerable Populations in Leyden		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	149	21%
Population with a Disability	96	14%
Population who Speak English Less than "Very Well"	10	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***

Table 3-40: Estimated Vulnerable Populations in Leyden		
Low Income Households (annual income less than $35,000)	41	14%
Householder Age 65 Years and Over Living Alone	32	11%
Households Without Access to a Vehicle	3	1%

*Total population = 710; Total households = 283
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Health Impacts

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention. A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th%ile (hot: 85-86°F), 90th%ile (very hot: 87-89°F) and 95th%ile (extremely hot: 89-92°F) there are between five and seven excess deaths per day in Massachusetts. These estimates were higher for communities with high%ages of African American residents and elderly residents on days exceeding the 85th%ile.[37] A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th%ile) in the 2 days before a heart attack resulted in an estimated 44% increase in mortality. Living in poverty appeared to increase this effect.[38] In 2015, researchers analyzed Medicare records for adults over the age of 65 who were living in New England from 2000 to 2008. They found that a rise in summer mean temperatures of 1°C resulted in a 1% rise in the mortality rate due to an increase in the number and intensity of heat events.[39]

Hot temperatures can contribute to deaths from heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Human bodies cool themselves primarily through sweating and through increasing blood flow to body surfaces. Heat events thus increase stress on cardiovascular, renal, and respiratory systems, and may lead to hospitalization or death in the elderly and those with pre-existing diseases.

Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma. In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to

[37] Hattis, D. et al. 2012. The Spatial Variability of Heat-Related Mortality in Massachusetts. Applied Geography. 33(2012) pg 45-52. http://wordpress.clarku.edu/yogneva/files/2012/04/Hattis-et-al-2011-The-spatial-variability-of-heat-related-mortality-in-Massachusetts.pdf

[38] Madrigano J, Mittleman MA, Baccarelli A, Goldberg R, Melly S, von Klot S, Schwartz J.Temperature, myocardial infarction, and mortality: effect modification by individual- and area-level characteristics. Epidemiology. 2013 May; 24(3):439-46.

[39] Shi L. et al. 2015. Impacts of temperature and its variability on mortality in New England. Nature Climate Change. Volume 5. November 2015.

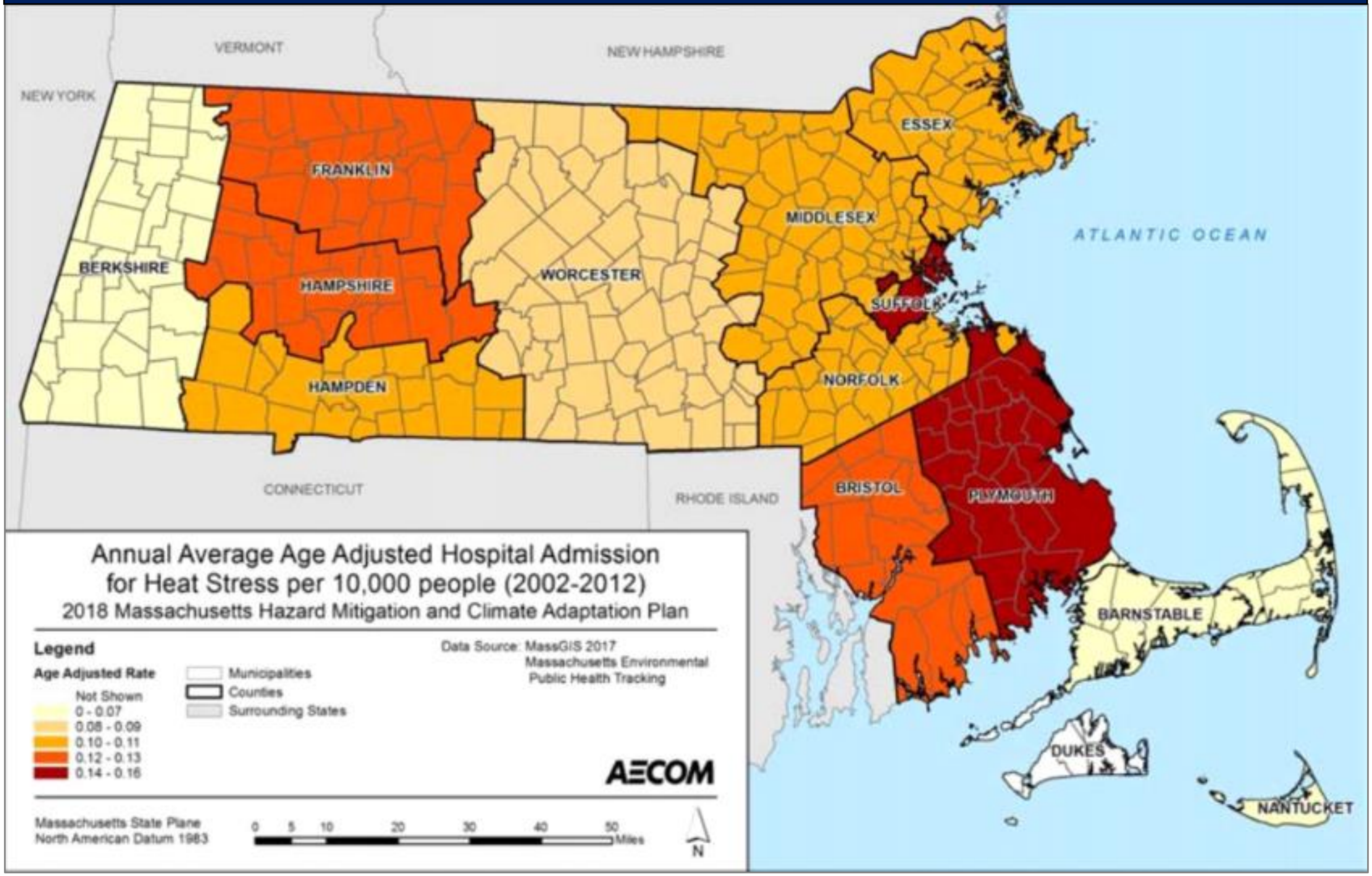
ozone. Particulate pollution may also accompany hot weather, as the weather patterns that bring heat waves to the region may carry pollution from other areas of the continent. Poor air quality can negatively affect respiratory and cardiovascular systems, and can exacerbate asthma and trigger heart attacks.

The rate of hospital admissions for heat stress under existing conditions is shown in Figure 3-29. Between 2002 and 2012, the annual average age-adjusted rate of hospital admission for heat stress was highest in Plymouth and Suffolk Counties. Franklin County ranked among the second highest, with a rate of 0.12-0.13 admissions per 10,000 people. As displayed in Figure 3-30, Franklin County experienced the highest annual average age-adjusted hospital admissions for heart attacks (4.29 to 4.17 per 10,000 people) during this period, along with Plymouth, Bristol, and Berkshire Counties. Hamden County had the highest annual average age emergency department visits due to asthma (see Figure 3-31), while Franklin County's rate was statistically significantly lower.

Some behaviors increase the risks of temperature-related impacts. These behaviors include voluntary actions, such as drinking alcohol or taking part in strenuous outdoor physical activities in extreme weather, but may also include necessary actions, such as taking prescribed medications that impair the body's ability to regulate its temperature or that inhibit perspiration.

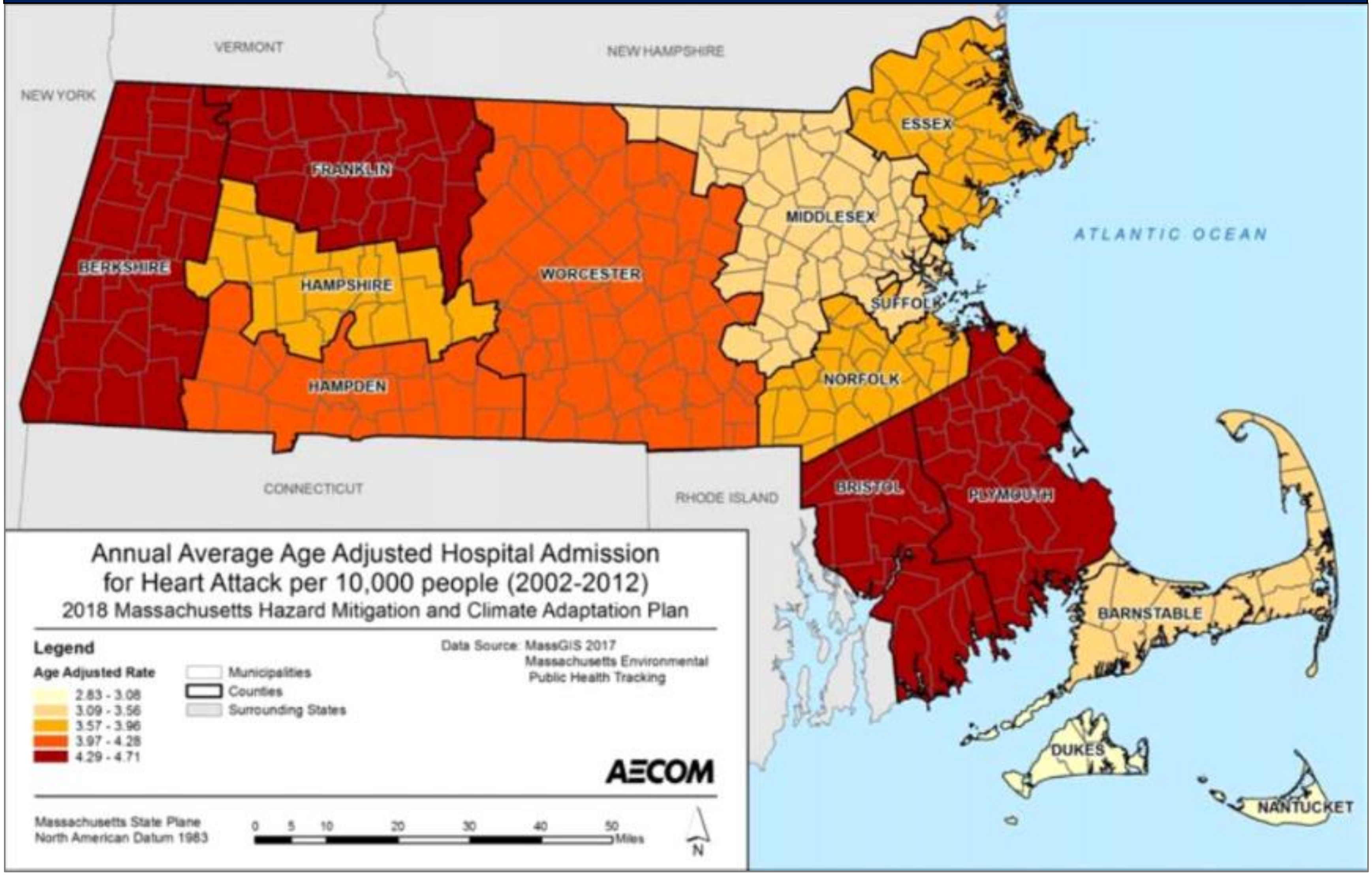
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described, cold weather can exacerbate pre-existing respiratory and cardiovascular conditions. Additionally, power outages that occur as a result of extreme temperature events can be immediately life-threatening to those dependent on electricity for life support or other medical needs. Isolation of these populations is a significant concern if extreme temperatures preclude their mobility or the functionality of systems they depend on. Power outages during cold weather may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fires.

Figure 3-29: Rates of Heat Stress-Related Hospitalization by County



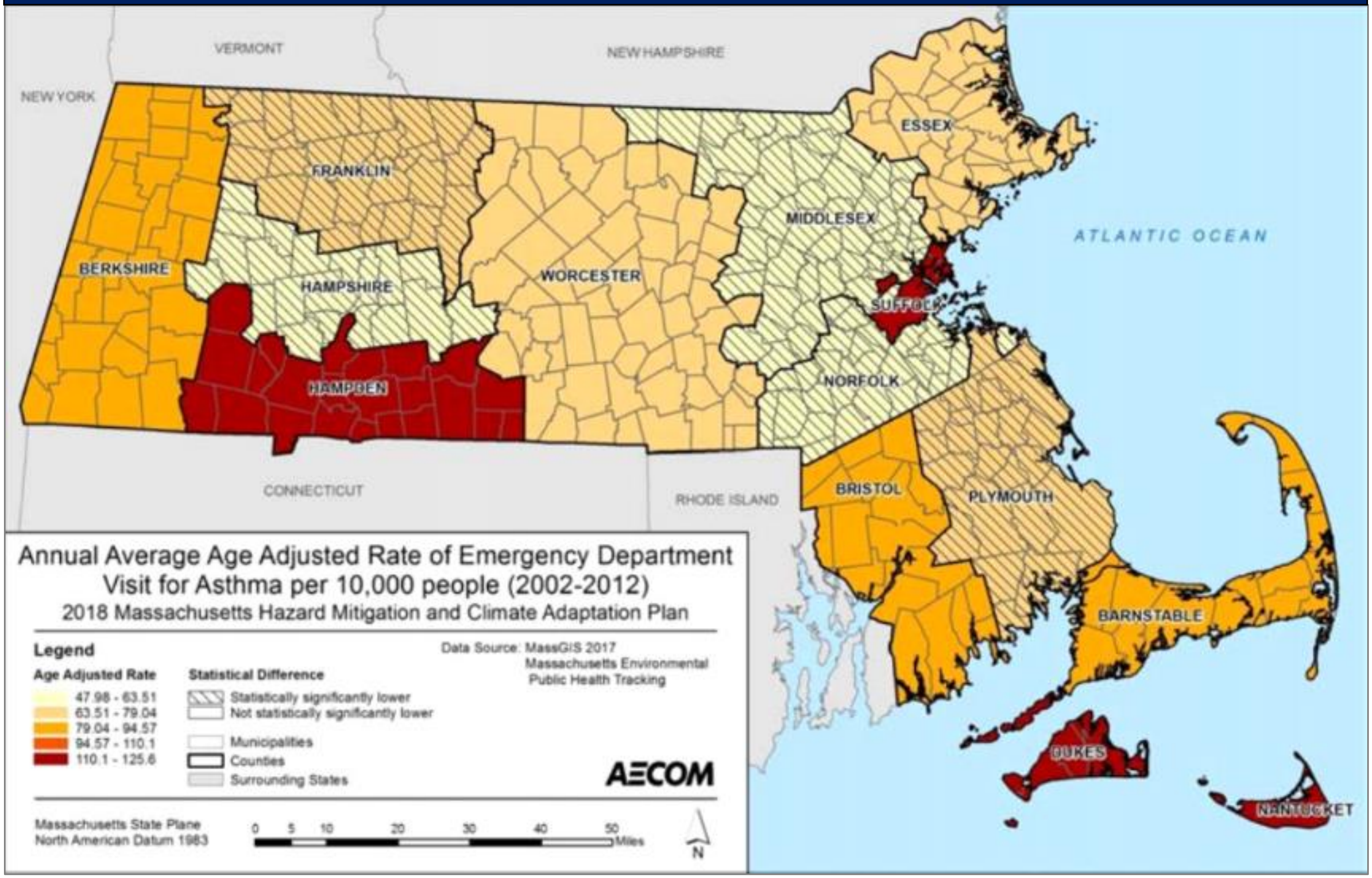
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-30: Rates of Hospital Admissions for Heart Attacks by County



Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-31: Rates of Emergency Department Visits Due to Asthma by County



Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Economic Impacts

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business owners may be faced with increased financial burdens due to unexpected building repairs (e.g., repairs for burst pipes), higher than normal utility bills, or business interruptions due to power failure (i.e., loss of electricity and telecommunications). Increased demand for water and electricity may result in shortages and a higher cost for these resources. Industries that rely on water for business (e.g., landscaping businesses) will also face significant impacts. There is a loss of productivity and income when the transportation sector is impacted and people and commodities cannot get to their intended destination. Businesses with employees that work outdoors (such as agricultural and construction companies) may have to reduce employees' exposure to the elements by reducing or shifting their hours to cooler or warmer periods of the day.

The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. Extreme heat can result in drought and dry conditions, which directly impact livestock and crop production. Increasing average temperatures may make crops more susceptible to invasive species. Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone. Additionally, as described in the Environment sub-section, changing temperatures can impact the phenology.

Livestock are also impacted, as heat stress can make animals more vulnerable to disease, reduce their fertility, and decrease the rate of milk production. Additionally, scientists believe the use of parasiticides and other animal treatments may increase as the threat of invasive species and pests increases.

Infrastructure

All elements of the built environment are exposed to the extreme temperature hazard. The impacts of extreme heat on buildings include: increased thermal stresses on building materials, which leads to greater wear and tear and reduces a building's useful lifespan; increased air-conditioning demand to maintain a comfortable temperature; overheated heating, ventilation, and air-conditioning systems; and disruptions in service associated with power outages. Extreme cold can cause materials such as plastic to become less pliable, increasing the potential for these materials to break down during extreme cold events. In addition to the facility-specific impacts, extreme temperatures can impact critical infrastructure sectors of the built environment in a number of ways, which are summarized in the subsections that follow.

Agriculture

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, peaches, and maple syrup—that rely on specific temperature regimes. Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. Increasing heat stress days (above 90°F) may stress livestock and some crops. More pest pressure from insects, diseases and weeds may harm crops and cause farms to increase pesticide use. Farmers may have the opportunity to introduce new crops that are viable under warmer conditions and longer growing seasons; however, a transition such as this may be costly.[40]

Energy

In addition to increasing demand for heating and cooling, periods of both hot and cold weather can stress energy infrastructure. Electricity consumption during summer may reach three times the average consumption rate of the period between 1960 and 2000; more than 25% of this consumption may be attributable to climate change.[41] In addition to affecting consumption rates, high temperatures can also reduce the thermal efficiency of electricity generation.

Extended-duration extreme cold can lead to energy supply concerns, as the heating sector then demands a higher%age of the natural gas pipeline capacity. When this occurs, New England transitions electricity generation from natural gas to oil and liquid natural gas. Limited on-site oil and liquid natural gas storage as well as refueling challenges may cause energy supply concerns if the events are colder and longer in duration.

Transportation

Extreme heat has potential impacts on the design and operation of the transportation system. Impacts on the design include the instability of materials, particularly pavement, exposed to high temperatures over longer periods of time, which can cause buckling and lead to increased failures.[42] High heat can cause pavement to soften and expand, creating ruts, potholes, and jarring, and placing additional stress on bridge joints. Extreme heat may cause heat stress in materials such as asphalt and increase the frequency of repairs and replacements. Roads are also vulnerable to rapid freeze and thaw cycles, which may cause damage to road surfaces. An increase in freeze and thaw cycles can also damage bridge expansion joints.[43]

Railroad tracks can expand in extreme heat, causing the track to "kink" and derail trains. Higher temperatures inside the enclosure-encased equipment, such as traffic control devices and signal control systems for rail service, may result in equipment failure. Rail operations will also be impacted when mandatory speed reductions are issued in areas where tracks have been exposed to high temperatures over many days, resulting in increased transit travel time and operating costs as well as a reduction in track capacity. Finally, extreme temperatures also discourage active modes of transportation, such as bicycling and walking. This will have a secondary impact on sustainable transportation objectives and public health.

---

[40] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.

[41] Massachusetts Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee (EOEEA). 2011. Massachusetts Climate Change Adaptation Report. https://www.mass.gov/files/documents/2017/11/29/Full%20report.pdf

[42] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets http://www.massdot.state.ma.us/Portals/17/docs/Sustainable/AssessmentExtremeTempImpacts_Final03172017.pdf

[43] Resilient MA: http://resilientma.org/sectors/transportation. Accessed March 4, 2019.

Operations are vulnerable to heat waves and associated power outages that affect electrical power supply to rail operations and to supporting ancillary assets for highway operations, such as electronic signing. Increased heat also impacts transportation workers, the viability of vegetation in rights-of-way, and vehicle washing or maintenance schedules.[44] Hot weather increases the likelihood that cars may overheat during hot weather, and also increases the deterioration rate of tires.

Water Infrastructure

Extreme temperatures do not pose as great a threat to water infrastructure as flood-related hazards, but changes in temperature can impact water infrastructure. For example, extreme heat that drives increases in air-conditioning demand can trigger power outages that disrupt water and wastewater treatment.[45] Hotter temperatures will also likely result in increased outdoor water consumption. Combined with other climate impacts such as an increase in surface water evapotranspiration, changing precipitation patterns, and groundwater recharge rates, increased water demand may challenge the capacity of water supplies and providers. Extreme heat can damage aboveground infrastructure such as tanks, reservoirs, and pump stations. Warmer temperatures can also lead to corrosion, water main breaks, and inflow and infiltration into water supplies. Extreme heat is likely to result in increased drought conditions, and this has significant implications for water infrastructure, as discussed in the Drought Section.

Extreme cold can freeze pipes, causing them to burst. This can then lead to flooding and mold inside buildings when frozen pipes thaw.

Environment

There are numerous ways in which changing temperatures will impact the natural environment. Because the species that exist in a given area have adapted to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function. High-elevation spruce-fir forests, forested boreal swamp, and higher-elevation northern hardwoods are likely to be highly vulnerable to climate change. Higher summer temperatures will disrupt wetland hydrology. Paired with a higher incidence and severity of droughts, high temperatures and evapotranspiration rates could lead to habitat loss and wetlands drying out.[46] Individual extreme weather events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, the impact on natural resources of changing average temperatures and the changing

---

[44] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets http://www.massdot.state.ma.us/Portals/17/docs/Sustainable/AssessmentExtremeTempImpacts_Final03172017.pdf

[45] Resilient MA: http://resilientma.org/sectors/water-resources. Accessed March 4, 2019.

[46] Manomet Center for Conservation Sciences (MCCS) and Massachusetts Division of Fisheries and Wildlife (DFW). 2010. Climate Change and Massachusetts Fish and Wildlife: Volume 3 Habitat Management.

frequency of extreme climate events is likely to be massive and widespread.

One significant impact of increasing temperatures may be the northern migration of plants and animals. Over time, shifting habitat may result in a geographic mismatch between the location of conservation land and the location of critical habitats and species the conserved land was designed to protect. One specific way in which average temperatures influence plant behavior is through changes in phenology, the pattern of seasonal life events in plants and animals. A recent study by the National Park Service found that of 276 parks studied, three-quarters are experiencing earlier spring conditions, as defined by the first greening of trees and first bloom of flowers, and half are experiencing an “extreme” early spring that exceeds 95% of historical conditions.[47] These changing seasonal cues can lead to ecological mismatches, as plants and animals that rely on each other for ecosystem services become “out of sync.” For example, migratory birds that rely on specific food sources at specific times may reach their destinations before or after the species they feed on arrive or are in season. Additionally, invasive species tend to have more flexible phenologies than their native counterparts; therefore, shifting seasons may increase the competitiveness of present and introduced invasive species.

Wild plants and animals are also migrating away from their current habitats in search of the cooler temperatures to which they are accustomed. This is particularly pertinent for ecosystems that (like many in the northeastern U.S.) lie on the border between two biome types. For example, an examination of the Green Mountains of Vermont found a 299- to 390-foot upslope shift in the boundary between northern hardwoods and boreal forests between 1964 and 2004.[48] Such a shift is hugely significant for the species that live in this ecosystem as well as for forestry companies or others who rely on the continued presence of these natural resources. Massachusetts ecosystems that are expected to be particularly vulnerable to warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production
- Hemlock forests, particularly those with the hemlock woolly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect

Additional impacts of warming temperatures include the increased survival and grazing damage of white-tailed deer, increased invasion rates of invasive plants, and increased survival and productivity of

---

[47] National Park System (NPS). 2016. Project Brief: Phenology and Climate Change. https://www.nps.gov/subjects/climatechange/upload/2016-10-26-NPS-Phen-Project-Brief.pdf

[48] U.S. Global Change Research Program (USGCRP). 2014. Hatfield, J. et al., Ch. 6: Agri-culture. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., pp 150-174

insect pests, which cause damage to forests.[49] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary
Based on the above assessment, Leyden has a High vulnerability to extreme temperatures.

[49] Manomet Center for Conservation Sciences (MCCS) and Massachusetts Division of Fisheries and Wildlife (DFW). 2010. Climate Change and Massachusetts Fish and Wildlife: Volume 3 Habitat Management.

3.14 INVASIVE SPECIES

Potential Impacts of Climate Change

A warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. This northward trend is already well documented, and is expected to accelerate in the future. As human populations move to escape increasingly inhospitable climates, they are likely to bring along products, food, and livestock that could introduce novel (and potentially invasive) species to the areas in which they settle.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it's likely that winter temperatures have been limiting the impact of hemlock woolly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.[50]

Figure 3-32: Impacts of Climate Change on Invasive Species

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ WARMING CLIMATE	A warming climate may place stress on colder-weather species, while allowing non-native species accustomed to warmer climates to spread northward.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ ECOSYSTEM STRESS	Changes in precipitation and temperature combine to create new stresses for Massachusetts' unique ecosystems. For example, intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected. The stresses experienced by native ecosystems as a result of these changes may increase the chances of a successful invasion of non-native species.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

"Invasives" are species recently introduced to new ecosystems that cause or are likely to cause significant harm to the environment, economy, or human health. Invasives compete with native plants and wildlife for resources, disrupt beneficial relationships, spread disease, cause direct mortality, and can significantly alter ecosystem function. Some of the more common invasives in Massachusetts may already be familiar - problematic invasive plants include purple loosestrife (Lythrum salicaria), Japanese barberry (Berberis thunbergi), glossy buckthorn (Frangula alnus), multiflora rose (Rosa multiflora), Japanese knotweed (Fallopia japonica), garlic mustard (Alliaria petiolata) and black locust (Robinia

---

[50] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

pseudoacacia). Invasive animals include forest pests such as the hemlock woolly adelgid (Adelgis tsugae), Asian longhorn beetle (Anoplophora glabripennis), and the emerald ash borer (Agrilus planipennis). The zebra mussel (Dreissena polymorpha) is a particularly detrimental aquatic invasive species that has recently been detected in Western Massachusetts.[51]

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by the Massachusetts Executive Office of Energy and Environmental Affairs to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self- sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage. MIPAG recognized 69 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive."

Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Massachusetts Department of Agricultural Resources (MDAR) maintains a list of prohibited plants for the state, which includes federally noxious weeds as well as invasive plants recommended by MIPAG and approved for listing by MDAR. Species on the MDAR list are regulated with prohibitions on importation, propagation, purchase, and sale in the Commonwealth. Additionally, the Massachusetts Wetlands Protection Act (310 CMR 10.00) includes language requiring all activities covered by the Act to account for, and take steps to prevent, the introduction or propagation of invasive species.

In 2000, Massachusetts passed an Aquatic Invasive Species Management Plan, making the Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP is part of the Northeast Aquatic Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force. This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species.

Code of Massachusetts Regulation (CMR) 330 CMR 6.0(d) requires any seed mix containing restricted noxious weeds to specify the name and number per pound on the seed label. Regulation 339 CMR 9.0 restricts the transport of currant or gooseberry species in an attempt to prevent the spread of white pine blister rust. There are also a number of state laws pertaining to invasive species. Chapters 128, 130,

[51] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

and 132 of Part I of the General Laws of the state include language addressing water chestnuts, green crabs, the Asian longhorn beetle, and a number of other species. These laws also include language allowing orchards and gardens to be surveyed for invasive species and for quarantines to be put into effect at any time.

Identification and monitoring is an important element in mitigating impacts from invasive species. The Outsmart Invasive Species project is a collaboration between the University of Massachusetts Amherst, the Massachusetts Department of Conservation and Recreation (MA DCR) and the Center for Invasive Species and Ecosystem Health at the University of Georgia. The goal of the project is to strengthen ongoing invasive-species monitoring efforts in Massachusetts by enlisting help from citizens. The web- and smartphone-based approach enables volunteers to identify and collect data on invasive species in their own time, with little or no hands-on training. By taking advantage of the increasing number of people equipped with iPhone or digital camera/web technology, this approach will expand the scope of invasive-species monitoring, in an effort to help control outbreaks of new or emergent invasive species that threaten our environment.[52]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire town of Leyden may experience impacts from these species. Furthermore, the ability of invasive species to travel far distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example). During the public outreach process, Leyden residents identified bittersweet on Midcounty Road and Japanese knotweed on Keets Brook and Simon Keets Roads. The risk area for invasive species in Leyden is Large.

Extent

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species. Some invasive species, such as the Asian longhorn beetle, have been successfully controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as "Invasive" (last updated April 2016) are identified in Table 3-41. The table also includes details on the nature of the ecological and economic challenges presented by each species. Eighteen of the invasive species on the list have been observed in Leyden since 2010.

[52] https://masswoods.org/outsmart. Accessed March 5, 2019.

Table 3-41: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Leyden**
***Acer platanoides* L. (**Norway maple**)**	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; out-competes native vegetation, including sugar maple; dispersed by water, wind and vehicles.	Y
***Aegopodium podagraria* L. (**Bishop's goutweed; bishop's weed; goutweed**)**	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in flood plains.	Y
***Ailanthus altissima* (P. Miller) Swingle (**Tree of heaven**)**	This tree occurs in all regions of the state in upland, wetland, & coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.	N
***Alliaria petiolata* (Bieb.) Cavara & Grande (**Garlic mustard**)**	A biennial herb occuring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.	Y
***Berberis thunbergii* DC. (**Japanese barberry**)**	A shrub occuring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escaping from cultivation; spread by birds; forms dense stands.	Y
***Cabomba caroliniana* A.Gray (**Carolina fanwort; fanwort**)**	A perennial herb occuring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.	Y
***Celastrus orbiculatus* Thunb. (**Oriental bittersweet; Asian or Asiatic bittersweet**)**	A perennial vine occuring in all regions of the state in uplands. Grows in full sun to partial shade. Escaping from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.	Y
***Cynanchum louiseae* Kartesz & Gandhi (**Black swallow-wort, Louise's swallow-wort**)**	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, out-competing native species: deadly to Monarch butterflies.	Y

Table 3-41: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Leyden**
***Elaeagnus umbellata* Thunb. (**Autumn olive**)**	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escaping from cultivation; berries spread by birds; aggressive in open areas; has the ability to change soil.	Y
***Euonymus alatus* (Thunb.) Sieb. (**Winged euonymus; Burning bush**)**	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escaping from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.	Y
***Frangula alnus* P. Mill. (**European buckthorn; glossy buckthorn**)**	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.	Y
***Hesperis matronalis* L. (**Dame's rocket**)**	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in flood plains.	Y
***Iris pseudacorus* L. (**Yellow iris**)**	A perennial herb occurring in all regions of the state in wetland habitats, primarily in flood plains. Grows in full sun to partial shade. Out-competes native plant communities.	N
***Lonicera japonica* Thunb. (**Japanese honeysuckle**)**	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are bird dispersed; more common in southeastern Massachusetts.	Y
***Lonicera morrowii* A.Gray (**Morrow's honeysuckle**)**	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	Y
***Lonicera x bella* Zabel [*morrowii* x *tatarica*] (**Bell's honeysuckle**)**	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	Y
***Lysimachia nummularia* L. (**Creeping jenny; moneywort**)**	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation; problematic in flood plains, forests and wetlands; forms dense mats.	Y

Table 3-41: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Leyden**
Lythrum salicaria **L. (**Purple loosestrife**)**	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.	Y
Myriophyllum heterophyllum **Michx. (**Variable water-milfoil; Two-leaved water-milfoil**)**	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	N
Myriophyllum spicatum **L. (**Eurasian or European water-milfoil; spike water-milfoil**)**	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	N
Phalaris arundinacea **L. (**Reed canary-grass**)**	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.	Y
Phragmites australis **(Cav.) Trin. ex Steud. subsp. australis (**Common reed**)**	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.	Y
Polygonum cuspidatum **Sieb. & Zucc. (**Japanese knotweed; Japanese or Mexican Bamboo**)**	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.	Y
Polygonum perfoliatum **L. (**Mile-a-minute vine or weed; Asiatic tearthumb**)**	This annual herbaceous vine is currently known to exist in several counties in MA, and has also has been found in RI and CT. Habitats include streamside, fields, and road edges in full sun to partial shade. Highly aggressive; bird and human dispersed.	Y
Potamogeton crispus **L. (**Crisped pondweed; curly pondweed**)**	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.	N

Table 3-41: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Leyden**
***Ranunculus ficaria* L. (**Lesser celandine; fig buttercup**)**	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.	N
***Rhamnus cathartica* L. (**Common buckthorn**)**	A shrub or tree occurring in all regions of the state in upland and wetland habitats.Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.	Y
***Robinia pseudoacacia* L. (**Black locust**)**	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to Massachusetts. It has been planted throughout the state since the 1700's and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.	Y
***Rosa multiflora* Thunb. (**Multiflora rose**)**	A perennial vine or shrub occurring in all regions of the state in upland, wetland and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.	Y
***Trapa natans* L. (**Water-chestnut**)**	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.	N

Source: Massachusetts Invasive Plant Advisory Group, https://www.massnrc.org/mipag/invasive.htm, and Bertin et. al. "Vascular Flora of Franklin County, Massachsuetts." A special publication of the New England Botanical Club. 2020..

Although there are less clear-cut criteria for invasive fauna, there are a number of animals that have disrupted natural systems and inflicted economic damage on the Commonwealth, and may impact Leyden (Table 3-42). One invasive species, the Zebra mussel, was first documented in Massachusetts in Laurel Lake in Erving and Warwick in 2009. Invasive fungi are also included in this table. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Table 3-42: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
Terrestrial Species	
Adelges tsugae Hemlock woolly adelgid (insect)	This species was introduced accidentally around 1924 and is now found from Maine to Georgia, including all of Massachusetts. It has caused up to 90% mortality in eastern hemlock species, which are important for shading trout streams and provide habitat for about 90 species of birds and mammals. It has been documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves.
Agrilus planipennis Emerald ash borer (insect)	Beetle of Asian origin, first detected in 2002 in Michigan. The larval stage of EAB feed in the nutrient- and water-conducting tissues beneath the barks of ash trees, which can lead to the eventual girdling of the tree. Now present in most Massachusetts counties, EAB is likely to eliminated ashes as major forest trees from MA in the next few decades.
Anoplophora glabripennis Asian long-horned beetle (insect)	This species was discovered in Worcester in 2008. The beetle rapidly infested trees in the area, resulting in the removal of nearly 30,000 infected or high-risk trees in just 3 years. The outbreak has been eradicated in the Boston area and is currently contained to the Worcester area.
Cronartium ribicola White pine blister rust (fungus)	This fungus is an aggressive and non-native pathogen that was introduced into eastern North America in 1909. Both the pine and plants in the Ribes genus (gooseberries and currants) must be present in order for the disease to complete its life cycle. The rust threatens any pines within a quarter-mile radius from infected Ribes.
Cryphonectria parasitica Chestnut blight (fungus)	This fungus was first detected in New York City in 1904. By 1926, the disease had devastated chestnuts from Maine to Alabama. Chestnuts once made up one-fourth to one-half of eastern U.S. forests, and the tree was prized for its durable wood and as a food for humans, livestock, and wildlife. Today, only stump sprouts from killed trees remain.

Table 3-42: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
Florinia externa Elongate hemlock scale (insect)	This species was first detected in New York City in 1908. Scales injure host plants by inserting piercing-sucking mouthparts into needles and withdrawing vital nutrients necessary for plan growth. Excessive loss of plant fluid reduces the growth and health of the plant.
Lymantria dispar dispar Gypsy moth (insect)	This species was imported to Massachusetts for silk production, but escaped captivity in the 1860s. It is now found throughout the Commonwealth and has spread to parts of the Midwest. This species is considered a serious defoliator of oaks and other forest and urban trees; however, biological controls have been fairly successful against it.
Neonectria spp. Beech bark disease (fungus)	Fungus spread by the non-native scale insect *Cryptococcus fagisuga* creates cankers on beech trees, which eventually result in girdling of the tree. The disease has been spreading in Massachusetts since 1929. Beeches are still abundant, but the number of large beeches is decreasing.
Ophiostoma ulmi, Ophiostoma himal-ulmi, Ophiostoma novo-ulmi Dutch elm disease (fungus)	In the 1930s, this disease arrived in Cleveland, Ohio, on infected elm logs imported from Europe. A more virulent strain arrived in the 1940s. The American elm originally ranged in all states east of Rockies, and elms were once the nation's most popular urban street tree. However, the trees have now largely disappeared from both urban and forested landscapes. It is estimated that "Dutch" elm disease has killed more than 100 million trees.
Aquatic Species	
Dreissena polymorpha (Zebra mussel)	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.

Source: Chase et al., 1997; Pederson et al., 2005, CZM, 2013, 2014; Defenders of Wildlife; Gulf of Maine; EOEEA, 2013a, 2013b; as presented in the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Probability of Future Events

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 exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals. The probability of future events was Very High (50% to 100% probability in the next year).

More generally, a warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. The impacts of invasive species and climate change is discussed in more detail below.

Impact

The impacts of invasive species may interact with those of climate change, magnifying the negative impacts of both threats. Furthermore, due to the very traits that make them successful at establishing in new environments, invasives may be favored by climate change. These traits include tolerance to a broad range of environmental conditions, ability to disperse or travel long distances, ability to compete efficiently for resources, greater ability to respond to changes in the environment with changes in physical characteristics (phenotypic plasticity), high reproductive rates, and shorter times to maturity.

To become an invasive species, the species must first be transported to a new region, colonize and become established, and then spread across the new landscape. Climate change may impact each stage of this process. Globally, climate change may increase the introduction of invasive species by changing transport patterns (if new shipping routes open up), or by increasing the survival of invasives during transport. New ornamental species may be introduced to Massachusetts to take advantage of an expanded growing season as temperatures warm. Aquatic invasives may survive in ships' ballast waters with warmer temperatures. Extreme weather events or altered circulation patterns due to climate change could also allow the dispersal of invasive species to new regions via transportation of seeds, larvae and small animals.

Species may shift their ranges north as the climate warms and be successful in regions they previously had not colonized. Invasives may also be able to spread more rapidly in response to climate change, given their high dispersal rates and fast generation times. These faster moving species may be at a competitive advantage if they can move into new areas before their native competitors.

Here in the Northeast, warming conditions may be particularly concerning for some invasives because species ranges in temperate regions are often limited by extreme cold temperatures or snowfall. There is concern that aquatic species, such as hydrilla (Hydrilla verticillata) and water hyacinth (Eichhornia crassipes), may be able to survive and overwinter in Massachusetts with increased temperatures and reduced snowfall. Nutria (Myocastor coypus), large, non-native, semi-aquatic rodents that are currently established in Maryland and Delaware, are likely to move north with warming temperatures - perhaps as far as Massachusetts.

Invasive species are often able to thrive or take advantage of areas of high or fluctuating resource availability such as those found in disturbed environments. For example, for invasive plants, insect outbreaks or storms often free up space in the forest allowing light to penetrate and nutrients and moisture balances to change, allowing invasive plants to move in. Climate change is likely to create these types of opportunities through increased disturbances such as storms and floods, coastal erosion and sea level rise.

Invasives may also be better able to respond to changing environmental conditions that free up resources or create opportunities. For example, greater plasticity in response to their environment may allow some invasive plants to respond faster to increases in spring temperature than native plants. These invasives are able to leaf-out earlier in warmer years, taking up available space, nutrients, and sunlight, and achieving a competitive advantage against native species. Increased carbon dioxide in the atmosphere may also benefit some weedy plant species, allowing them to compete for other resources (like water) more effectively than their native counterparts.

Species roles may change as the climate changes, further complicating the management and policy response. As species ranges shift and existing inter-species relationships are broken, there is the potential that some species, including native species, may become pests because the interspecies interactions (e.g., predation, herbivory) that used to keep their population numbers in check are no longer functional.[53]

Once established, invasive species often escape notice for years or decades. Introduced species that initially escaped many decades ago are only now being recognized as invasives. Because these species can occur anywhere (on public or private property), new invasive species often escape notice until they are widespread and eradication is impractical. As a result, early and coordinated action between public and private landholders is critical to preventing widespread damage from an invasive species. Because of all these factors, the Core Team determined that the impacts on the town would be Critical.

Vulnerability

Because plant and animal life is so abundant in Leyden, the entire town is considered to be exposed to the invasive species hazard. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated areas; however, invasive species can disrupt ecosystems of all kinds.

Society

The majority of invasive species do not have direct impacts on human well-being; however, as described in the following subsections, there are some health impacts associated with invasive species.

<u>Vulnerable Populations</u>

Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to

[53] This section excerpted from the MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

specific species that may be present in the state in the future. These include people with compromised immune systems, children under the age of 5, people over the age of 65, and pregnant women. Those who rely on natural systems for their livelihood or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

Health Impacts

Of particular concern to human health are species like the Asian tiger mosquito (Aedes albopic-tus). This invasive mosquito, originally from southeast and subtropical Asia has moved through the Eastern U.S. and has recently arrived in Massachusetts. Capable of spreading West Nile Virus, Equine Encephalitis, and numerous other tropical diseases, this aggressive mosquito is likely range-limited by cold winter temperatures, suitable landscape conditions (it prefers urban areas), and variation in moisture. As winter temperatures increase, the species is likely to become more prevalent in Massachusetts and throughout the Northeast, increasing the risk of serious illness for residents in summer months.[54]

Additional invasive species have negative impacts on human health. The Tree of Heaven (Ailanthus altissima) produces powerful allelochemicals that prevent the reproduction of other species and can cause allergic reactions in humans. Similarly, due to its voracious consumption, the zebra mussel accumulates aquatic toxins, such as polychlorinated biphenyls or polyaromatic hydrocarbons, in their tissues at a rapid rate. When other organisms consume these mussels, the toxins can accumulate, resulting in potential human health impacts if humans consume these animals.

Loss of urban tree canopy from invasive species and pests can lead to higher summertime temperatures and greater vulnerability to extreme temperatures. Health impacts from extreme heat exposure is discussed in the Extreme Temperature section.

Economic Impacts

Economic impacts include the cost to control invasive species on public and private land. Individuals who are particularly vulnerable to the economic impacts of this hazard include all groups who depend on existing ecosystems in Leyden for their economic success. This includes all individuals working in forestry and agriculture-related fields, as well as those whose livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports. Businesses catering to visitors who come to a town for outdoor recreation opportunities can also suffer from loss of business. Additionally, homeowners whose properties are adjacent to vegetated areas or waterbodies experiencing decline from an invasive species outbreak could experience decreases in property value.

Infrastructure

The entire town of Leyden is considered exposed to this hazard; however, the built environment is not expected to be impacted by invasive species to the degree that the natural environment is. Buildings are not likely to be directly impacted by invasive species. Amenities such as outdoor recreational areas that

[54] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

depend on biodiversity and ecosystem health may be impacted by invasive species. Facilities that rely on biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

<u>Agriculture</u>
The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. More pest pressure from insects, diseases, and weeds may harm crops and cause farms to increase pesticide use. In addition, floodwaters may spread invasive plants that are detrimental to crop yield and health. Agricultural and forestry operations that rely on the health of the ecosystem and specific species are likely to be vulnerable to invasive species.

<u>Public Health</u>
An increase in species not typically found in Massachusetts could expose populations to vector-borne disease. A major outbreak could exceed the capacity of hospitals and medical providers to care for patients.

<u>Transportation</u>
Water transportation may be subject to increased inspections, cleanings, and costs that result from the threat and spread of invasive species. Species such as zebra mussels can damage aquatic infrastructure and vessels.

<u>Water Infrastructure</u>
Water storage facilities may be impacted by zebra mussels. Invasive species may lead to reduced water quality, which has implications for the drinking water supplies and the cost of treatment.

Environment
Leyden is 82% forested, and is therefore vulnerable to invasive species impacts to forests. Invasive plants can out-compete native vegetation through rapid growth and prolific seed production. Increased amounts of invasive plants can reduce plant diversity by dominating forests. When invasive plants dominate a forest, they can inhibit the regeneration of native trees and plants. This reduced regeneration further reduces the forest's ability to regenerate in a timely and sufficient manner following a disturbance event. In addition, invasive plants have been shown to provide less valuable wildlife habitat and food sources.

As discussed previously, the movement of a number of invasive insects and diseases has increased with global trade. Many of these insects and diseases have been found in New England, including the hemlock woolly adelgid, the Asian long-horned beetle, and beech bark disease. These organisms have no natural predators or controls and are significantly affecting our forests by changing species composition as trees susceptible to these agents are selectively killed.

Invasive species interact with other forest stressors, such as climate change, increasing their negative impact. Examples include:

- A combination of an earlier growing season, more frequent gaps in the forest canopy from wind and ice storms, and carbon dioxide fertilization will likely favor invasive plants over our native trees and forest vegetation.
- Preferential browse of native plants by larger deer populations may favor invasive species and inhibit the ability of a forest to regenerate after wind and ice storms.
- Warming temperatures favor some invasive plants, insects, and diseases, whose populations have historically been kept in check by the cold climate.
- Periods of drought weaken trees and can make them more susceptible to insects and diseases.55

Aquatic invasive species pose a particular threat to water bodies. In addition to threatening native species, they can degrade water quality and wildlife habitat. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals
- Impairment of recreational uses, such as swimming, boating, and fishing
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Local and complete extinction of rare and endangered species

Vulnerability Summary

Overall Leyden faces a High vulnerability to invasive species. Impacts from invasive species have the potential to dramatically alter Leyden's forests and other natural landscapes.

[55] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

3.15 OTHER HAZARDS

In addition to the hazards identified above, the Core Team reviewed the full list of hazards listed in the Massachusetts Hazard Mitigation and Climate Adaptation Plan. Due to the location and context of the Town of Leyden, coastal erosion, coastal flooding, and tsunamis were determined not to be a threat. Manmade hazards are not addressed in the State plan, but were addressed in the 2016 Leyden Hazard Mitigation Plan, and are considered a risk to the town.

This plan does not address all manmade hazards that could affect Leyden. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of the 2022 plan, the Core Team discussed and updated the information from the 2016 Plan, where available, and discussed non-natural hazards that are of an accidental nature, including industrial transportation accidents and industrial accidents in a fixed facility. New to the 2021 plan are evaluations of vector-borne diseases and cyber-security, which have become threats of greater concern in recent years.

3.15.1 VECTOR-BORNE DISEASES[56]

Hazard Profile
The Town of Leyden chose to include a discussion of the hazards posed by vector-borne disease in their community as part of this Plan update. Vector-borne disease is defined by the Centers for Disease Control (CDC) as illnesses in humans that are caused by contact (being bitten by) a vector such as mosquito, tick, or flea. Examples of mosquito-borne diseases include Chikungunya, Eastern Equine Encephalitis (EEE), Zika and West Nile Virus. Examples of tick-borne disease include Lyme disease, Anaplasmosis/Ehrlichiosis, Babesiosis and Powassan.

In the US in 2016, a total of 96,075 cases of vector-borne diseases were reported, 1,827 of which were reported in Massachusetts. The CDC indicates that cases of vector-borne diseases are substantially underreported. Tick-borne illnesses more than doubled between 2004 and 2016 and accounted for 77% of all vector-borne disease reports in the United States. Lyme disease accounted for 82% of all tick-borne cases, but cases of Spotted fever rickettsioses, Babesiosis and Anaplasmosis/Ehrlichiosis also increased. Between 2004 and 2016, nine vector-borne human diseases were reported for the first time from the United States and its territories. According to the CDC, vector-borne diseases have been difficult to prevent and control, and a Food and Drug Administration approved vaccine is only available for yellow fever virus. Insecticide resistance is widespread and is increasing.

The impacts of vector-borne diseases can be significant in a community and can affect residents' quality of life and ability to work. Other impacts of these diseases can include an increase in life-long morbidity

[56] This section relies heavily on a template prepared by the Berkshire Regional Planning Commission (BRPC) for towns in their region that are working to update local hazard mitigation plans. FRCOG updated available statistics for Massachusetts using information from MA DPH's website and for Franklin County (FRCOG Public Health Nurse and MAVEN).

and an increase in mortality. The impact of vector-borne diseases, therefore, is considered Critical by the Core Team.

Probability of Occurrence

According to the CDC, the geographic and seasonal distribution of vector populations and the diseases they can carry depends not only on the climate, but also on land use, socioeconomic and cultural factors, pest control, access to health care, and human responses to disease risk. Climate variability can result in vector/pathogen adaptation and shifts or expansions in their geographic ranges. Infectious disease transmission is sensitive to local, small-scale differences in weather, human modification of the landscape, the diversity of animal hosts and human behavior that affects vector/human contact.

Franklin County provides many and varied outdoor recreation opportunities for both residents and visitors, including hiking, swimming, mountain biking, and camping. Increased exposure to the outdoors, particularly to areas with heavy tree and forest cover, and areas with tall grass or standing water, significantly increase a person's exposure to vector-borne illnesses. Increases in average year-round temperature during the past few decades has also led to the over-wintering of ticks in Franklin County and across the Commonwealth. A lengthening warm season has also increased tick and mosquito populations significantly. The probability of future vectore-borne diseases is Very High.

Location

The entire Town of Leyden is likely already impacted by vector-borne disease and is likely to be increasingly impacted. Exposure to any outdoor area with tall grasses, standing water, and trees increases risk. Residents and visitors can be exposed at home and in more commercial areas, although exposure in commercial areas is generally less likely. The risk area for vector-borne diseases in Leyden is Medium.

Extent

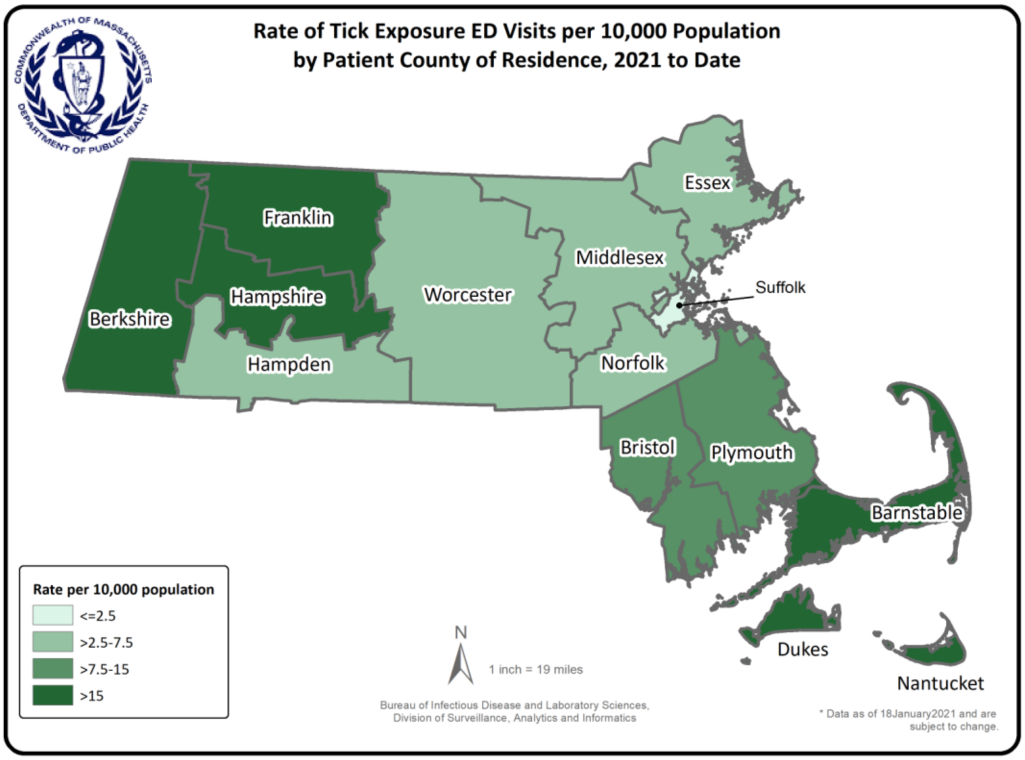
Tick-borne Illness[57]

Massachusetts has seen cases of once non-existent or very rare tick-borne illnesses rise, including Anaplasmosis, Babesiosis, Lyme, Powassan, Spotted fever rickettsiosis and Tularemia. Tick activity and tick-borne diseases occur year-round in Massachusetts. Although tick activity is weather dependent, there are two peaks during the year; the first begins in March/April and lasts through

[57] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#monthly-tick-report-page-

August, and the second occurs in October-November. The majority of cases of tick-borne disease occur in June through August. Figure 3-33 shows the rate, per 10,000 total population, of emergency department (ED) visits by patients who had a visit related to a tick exposure, by Massachusetts county of residence, 2021 to date. Although there are differences in the rate of patient visits, this shows that people are exposed to ticks throughout all of Massachusetts and should take recommended steps to reduce the chance of being bitten.[58]

Figure 3-33: Rate of Tick Exposure ED Visits by County



The Town of Leyden is a member of the Franklin Regional Council of Governments' Cooperative Public Health Services Health District (CPHS). The CPHS Public Health Nurse supplied information for reported cases of vector-borne illnesses in 2019 and 2021 (Table 3-43):[59]

accessed March 19, 2020.

[58] https://www.mass.gov/info-details/monthly-tick-report-november-2019 accessed August 26, 2021.

[59] Note: It is never clear if these trends actually represent an increase in infection/illness as small sample, underreporting is assumed, reporting of cases determined by clinical judgement. Virtually all of the reports that reach MAVEN are due to a laboratory result.

Table 3-43: Vector-Borne Illnesses and Case Counts for CPHS Towns, 2020-2021		
Vector-Borne Illness	**Status[60]**	**Case Count**
Babesiosis[61]	Confirmed	5
	Suspect	1
Borrelia miyamotoi[62]	Probable	1
	Suspect	2
Ehrlichiosis[63]	Confirmed	1
Human Granulocytic Anaplasmosis[64]	Confirmed	55
	Probable	3
	Suspect	19
Lyme Disease[65]	Confirmed	1
	Probable	1
	Suspect	201

Mosquito-borne Illnesses[66]

West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE or "Triple E") are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. There are other diseases spread by mosquitoes that people may be exposed to when traveling in other regions of the world. These include Zika virus, Dengue fever, and Chikungunya.

Eastern equine encephalitis (EEE) is a rare but serious disease caused by a virus that can affect people of all ages. EEE is generally spread to humans through the bite of a mosquito infected with the virus. EEE can cause severe illness and possibly lead to death in any age group; however, people under age 15 are at particular risk.[67]

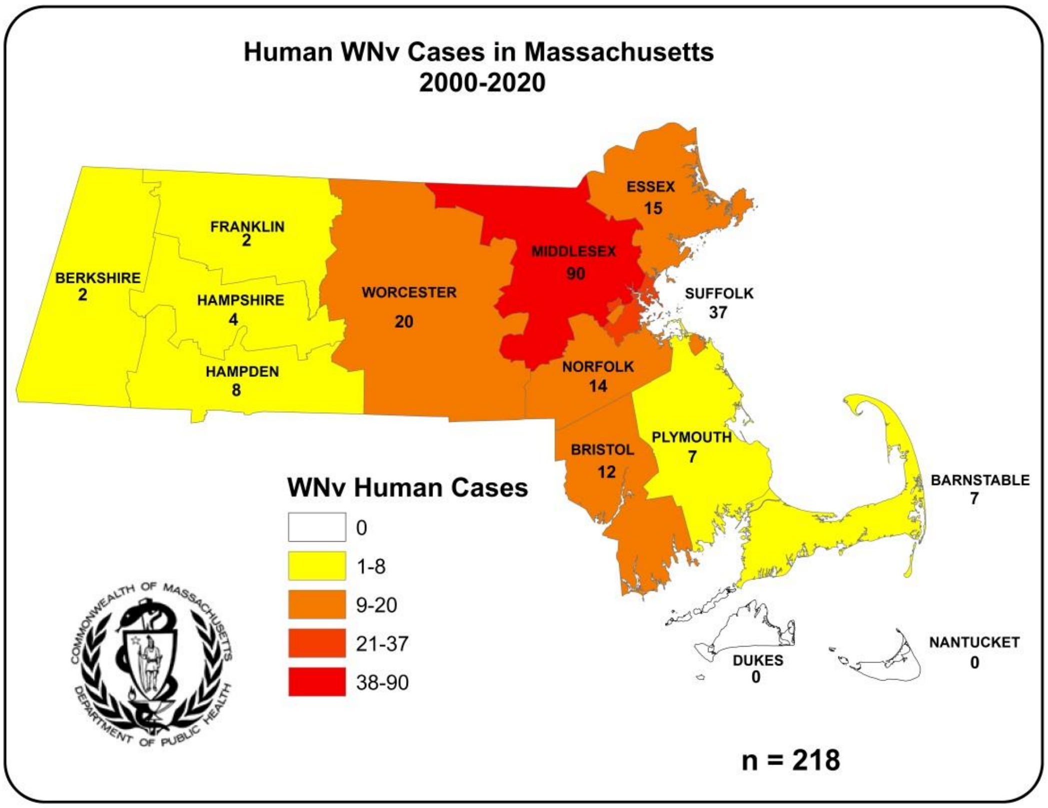
EEE has a 30-50% mortality and lifelong neurological disability among many survivors. The first symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease rapidly worsens and some patients may go into a coma within a week. There is no treatment for EEE. In Massachusetts, approximately half of the people identified with EEE have died from the infection. People who survive this disease will often be permanently disabled due to neurologic damage. Few people recover completely.

[60] Case counts for each vector-borne illness are listed with a CDC Event Classification of Confirmed, Probable, or Suspect. For definitions of each Event Classification, please refer to the document listed in the footnote for each illness.
[61] http://www.maven-help.maventrainingsite.com/pdf/case-classification-manual/BABESIOSIS_02222021.pdf
[62] http://www.maven-help.maventrainingsite.com/pdf/case-classification-manual/BMIYAMOTOI_02262021.pdf
[63] http://www.maven-help.maventrainingsite.com/pdf/case-classification-manual/HME_08062021.pdf
[64] http://www.maven-help.maventrainingsite.com/pdf/case-classification-manual/HGA_02252021.pdf
[65] http://www.maven-help.maventrainingsite.com/pdf/case-classification-manual/LYME_03292022.pdf
[66] https://www.mass.gov/mosquito-borne-diseases accessed March 20, 2020.
[67] https://www.mass.gov/guides/eee-in-massachusetts accessed March 20, 2020

Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 1972-74, 1982-84, 1990-92, and, 2004-06. Two cases of EEE occurred in each of 2010 and 2011; one case each of these years occurred in visitors to Massachusetts. Seven human cases of EEE occurred in 2012, a single case in 2013 and no cases from 2014 - 2018.

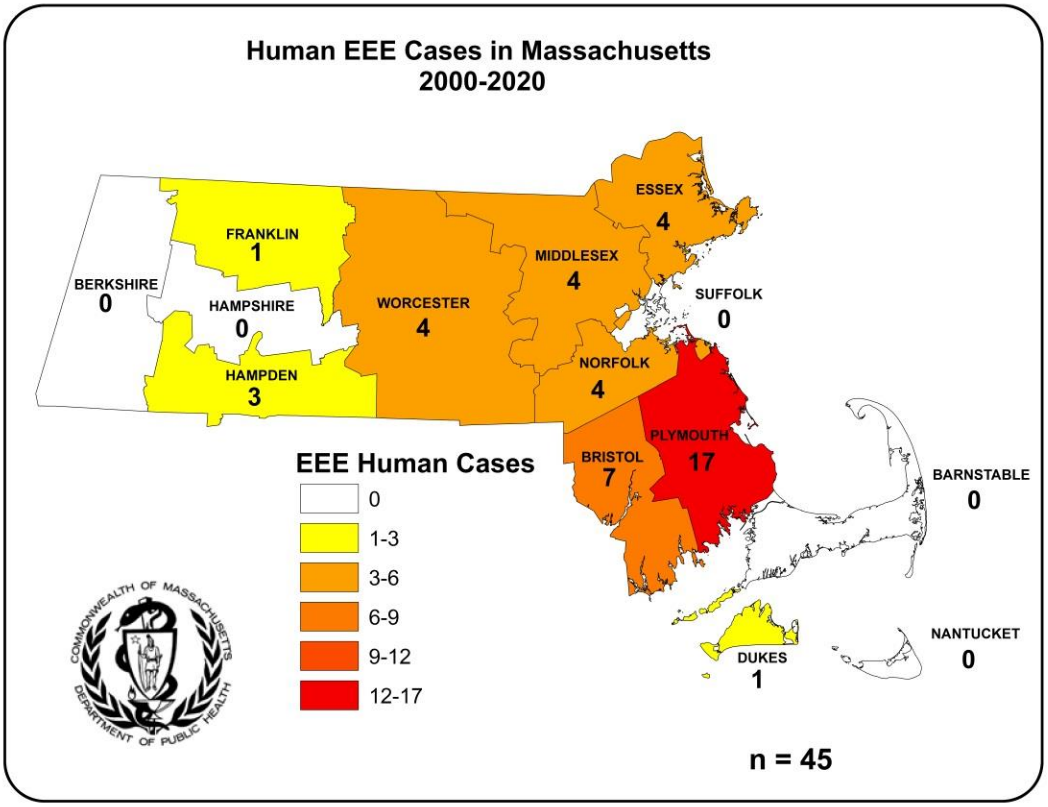
The narrative above and the following figures are from the MA Department of Public Health's 2021 Arbovirus Surveillance and Response Plan.[68]

Figure 3-34: Municipality of Residence of West Nile Virus Human Cases, 2001 - 2020



[68] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed April 2022. Narrative copied from p. 2 of the report. Figures from pp. 29-30.

Figure 3-35: County of Residence of EEE Human Cases, 2000-2020



West Nile virus (WNV) first appeared in the United States in 1999. Since the initial outbreak in New York City, the virus has spread across the US from east to west. Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state, and federal officials, academicians, environmentalists and the public to develop recommendations to adapt the arbovirus surveillance and response plan to include activities appropriate for WNV. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity, and communication.

WNV infection may be asymptomatic in some people, but it leads to morbidity and mortality in others. WNV causes sporadic disease of humans, and occasionally significant outbreaks. Nationally, 2,554 human cases of WNV neuroinvasive disease (meningitis and encephalitis) and WNV fever were reported to the CDC in 2018. The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller proportion of people who become infected (~ 20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach, and back. Less than 1% of people infected with WNV will develop severe illness, such as encephalitis or meningitis. The symptoms of severe illness can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness, and paralysis. Persons older than 50 years of age have a higher risk of developing severe illness. In Massachusetts, there were at least 12 fatal WNV human cases identified between 2002 and 2018. All but three of these fatalities were in individuals 80 years of age or older; all of them were in individuals over 60.[69] In September 2020, Massachusetts Department of Public Health reported a total of seven West Nile Virus cases in the state that year. In 2019, there were five human cases of WNV infection.[70] The Department of Public Health's 2021 Arbovirus results summary shows that there were no positive EEE or WNV cases in animals or humans in Massachusetts as of August 26, 2021.[71]

Vulnerability Assessment

Society

Vector-borne illness has a significant impact on humans and on a community. These illnesses can significantly impact the health, long-term morbidity and mortality, and quality of life of town residents and can reduce a person's ability to work or contribute to the community in other ways. In addition, pesticides and herbicides used to control vector populations can also negatively impact human health.

Infrastructure

Vector-borne illnesses pose little threat to infrastructure and the built environment. Overtime, changes in development patterns may occur as people respond to the increase in disease carrying insects.

Natural Environment

Increases in vector-borne illnesses can increase the likelihood that a community needs to use chemical pesticides and herbicides to control vector populations. The increased use of these products and chemicals can negatively impact the natural environment, including vegetation, rivers and streams, and animal populations. Reducing populations of ticks and mosquitoes can reduce the food source for other dependent animal populations. Additionally, diseases carried by insects can affect wildlife. There is also the risk of people reacting to the threat of disease by altering the environment to not support vector habitat, which can severely damage the long-term health of ecosystems.

Economy

The economy is susceptible to the indirect impacts of vector-borne illnesses. If a community decides to engage in a pest-control program or another program to reduce vector populations, this can significantly affect their operating budget. Incorporation of any program to reduce vector populations in a community will likely cause tax increases within the municipality. Long-term, the more individuals in a population affected by vector-borne disease that results in life-long morbidity or mortality will reduce the overall economic participation and output of the population in a municipality. The can also be impacts on the outdoor recreation economy, which is a major revenue driver for Franklin County.

---

[69] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. pp.3-4.
[70] https://www.mass.gov/news/state-public-health-officials-announce-four-new-human-cases-of-west-nile-virus-in-massachusetts, August 30, 2021.
[71] https://www.mass.gov/info-details/massachusetts-arbovirus-update#arbovirus-results-summary- accessed August 30, 2021.

People today choose to or may be advised by public health officials to avoid outdoor activities for fear of tick and mosquito bites.

Future Conditions

Continued changes to the climate, extreme precipitation events, issues with the control of stormwater, changes to animal and vector populations, and increases in insecticide resistance will lead to an ongoing and growing threat to individuals, governments and businesses. Local governments will need to invest in methods to reduce or prevent exposure to vector-borne diseases and should strongly consider methods that do not include the increased use of insecticides and herbicides. This may include methods such as promoting populations of bats, opossums and other animals that consume vectors of concern, increasing opportunities for residents to get ticks tested, reducing the cost and burden of tick testing and increasing the level of education and outreach to the public and health care practitioners about current and new vector-borne illnesses so treatment can be expedited.

Leyden recently joined the PV Mosquito Control District, which provides testing and trapping services. The State accepted the Town's alternative plan for mosquito management after they opted out of the state's aerial spraying programs.

Leyden considers itself to have High overall vulnerability to vector-borne diseases.

3.15.2 MANMADE HAZARDS

Hazard Description

Most non-natural or manmade hazards fall into two general categories: intentional acts and accidental events, although these categories can overlap. Some of the hazards included in these two categories, as defined by MEMA, consist of intentional acts such as explosive devices, biological and radiological agents, arson and cyberterrorism and accidental events such as nuclear hazards, invasive species, infrastructure failure, industrial and transportation accidents. Accidental events can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials.

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products are shipped daily on the nation's highways, railroads, waterways, and pipelines. Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants.

Location and Extent

A release may occur at a fixed facility or in transit. Communities with a large industrial base, may be more inclined to experience a hazardous materials release due to the number of facilities using such materials in their manufacturing process. Communities with several major roadways may be at a greater risk due to the number and frequency of trucks transporting hazardous materials passing through, with similar risks associated with the location of railways in a town. There is minimal transit and no fixed facilities of concern in Leyden. Ledyen is considered to have an Isolated risk area for manmade hazards.

Industrial Accidents - Transportation

Franklin County transportation systems include road, rail, and air. Accessible and efficient freight transportation plays a vital function in the economy of the region. Most freight and goods being transported to and from Franklin County are by truck; however, a significant amount of freight that moves through the county is being hauled over the three main rail lines. Given that any freight shipped via air needs first to be trucked to an airport outside the region, air transportation is not being evaluated in this plan.

According to the Franklin County Hazardous Material Emergency Plan,[72] 13 or more trucks per hour travel through the region containing hazardous materials (Table 3-43). Most of these vehicles are on Interstate 91 and up to one truck per hour may be carrying hazardous materials along Routes 5/10, neither of which pass through Leyden. None of the roads in Leyden were identified as roads that routinely carry hazardous materials.

[72] Franklin County Regional Emergency Planning Committee, Franklin County Hazardous Material Emergency Plan and Maps, 2015.

Table 3-44: Estimated Levels of Hazardous Material Transported on Area Roadways	
Roadway	**Number of Tank or Van Trucks Carrying Hazardous Materials per hour**
Interstate 91	10
Route 2	2
Other state highways *(Routes 5/10, 63, 47, 116,202, 8A, 78, 122, 142, and 2A)*	1 or 0

The following hazardous materials are frequently transported on Interstate 91 and Routes 5/10:

- Gasoline
- Fuel oil
- Kerosene
- Liquefied Petroleum Gas
- Propane

Brattleboro Road and Greenfield/West Leyden Road were identified as hazardous transportation routes Leyden's 2014 eCEMP and 2016 Multi-Hazard Mitigation Plan. Safe and efficient transportation routes for trucks to and through the region are important to the region's economy and to the safety of its citizens. The safer the transportation routes are, the less likely a transportation accident will occur.

Two to three trains per day travel on the Pan Am Systems Connecticut River Line, which runs a few miles east of Leyden. Rail accidents can be caused by flooding that washes out track beds, faulty or sabotaged track; collision with another train, vehicle or other object on the track; mechanical failure of the train; or driver error. Depending on the freight, an accident could cause residents to evacuate the area.

The hazardous chemicals carried by rail through the county in 2013 were:

- Petroleum crude
- Liquefied petroleum
- Petroleum gases
- Sodium chlorate
- Sodium hydroxide
- Carbon dioxide
- Phenol molten
- Hydrochloric acid
- Acetone
- Methanol
- Air bag inflation chemicals
- Methyl methacrylate
- Alkylphenols
- Batteries, wet
- Adhesives
- Caustic alkali
- Helium, compressed
- Fire extinguisher chemicals
- Sulfuric acid
- Paint
- Gasoline
- Toluene
- Hydrogen peroxide

Table 3-45: Estimated Level of Hazardous Material Transport on Area Train Lines			
Train Line	**Trains per Day (General Merchandise)**	**Average Number of Cars per Train**	**Average Number of Cars per Train with Hazardous Materials**
Main Freight Line, Pan Am Systems	10 to 24	50	4
Connecticut River Line, Pan Am Systems	2 to 3	30	2
East Deerfield Rail Yard, Pan Am Systems	10 to 15 trains passing through yard	n/a	2 to 5
New England Central	2	60	5

Industrial Accidents - Fixed Facilities

An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. Those facilities using, manufacturing, or storing toxic chemicals are required to report their locations and the quantities of the chemicals stored on-site to state and local governments.

The Toxics Release Inventory (TRI) tracks the management of over 650 toxic chemicals that pose a threat to human health and the environment. U.S. facilities in different industry sectors that manufacture, process, or otherwise use these chemicals in amounts above established levels must report how each chemical is managed through recycling, energy recovery, treatment, and environmental releases. *Note: a "release" of a chemical means that it is emitted to the air or water, or placed in some type of land disposal*. The information submitted by facilities to the EPA and states is compiled annually as the Toxics Release Inventory or TRI, and is stored in a publicly accessible database. TRI information helps support informed decision-making by industry, government, non-governmental organizations and the public. Note that TRI does not provide any safety or health information about these chemicals and compounds. TRI data, in conjunction with other information, can be used as a starting point in evaluating exposures that may result from industrial activities that involve toxic chemicals.[73]

It is important to note that inclusion on the TRI in no way indicates any issues with any of the sites, but rather is an inventory of those facilities meeting TRI reporting requirements. There are no facilities in Leyden that fall within the reporting requirements for the inventory (Table 3-43). The Leyden eCEMP identified one facility in town, the Highway Department at 16 West Leyden Road, as a hazardous facility because of diesel fuel storage.

[73] https://www.epa.gov/toxics-release-inventory-tri-program

According to The Franklin County Regional Emergency Planning Committee (REPC) 2018 List of Tier II Facilities, there are no Tier II Facilities located in Leyden (Table 3-44). Facilities covered by the reporting requirements of the Federal Emergency Planning and Community Right-to-Know Act (EPCRA) must submit annual Tier II reports to their Emergency Planning Committee (EPC), and Local Fire Department, and the State Emergency Response Commission (SERC).

Many farmers store agricultural chemicals on their properties. Given that much farmland is located in or near floodplains and their adjacent water bodies, the potential for an accidental hazardous materials spill to impact water quality is present. This plan does not include an in-depth evaluation of hazardous materials as they relate to farming. In many cases, famers do use and store pesticides, herbicides and fertilizers on their property. In most cases, farmers are utilizing best management practices in the use and storage of agricultural chemicals and have undergone any required training and licensing if they are applying these chemicals to the land. Despite training and best management practices, an accidental release of hazardous materials can occur and potentially threaten human health and the environment. One approach that the Town could take to help prepare for a hazardous materials spill on a farm, possibly through coordination with the Agricultural Commission, would be to become familiar with the types and quantities of chemicals stored on-site at the larger farms within the Town.

Another potential source of contamination from hazardous materials stored and use on-site could be the many local public and private schools that maintain sports fields, often with the use of pesticides and herbicides. These sites and the chemicals that are stored there could be documented as well. These actions would assist first responders in being adequately prepared to protect human health and prevent contamination of the environment in the event of a major spill or other accidental release of hazardous materials.

Hazardous facilities located outside of town boundaries can also be of concern to Leyden. The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border, approximately 8 miles from the Leyden Town Hall. In January 2010, the facility notified the Vermont Department of Health that samples taken in November 2009 from a ground water monitoring well on site contained tritium. This finding signals an unintended release of radioactive material into the environment. Testing has shown that contaminated groundwater has leaked into the Connecticut River, though tritium levels in the river have remained below the lower limit of detection.[74]

The 2011 tsunami and earthquake in Japan that damaged a nuclear power plant demonstrates the potential vulnerability of these facilities to natural disasters, and the geographic extent that could be impacted by an accident. The Nuclear Regulatory Commissions extended the Vermont Yankee plant's operating license for 20 more years, which was to expire in March 2012. However, Entergy, the plant's owner, shut down the plant as of the end of 2014.

Leyden officials should stay abreast of proper evacuation procedures in the event of an accident at the

[74] Vermont Department of Health. http://healthvermont.gov/enviro/rad/vt_yankee.aspx

Vermont Yankee nuclear power plant. Because Leyden falls within a ten-mile radius of Vermont Yankee, the Town's emergency personnel previously participated in regular trainings that evaluate shelters, evacuation procedures, traffic control, and what equipment and materials would be needed in the event of an accident at the plant. With the plant no longer in operation, these trainings are not provided. In addition, the Town had a nuclear planning document that was updated regularly. The plan still exists and could be used as a reference, but Vermont Yankee no longer provides support for updating the plan. These trainings helped the Town to be better prepared for a nuclear event, and also served as a basis for dealing with other emergencies. The Nuclear Regulatory Commission has approved Entergy's request to eliminate the 10-mile emergency zone around the plant.[75] Leyden will keep its emergency siren, however the Town will now be responsible for maintaining it. The Vermont Yankee site will continue to be the repository of spent fuel rods for which there is as of yet no federal storage location.

Cyber Threats

A failure of networked computer systems could result in the interruption or disruption of Town services (including public safety and other critical services), the disruption or interruption of the functioning of Town departments, and the potential for loss or theft of important data (including financial information of the Town and residents).

There are many possible causes of a network failure, but most either happen because of damage to the physical network/computer system infrastructure or damage to the network in cyberspace. Physical damages are incidents that damage physical telecommunications infrastructure or server/computer hardware. Examples are a water main break above a server room, fire/lighting strike that destroys equipment, construction accident damaging buried fiber line, or power outage and other issues effecting the Internet Service Provider (ISP) that interrupts access to the internet to the Town.

Damage to the cyber infrastructure can be malicious attacks or critical software errors that affect computer systems, from individual computers to the entire network. These virtual hazards can cause lack of access to the network, permanent data loss, permanent damage to computer hardware, and impact the ability to access programs or systems on the network.

When incidents are malicious attacks, they can impact:

- Confidentiality: protecting a user's private information.
- Integrity: ensuring that data is protected and cannot be altered by unauthorized parties.
- Availability: keeping services running and giving administration access to key networks and controls.
- Damage: irreversible damage to the computer or network operating system or "bricking" and physical, real world damages, caused by tampering with networked safety systems.
- Confidence: confidence of stakeholders in the organization who was victim of the attack.

[75] "Vermont Yankee gets ok to nix emergency plan zone." *The Recorder*. Published Monday, December 14, 2015.

Motives for cyber-attacks can vary tremendously, ranging from the pursuit of financial gain—the primary motivation for what is commonly referred to as "cyber-crimes" is for profit, retribution, or vandalism. Other motivations include political or social aims. Hacktivism is the act of hacking, or breaking into a computer system, for a political or social purpose. Cyber espionage is the act of obtaining secrets without permission of the holder of the information, using methods on the Internet, networks, or individual computers. [76] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

For Leyden, the most likely cyber-threat affecting the Town and Town departments comes from malware and social engineering. These crimes prey on the vulnerable and unprepared and every individual and organization that connects a device to the internet is a potential mark. Leyden's Municipal Assistant recently completed a cyber security series and has an IT consultant commissioned to improve Leyden's cyber security.

Social Engineering

Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[77] These techniques are referred to as 'Phishing'.

Malware

Malware, or malicious software, is any program or file that is harmful to a computer user. Types of malware can include computer viruses, worms, Trojan horses, and spyware. These malicious programs can perform a variety of different functions such as stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission. The most common way for malware to infect a Town's network is through an employee opening an infected email attachment.

Previous Occurrences

Over the past few years a type of malware called ransomware has been targeted at local governments. Cyber-criminals will use social-engineering to infect a network, take control and block user access to that network, then request a ransom from the organization. Once the ransomware is on the network, it can be extremely expensive and time consuming to restore that network without paying the ransom. When the cost of the ransom is less than the cost of resorting the system is when the cyber-criminals succeed.

In July 2019, school districts all across the United States were targeted by ransomware. Since 2013, there have been some 170 attacks against state and local governments and there is no sign that this

[76] NYC Hazard Mitigation, Cyber Threats, https://nychazardmitigation.com/hazard-specific/cyber-threats/what-is-the-hazard/

[77] Cybersecurity Precautions, MA Executive Office of Technology Services & Security, 2017

trend is slowing. Unlike other hazards, cyber-threats are global. Cyber-criminals don't care where you are or how small your town is. Many cyber-crimes are not just lone criminals, they are more often than not committed by sophisticated criminal organizations and foreign governments who work around the clock looking to exploit small towns and big businesses alike.

The best way to prevent a cyber-attack is to follow best practices in cyber-security. Following these best practices will greatly mitigate the likelihood a cyber-attack is successful. MA Executive Office of Technology Services and Security (EOTSS)[78] is the chief MA State program that can assist local governments with cyber-security. There are educational opportunities available throughout the region that aim to assist municipalities learn and implement these best practices. The probablility of future occurances is considered to be low.

The Core Team sees the potential impact of manmade hazards as Limited, and the overall vulnerability rating as Low.

[78] https://www.mass.gov/cybersecurity

4 MITIGATION CAPABILITIES & STRATEGIES

4.1 NATURE-BASED SOLUTIONS FOR HAZARD MITIGATION & CLIMATE RESILIENCY

Nature-Based Solutions are actions that work with and enhance nature to help people adapt to socio-environmental challenges. They may include the conservation and restoration of natural systems, such as wetlands, forests, floodplains and rivers, to improve resiliency. NBS can be used across a watershed, a town, or on a particular site. NBS use natural systems, mimic natural processes, or work in tandem with engineering to address natural hazards like flooding, erosion and drought.

The 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan and the MVP program both place great emphasis on NBS, and multiple state and federal agencies fund projects that utilize NBS. For this plan, Low Impact Development (LID) and Green Infrastructure (GI) are included under the blanket term of NBS. Following are examples of how NBS can mitigate natural hazards and climate stressors, and protect natural resources and residents:

- Restoring and reconnecting streams to floodplains stores flood water, slows it down and reduces infrastructure damage downstream.
- Designing culverts and bridges to accommodate fish and wildlife passage also makes those structures more resilient to flooding, allowing for larger volumes of water and debris to safely pass through.
- Managing stormwater with small-scale infiltration techniques like rain gardens and vegetated swales recharges drinking water supplies, reduces stormwater runoff, and reduces mosquito habitat and incidents of vector-borne illness by eliminating standing pools of water following heavy rain events.
- Planting trees in developed areas absorbs carbon dioxide, slows and infiltrates stormwater, and provides shade, reducing summertime heat, lowering energy costs for village residents and improving air quality by reducing smog and particulate matter.
- Vegetated riparian buffers absorb and filter pollutants before they reach water sources, and reduce erosion and water velocity during high flow events.

This update of the Leyden Hazard Mitigation Plan incorporates Nature-Based Solutions into mitigation strategies where feasible.

4.2 EXISTING AUTHORITIES, POLICIES, PROGRAMS & RESOURCES

One of the steps of this Hazard Mitigation Plan update process is to evaluate all of the Town's existing policies and practices related to natural hazards and identify potential gaps in protection.

Leyden has most of the no-cost or low-cost hazard mitigation capabilities in place, such as land use zoning, subdivision regulations, and an array of specific policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Leyden is currently in the process of increasing its capacity for emergency management. A Public Safety Advisory Committee formed in 2021 to oversee changes in the structure of public safety in Leyden, including selecting a new Emergency Management Director and studying the feasibility of regionalizing the Town's police, fire, and emergency services. The Public Safety Advisory Committee is also developing an emergency management plan, and may transition into acting as an Emergency Management Committee once the restructuring of public safety is complete. Current emergency staff include the Town Administrator, a professionally run Highway Department, and a Tree Warden. Leyden is a member of the Franklin County Inspection Service, which provides building, plumbing, and electrical permitting and inspections to the town. In addition to Town staff, Leyden has an experienced Planning Board that reviews all proposed developments and assures that buildings are built to the current zoning requirements.

Leyden has a few recommended plans in place at this time. The Comprehensive Management Plan (CEMP) was completed in 2014 and is due for renewal. The Town does not have a Master Plan; a Community Development Plan was created in 2004. The Open Space and Recreation Plan expired in 2017 and the town is interested in updating it. A Municipal Vulnerability Preparedness Plan is integrated into this plan.

The Town does have very committed and dedicated volunteers who serve on boards and committees and in other volunteer positions. The Town collaborates closely with surrounding communities and is party to Mutual Aid agreements through MEMA. Leyden is also a member community of the Franklin Regional Council of Governments, and participates in the Franklin County Regional Emergency Planning Committee (REPC), though it has not been active in the REPC recent years.

Overview of Mitigation Strategies by Hazard

An overview of the general concepts underlying mitigation strategies for each of the hazards identified in this plan is as follows:

Flooding

The key factors in flooding are the water capacity of water bodies and waterways, the regulation of waterways by flood control structures, and the preservation of flood storage areas (like floodplains) and wetlands. As more land is developed, more flood storage is demanded of the town's water bodies and waterways. FEMA has identified no flood control structures within the Town of Leyden. Floods on the Connecticut River and portions of its major tributaries that are prone to backwater effects are controlled by nine flood control reservoirs located upstream in Massachusetts, New Hampshire, and Vermont.

The Town of Leyden has adopted several land use regulations that serve to limit or regulate development in floodplains, to manage stormwater runoff, and to protect groundwater and wetland resources, the latter of which often provide important flood storage capacity. These regulations are summarized in Table 4-1.

Infrastructure like dams and culverts are also in place to manage the flow of water. However, some of this infrastructure is aging and in need of replacement, or is undersized and incapable of handling heavier flows our region is experiencing due to climate change.

Severe Winter Storms
Winter storms can be especially challenging for emergency management personnel even though the duration and amount of expected amount of snowfall usually is forecasted. The Massachusetts Emergency Management Agency (MEMA) serves as the primary coordinating entity in the statewide management of all types of winter storms and monitors the National Weather Service (NWS) alerting systems during periods when winter storms are expected.

To the extent that some of the damages from a winter storm can be caused by flooding, flood protection mitigation measures also assist with severe snowstorms and ice storms. The Town has adopted the State Building Code, which ensures minimum snow load requirements for roofs on new buildings. There are no restrictions on development that are directly related to severe winter storms, however, there are some Subdivision Rules and Regulations that pertain to severe winter storms, summarized in Table 4-1.

Severe winter storms can often result in a small or widespread loss of electrical service. Should a natural hazard cause a power outage, Heath residents would be vulnerable to losing domestic heat and water supplies reliant on electricity. When a State of Emergency is declared for Leyden, the Town will be able to use the Town Offices as an emergency operations center once the new generator is installed in 2022.

Hurricanes and Tropical Storms
Hurricanes provide the most lead warning time of all identified hazards, because of the relative ease in predicting the storm's track and potential landfall. MEMA assumes "standby status" when a hurricane's location is 35 degrees North Latitude (Cape Hatteras) and "alert status" when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes cause significant damage – both due to flooding and severe wind.

The flooding associated with hurricanes can be a major source of damage to buildings, infrastructure and a potential threat to human lives. Flood protection measures can thus also be considered hurricane mitigation measures. The high winds that often accompany hurricanes can also damage buildings and infrastructure, similar to tornadoes and other strong wind events. For new or recently built structures, the primary protection against wind-related damage is construction according to the State Building Code, which addresses designing buildings to withstand high winds. The Town of Leyden is a member of the Franklin County Cooperative Building Inspection Program, which provides building inspection services.

Severe Thunderstorms / Winds / Microbursts and Tornadoes
Most damage from tornadoes and severe thunderstorms come from high winds that can fell trees and electrical wires, generate hurtling debris and, possibly, hail. According to the Institute for Business and Home Safety, the wind speeds in most tornadoes are at or below design speeds that are used in current building codes, making strict adherence to building codes a primary mitigation strategy. In addition, current land development regulations, such as restrictions on the height and setbacks of telecommunications towers, can also help prevent wind damages.

Wildfires / Brushfires
Eighty two percent of Leyden is forested; a large portion of the Town is therefore at risk of fire. Wildfire and brushfire mitigation strategies involve educating people about how to prevent fires from starting, controlling burns within the town, as well as managing forests for fire prevention.

Burn permits for the Town of Leyden are issued from the Shelburne Control Center of the Massachusetts State Police either online or over the phone. During this process, the applicant is read the State Law, which includes guidelines for when and where the burn may be conducted as well as fire safety tips provided by the control center. Specific burn permit guidelines are established by the state, such as the burning season and the time when a burn may begin on a given day.

There are currently no restrictions on development based on the need to mitigate wildfires. However, the Leyden Fire Department reviews subdivision plans to ensure that their trucks will have adequate access and that the water supply is adequate for firefighting purposes.

Earthquakes
Although there are five mapped seismological faults in Massachusetts, there is no discernible pattern of previous earthquakes along these faults nor is there a reliable way to predict future earthquakes along these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard for which to plan. Most buildings and structures in the state were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during the town’s recovery from an earthquake.

Dam Failure
Dam failure is a highly infrequent occurrence, but a severe incident could prove catastrophic. In addition, dam failure most often coincides with flooding, so its impacts can be multiplied, as the additional water has nowhere to flow. The only mitigation measures currently in place are the state regulations governing the construction, inspection, and maintenance of dams. This is managed through the Office of Dam Safety at the Department of Conservation and Recreation. Owners of dams are responsible for hiring a qualified engineer to inspect their dams and report the results to the DCR. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans. Potential problems may arise if the ownership

of a dam is unknown or contested. Additionally, the cost of hiring an engineer to inspect a dam or to prepare an Emergency Action Plan may be prohibitive for some owners.

Drought

The Northeast is generally considered to be a moist region with ample rain and snow, but droughts are not uncommon. Widespread drought has occurred across the region as recently as 2016, and before that in the early 2000s, 1980s, and mid-1960s. More frequent and severe droughts are expected as climate change continues to increase temperatures, raise evaporation rates, and dry out soils, in spite of more precipitation and heavier rainfall events.[79] Leyden could consider promoting or requiring drought and heat-tolerant grass, plants and trees in new development, to limit the amount of irrigation needed.

Forest landowners in town can be encouraged to conserve and manage their forests for climate resiliency. Strategies for promoting a resilient forest include increasing the diversity of tree species and age of trees in a forest, and promoting trees not currently threatened by pests or diseases that will thrive in a warming climate.[80]

Extreme Temperatures

A primary mitigation measure for extreme temperatures is establishing and publicizing warming or cooling centers in anticipation of extreme temperature events. Getting the word out to vulnerable populations, especially the homeless and elderly, and providing transportation is particularly important but can be challenging. The Town's Council on Aging has a vehicle to transport the elderly or supplies in the event of a hazard or emergency.

Planting and maintaining shade trees in villages and developed areas of towns can help mitigate extreme heat in these areas. Roofs and paving absorb and hold heat from the sun, making developed areas hotter during the summer than surrounding forested areas. Trees that shade these surfaces can significantly lower the temperature in a neighborhood, making it easier to be outside and reducing cooling costs for homeowners.

Invasive Species

The spread of invasive species is a serious concern as species ranges shift with a changing climate. People can also be a carrier of invasive plant species. Installing boot brushes at hiking entrances can help slow the spread of invasive species by removing seeds being carried in soil on hiking boots. Landowners can learn the top unwanted plants and look for them when out on their land, and can be encouraged to work with neighbors to control invasive exotic plants.

Before implementing any forest management, landowners should be sure to inventory for invasive exotic species. They will need to be controlled before harvesting trees and allowing sunlight into the

---

[79] MassWildlife Climate Action Tool: https://climateactiontool.org/content/drought. Accessed March 8, 2019.
[80] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

forest, which will trigger their growth and spread. Also, the timber harvester should be required to powerwash their machines before entering the woods. Financial assistance may be available to landowners through the USDA NRCS Environmental Quality Incentives Program (EQIP) to address invasive species.[81]

In addition, Leyden can require only native, non-invasive species be used in new development and redevelopment.

All Hazards

Because there are no officially designated emergency shelters and sheltering plans in Leyden', the Town prefers to send people to regional shelters in the event of a storm or emergency. A regional sheltering plan that identifies regional shelter sites was completed for Franklin County with funds from the Western Region Homeland Security Advisory Council (WRHSAC). However, the Franklin County REPC has not had the funds or staff capacity to operationalize the plan by creating Shelter Management Teams and cost sharing agreements between towns.

Primary and secondary evacuation routes are shown on the Critical Infrastructure map for Leyden. The Town's reliance on bridges to access neighboring communities and primary evacuation routes is a vulnerability if one or more of these bridges are damaged or inaccessible.

The Regional Debris Management Plan created by the Regional Emergency Planning Committee (REPC) approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute a Memorandum of Understanding (MOU) with neighboring communities.

The Town may need to adopt and submit to MEMA/FEMA a Town-specific version of the Franklin County Regional Debris Management Plan (accepted by FEMA on 7-17-15), which contains information about Disaster Debris Management Sites pre-certified by MassDEP and identifies pre-qualified contractors for disaster debris management and monitoring services. Adoption of the plan would enable the Town to benefit from the increased cost share adjustments available under the FEMA Public Assistance Alternative Procedures (PAAP) Pilot Program for Debris Removal. The Town could also build their own Disaster Debris Management Plan using a template that is available on the Western Region Homeland Security Advisory Council (WRHSAC) website.[82]

Existing Mitigation Capabilities

The Town of Leyden had numerous policies, plans, practices, programs and regulations in place, prior to the creation of this plan, that were serving to mitigate the impact of natural hazards in the town. These

[81] MassWildlife Climate Action Tool: https://climateactiontool.org/content/maintain-or-restore-soil-quality-limit-recreational-impacts. Accessed March 8, 2019.

[82] https://wrhsac.org/projects-and-initiatives/disaster-debris-management/

various initiatives are summarized, described, and assessed on the following pages and have been evaluated in the “Effectiveness” column.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
State Building Code	Regulation	The Town of Leyden has adopted the Massachusetts State Building Code.	Multiple Hazards	State Building Code Effective for new buildings or substantial renovations of existing buildings only.
Zoning Bylaws: Section 5.1: Height Requirements	Regulation	Buildings: Except for barns and silos, building height shall not exceed 35 feet. Antennas and Towers: No element of any antenna, tower, spire, wind turbine, or similar device exempt from the definition of "Building Height" shall be nearer any property line than a distance equal to its height above average grade at that property line, nor shall any such device exceed the maximum allowable building height by more than ten (10) feet, unless in either case authorized on Special Permit by the Planning Board upon its determination that the device will not be hazardous or detrimental to the neighborhood.	Hurricanes and Tropical Storms	Effective
Zoning Bylaws: Section 5.8: Personal Wireless Service Facilities	Regulation	Regulates the height and setback of Personal Wireless Service Facilities. Setbacks must meet the requirements for the zoning district where located. In reviewing a Special Permit application for a personal wireless service facility, the Planning Board may reduce the required setback distance of the zoning district by as much as 50% of the required distance if it finds that a substantially better design will result from such reduction. In making such a finding, the Planning Board shall consider both the visual and safety impacts of the proposed use.	Hurricanes and Tropical Storms	Effective
Zoning Bylaws: Section 5.5:	Regulation	Required for development with enclosed area of over ten thousand (10,000) square feet, or subdivision of a parcel of land	Multiple Hazards	Effective for mitigating or preventing localized flooding,

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Review of Large Developments		into more than three (3) lots within one year. Requires site plan (see Section 5.6 below) and an impact statement, including the following information: • changes in surface drainage • land erosion of loss of tree cover • disturbance of other aspects of the natural ecology		erosion, and hazardous impacts from stormwater runoff if erosion control measures are enforced during site construction and low impact development (LID) stormwater best management practices (BMPs) are implemented in the final site plan. The Planning Board could consider a LID zoning bylaw applicable to all new development and redevelopment including special permits, site plan review applications, subdivision applications and applications for earth removal permits in all zoning districts. All new land alterations (with the exception of single or two family residential development on a single lot or activities that will disturb less than one acre) must incorporate LID practices or demonstrate the consideration of the use of LID.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
				Require fire prevention and protection and adequate access for police, fire and emergency vehicles as a criteria for Site Plan approval.
Zoning Bylaws: Section 5.6: Site Plan Review	Regulation	In approving or disapproving a site plan, the Planning Board shall consider the following: 1. Preservation of Landscape. The landscape shall be preserved in its natural state, insofar as practicable by minimizing tree removal, and any grade changes shall be in keeping with the general appearance of neighboring developed areas. 2. Relation of Buildings to the Environment. Proposed development shall be related harmoniously to the terrain and to the use, scale, and proportions of existing and proposed buildings in the vicinity that have functional or visual relationship to the proposed buildings. Consideration shall be given to the extent to which building sites avoid farmland, steep slopes, hilltops, and land associated with vistas seen from public ways. 6. Surface Water Drainage. Special attention shall be given to proper site surface drainage so that removal of surface waters will not adversely affect neighboring properties. Surface water in all paved areas shall be collected at intervals so that it will not obstruct the flow of vehicular or pedestrian traffic, and will not create puddles in paved areas. 8. Water Resources. The effect that the proposed activity is	Flooding, Severe Winter Storms, Hurricanes	Effective. The Planning Board could consider a dedicated LID zoning bylaw applicable to all new development and redevelopment including special permits, site plan review applications, subdivision applications and applications for earth removal permits in all zoning districts. All new land alterations (with the exception of single or two family residential development on a single lot or activities that will disturb less than one acre) must incorporate LID practices or demonstrate the consideration of the use of LID.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		likely to have on the quality and quantity of ground and surface water. If the activity is likely to degrade the quality or quantity of ground or surface water, it shall be denied, or the proposal amended to ensure the continued high quality of the water supplies of Leyden.		
Zoning Bylaws: Section 5.9: Flood Plain District	Regulation	The purposes of the Floodplain Overlay District are to: 1. Ensure public safety through reducing the threats to life and personal injury; 2. Eliminate new hazards to emergency response officials; 3. Prevent the occurrence of public emergencies resulting from a reduction in water quality, contamination, and/or pollution due to flooding; 4. Avoid the loss of utility services which if damaged by flooding would disrupt or shut down the utility network and impact regions of the community beyond the site of flooding; 5. Reduce costs associated with the response and cleanup of flooding conditions; 6. Reduce damage to public and private property resulting from flooding waters. No new impoundments, dams, or other water obstructions may be constructed within the district.	Flooding	Effective for reducing the impact of new development within the 100-year floodplain. Effective for mitigating impacts to the floodplain of new dams. However, the 100-year floodplain data in Leyden is outdated and inaccurate, does not include smaller streams, and does not reflect the impact of climate change. Accurate floodplain mapping would allow the town to create an effective floodplain overlay district. The Town of Leyden will need to update the Flood Plain District

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
				bylaw using the 2020 MA Model Floodplain bylaw to ensure compliance with the NFIP program.
Zoning Bylaws: Section 5.10: Natural Resource Protection Zoning	Regulation	Natural Resource Protection Zoning (NRPZ) reduces development impacts on farmland, forests, wildlife habitat, large tracts of contiguous open space, environmentally sensitive areas, steep slopes, hilltops, and historically significant areas. A minimum of 80% of the total acreage of a project must be preserved with a Conservation Restriction or other method. Requires a conservation analysis to determine which land to preserve and where development should be located.	Multiple Hazards	Effective for mitigating the potential for localized flooding and erosion by preserving open space in the watershed and regulating stormwater runoff within the NRPZ. Effective for balancing new residential development with the protection of natural resources. Consider adopting Conservation Development bylaw for the entire town with equivalent standards.
Zoning Bylaws: Section 4.2: Uses Requiring a Special Permit	Regulation	Except for weed control in an agricultural operation which is exempted from this section, the rendering impervious by any means of more than 11,000 square feet or 25% which ever is less, of any single lot, may be allowed only by Special Permit granted by the Planning Board. In order to grant the Special Permit, the Planning Board must find that all surface runoff and erosion will be contained and managed on site.	Flooding	Effective for managing erosion and runoff due to large developments. Not effective for preventing uncontrolled stormwater runoff on smaller sites or steeply sloped construction. The Planning Board could consider grade thresholds and require

Table 4-1: Existing Mitigation Strategies				
Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
				controls on land parcels less than 2 acres in size. Climate change and indigenous soil types should be part of the considerations. Metrics regarding slope and grading on building permit applications could help the building inspector to flag projects that may require a special permit under these sections
Zoning Bylaws: Section 5.7: Driveways, Common Driveways, and Flexible Frontage	Regulation	The Planning Board may approve in it s special permit for a common driveway, a reduction or elimination in frontage requirements on a public or private way for one or more of the lots proposed to be served by the common driveway. In order to reduce the number of curb cuts onto Town roadways, preserve the natural, cultural, or scenic resources along these roadways, facilitate the movement of wildlife across roadways, protect recreational trailheads at the roadside, and improve the design and site planning of smaller residential neighborhoods.	Flooding, Multiple Hazards	Somewhat effective for ensuring the protection of open space and natural resources. Only applies to projects seeking special permit for a common driveway and does not apply to allowed projects.
Zoning Bylaws: Section 4.4: Restricted Uses	Regulation	Regulates the removal of soil, loam, sand & gravel for commercial projects through a permitting process. No commercial excavation for the removal of sod, loam, clay, sand, gravel, or quarried stone from any site may be undertaken without a Special Permit from the Planning Board.	Flooding	Not effective for controlling stormwater flooding and erosion hazards. Consider requiring up-to-date stormwater and erosion control

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		This restriction shall not apply to activities incidental to permitted uses, including but not limited, to providing for the installation or maintenance of building foundations, freshwater ponds, utility conduits, or on-site sewage disposal.		practices for excavation projects related to all development and permitted uses, including residential projects, to minimize the hazards that that soil removal can cause.
Subdivision Rules and Regulations: Section 234-10: Subdivision standards in the Floodplain		All subdivision proposals shall be reviewed to determine whether such proposals will be reasonably safe from flooding. If any part of a proposed subdivision is located within the Special Flood Hazard Area as defined by the Federal Insurance Administration (FIA) Flood Hazard Boundary Maps, it shall be reviewed to assure compliance with the Town of Leyden Zoning Bylaw and the following: A. The proposed subdivision design is consistent with the need to minimize flood damage. B. All public and private utilities and facilities, such as sewer, gas, electrical and water systems, shall be located and constructed to minimize or eliminate flood damage. C. Adequate drainage systems shall be provided to reduce exposure to flood hazards. D. Base flood elevation (the level of the one-hundred-year flood) data shall be provided for proposals greater than five (5) lots or five (5) acres, whichever is the lesser, for that portion within the Flood Hazard Area or the 100-Year Floodplain.	Flooding	Effective for minimizing flooding impacts on new development. Consider prohibiting new development and substantial alterations in the Special Flood Hazard Area and mapped river corridor.
Subdivision Rules	Regulation	The storm drainage system shall be designed to intercept all	Flooding	Effective for mitigating flooding

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
and Regulations: Section 234-15: Drainage		stormwater drainage from the particular subdivision or any additional runoff that may be created by that subdivision.		impacts to adjacent properties. Consider requiring or encouraging Low Impact Development techniques to allow stormwater to infiltrate close to where it falls and to mitigate flooding within a subdivision.
Subdivision Rules and Regulations: Section 234-8: Preliminary Plan Contents	Regulation	Requires plan to show proposed system of drainage including adjacent natural waterways, and the topography of the land, in a general manner.	Flooding	Effective for preliminary review of drainage system.
Subdivision Rules and Regulations: Section 234-9: Definitive Plan Contents	Regulation	Requires plan to show the location of all natural waterways and water bodies within and adjacent to the subdivision as well as floodplains.	Flooding	Effective for determining the most appropriate location for new development on a site.
	Regulation	Requires utilities to be placed so as to minimize flood damage.	Flooding	Effective for mitigating flood impacts on utilities.
	Regulation	Environmental impact report requires an analysis of stormwater runoff, soil erosion and other potential land capability effects of the proposed subdivision, and a description of the measures planned to protect the natural land features against potential deterioration resulting from the proposed subdivision. (b) Identification of surface and subsurface water features	Flooding	Effective for mitigating impacts from new development on the environment.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		within the proposed subdivision, as well as those water features potentially affected by it, including underground aquifers, brooks, streams, rivers, lakes and wetlands, and a description of the measures planned to protect those surface and subsurface features against potential deterioration resulting from the proposed subdivision. (c) A description of special physical conditions existing within the proposed subdivision, (e.g., floodplains, unique landscape features, etc.) and a description of the measures to accommodate these special conditions.		
	Regulation	Conservation analysis: Must show lakes, ponds, streams, rivers, wetlands, floodplain; slopes exceeding 20%.	Flooding	Effective for determining the most appropriate location for new development on a site.
Subdivision Rules and Regulations: Section 234-28: Utilities	Regulation	All electrical, telephone, fire alarm and other wires and cables shall be installed underground unless, in the opinion of the Board and the appropriate utility company, such installation is impractical or not in the best interest of the town. If located within a flood-prone area, as determined by the Board, transformers, switching equipment or other vital components shall be flood-proofed and approved by the Board or a Board-appointed engineer at the subdivider's expense.	Multiple Hazards	Effective for mitigating flooding impacts on utilities. Consider prohibiting new development in flood-prone areas.
Protection of rivers, streams and wetlands	Regulation	The Town follows the standards set by the Wetlands Protection Act.	Flooding, Manmade Hazards	Effective in minimizing impacts to sensitive areas. A local wetlands bylaw could increase these

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
				protections.
Participation in the National Flood Insurance Program	Program	Leyden is enrolled in the National Flood Insurance Program. As of 2018, there are 0 homeowners in Leyden with flood insurance policies.	Flooding	Not effective with no policies in force. The Town could encourage participation among houses in the flood plain when digitized flood maps are published in the next decade.
Leyden 2010 Open Space & Recreation Plan	Plan	Raises awareness of water resources in Town and potential negative impacts of uncontrolled development (loss of open space, farmland, stormwater runoff and other nonpoint source pollution).	Flooding	Somewhat effective. Consider updating the expired OSRP.
Zoning Bylaws: Section 4.3: Prohibited Uses Mobile Homes and Mobile Home Parks	Regulation	Mobile Homes and Mobile Home Parks are listed under prohibited uses (A.) in the Town of Leyden Zoning Bylaw 4.3.	Severe Wind	Effective.
Subdivision Rules and Regulations: Section 234-17: Water	Regulation	A local water supply should be provided within the subdivision for fire fighting purposes.	Wildfire	Effective.
Town Fire Roads	Practice	Adequate and well-maintained fire roads provide access to town forests for firefighting purposes.	Wildfire	Effective. However, there are some unmaintained logging and

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
				recreational roads/trails in forest lands, which will require the Town to work with land owners. This recommendation is included in the Action Plan.
Permits required for new dam construction	Program	State law requires a permit for the construction of any dam.	Dam Failure	Effective. Ensures dams are adequately designed.
Dam Inspection	Program	DCR has an inspection schedule that is based on the hazard rating of the dam (low, significant, high hazard). FERC requires Emergency Action Plans for all high hazard dams it oversees.	Dam Failure	Not effective. The DCR does not have adequate staff and resources to inspect dams according to the required schedule. Owners of High Hazard Potential and certain Significant Hazard Potential dams are also responsible for preparing Emergency Action Plans.
Evacuation Plans	Plan	Comprehensive evacuation plans ensure the safety of the citizens in the event of dam failure. A plan is in place for the Lake Wyola and N. Leverett corridor. Evacuation routes have been identified for the Town.	Dam Failure	Effective.
Zoning Bylaws: Section 4.3: Prohibited and Restricted Uses	Regulation	Prohibited Uses: B. Disposal of liquid or leachable wastes, except: 1. The installation or enlargement of a subsurface waste disposal system for a residential dwelling. 2. Normal agricultural operations. 3. Commercial or industrial uses which use septic systems only for wastes from personal hygiene and food	Manmade Hazards	Effective for all new construction, reconstruction, or expansion of existing buildings and new or expanded uses.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		preparation for residents, patrons, and employees. C. The use of privately owned wastewater treatment plants. D. The installation of a new underground storage tanks for oil, or other petroleum products, excluding liquefied petroleum gas. The underground storage of gasoline may be allowed by Special Permit, as provided by Section 4.4, Restricted Uses. E. The outdoor storage of salt, de-icing materials, or pesticides exposed to the environment. F. Commercial or industrial uses, not including restaurants, which use septic systems for wastes other than from personal hygiene and food preparation for residents, patrons, and employees. Wastes from personal hygiene shall not include wastes from beauty salons, hairdressers, or similar commercial uses. H. Construction of a building, septic system, or other accessory use in any wetland resource, as defined by the State Wetlands Protection Act. If a lot already in existence at the passage of this by-law has no place to build because of the presence of wetland resources, a Special Permit may be granted by the Planning Board as long as the building, septic system, or other accessory use is allowed by the Wetlands Protection Act and under the conditions provided by the conservation commission or Department of Environmental Protection.		

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Leyden Municipal Vulnerability Preparedness Plan	Town Plan	The State awarded Leyden with a grant to complete a MVP plan in late 2020. Leyden will complete the planning process in 2022 in conjunction with this plan to develop recommendations and action items related to climate resiliency.	Multiple Hazards	Effective.
Emergency Shelters	Program	Warming and feeding facilities for Leyden have been identified at Leyden Town Offices, which both have back up generators and kitchen facilities. The Town does not have a designated emergency shelter.	All hazards	Minimally effective. The forthcoming emergency management plan should review the available facilities to determine each facility's potential occupancy, accessibility via evacuation routes, susceptibility to hazards (such as floods and high winds), access to back-up utilities, and available supplies prior to designating an official emergency shelter. The plan could also outline emergency activation and distribution plans for feeding, heating, cooling, and sheltering.
Regionalization of Services	Study	In 2022 Leyden and Bernardston received an Efficiency and Regionalization grant from the Commonwealth of Massachusetts Community Compact Cabinet to have the UMass Boston Collins Center for Public Management conduct a public safety services feasibility study. In addition to the study, the Towns of Leyden and Bernardston are developing a draft agreement for shared policing services.	Multiple Hazards	Effective. Implementing recommendations from the study will increase the Town's capacity to respond to events.

Table 4-1: Existing Mitigation Strategies				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Mass Communication System (Reverse 911)	Program	Allows for the Town to send emergency alerts to residents. Program considered effective if contact list is maintained, if the system is used regularly, and multiple town officials have access and training for use of this system.	All Hazards	Somewhat effective. Poor cell service results in not all residents receiving emergency alerts in a timely manner. Potential new cell tower may improve this.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the hazard mitigation planning process undertaken by the Leyden Hazard Mitigation Planning Core Team, existing gaps in protection and possible deficiencies were identified and discussed. The Core Team then developed general goal statements and mitigation action items that, when implemented, will help to reduce risks and future damages from multiple hazards. The goal statements, action items, Town department(s) responsible for implementation, and the proposed timeframe for implementation for each category of hazard are described below. It is important to note that the Town of Leyden has limited capabilities and resources (especially staffing) to be able to expand and improve upon existing policies and programs when a need for improvement is identified.

Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous Town plans and reports, the Leyden Hazard Mitigation Planning Core Team has developed the following goals to serve as a framework for mitigating the hazards identified in this plan:

- To provide adequate shelter, water, food and basic first aid to displaced residents in the event of a natural disaster.
- To provide adequate notification and information regarding evacuation procedures, etc., to residents in the event of a natural disaster.
- To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to natural hazards.

Prioritization of Hazards

The Core Team examined the results of the Risk Assessment (see Section 3) and used the results to prioritize the identified hazards. The Core Team evaluated the natural hazards that can impact the town based on probability of occurrence, severity of impacts, and area of occurrence. The Core Team also reviewed the town's Existing Mitigation Strategies (Table 4-1) and the work completed since the 2016 plan (Table 4-4) to determine the Priority Level for each hazard.

The Core Team developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Leyden's structures, systems, populations and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify the town's greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4). For the most part, those hazards receiving the highest Overall Hazard Vulnerability Rating were also assigned a Priority Level of High, as shown in Table 4-2. There are exceptions, most notably Flooding.

Table 4-2: Hazard Priority Level Rating		
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**
Flooding	2 – Medium	High
Severe Winter Storms	1 – High	High
Hurricanes / Tropical Storms	2 – Medium	Medium
Severe Thunderstorms / Wind / Microbursts	1 – High	High
Tornadoes	3 – Low	Low
Wildfire	2 – Medium	Medium
Earthquakes	3 – Low	Low
Dam Failure (other dams and beaver dams)	2 – Medium	Medium
Drought	1 – High	High
Landslides	3 – Low	Low
Extreme Temperatures	1 – High	High
Invasive Species	1 – High	Medium
Vector-Borne Diseases	1 – High	Medium
Manmade Hazards	3 – Low	Low

Prioritization of Action Items

The Hazard Mitigation Core Team identified several strategies that are currently being pursued, and other strategies that will require additional resources to implement. Strategies are based on the work of the Core Team, as well as the hazard identification and risk assessment (Section 3) and the information in Tables 4-1, 4-3 and 4-4 of this plan.

Prioritization Methodology

The Leyden Hazard Mitigation Planning Core Team reviewed and prioritized a list of mitigation strategies using the following criteria:

- **Application to high priority or multiple hazards** – Strategies are given a higher priority if they assist in the mitigation of hazards identified as high priorities (Table 4-2) or apply to several natural hazards.

- **Time required for completion** – Projects that are faster to implement, either due to the nature of the permitting process or other regulatory procedures, or because of the time it takes to secure funding, are given higher priority.
- **Estimated benefit** – Strategies which would provide the highest degree of reduction in loss of property and life are given a higher priority. This estimate is based on the Hazard Identification and Risk Assessment Chapter, particularly with regard to how much of each hazard's impact would be mitigated.
- **Cost effectiveness** – In order to maximize the effect of mitigation efforts using limited funds, priority is given to low-cost strategies. For example, regular tree maintenance is a relatively low-cost operational strategy that can significantly reduce the length of time of power outages during a winter storm. Strategies that have identified potential funding streams, such as the Hazard Mitigation Grant Program, are also given higher priority.

The following categories are used to define the priority of each mitigation strategy:

- **Low** – Strategies that would not have a significant benefit to property or people, address only one or two hazards, or would require funding and time resources that are impractical.
- **Medium** – Strategies that would have some benefit to people and property and are somewhat cost effective at reducing damage to property and people.
- **High** – Strategies that provide mitigation of high priority hazards or multiple hazards and have a large benefit that warrants their cost and time to complete.
- **Very High** – extremely beneficial projects that will greatly contribute to mitigation of high priority and multiple hazards and the protection of people and property. These projects are also given a numeric ranking within the category.

Cost Estimates

Each of the following implementation strategies is provided with a cost estimate. Projects that already have secured funding are noted as such. Where precise financial estimates are not currently available, categories were used with the following assigned dollar ranges:

- **Low** – cost less than $25,000
- **Medium** – cost between $25,000 – $100,000
- **High** – cost over $100,000

Cost estimates take into account the following resources:

- Town staff time for grant application and administration (at a rate of $25 per hour)
- Consultant design and construction cost (based on estimates for projects obtained from town and general knowledge of previous work in town)

- Town staff time for construction, maintenance, and operation activities (at a rate of $25 per hour)

Project Timeline

The timeframe for implementation of the action items are listed in the Action Plan as Year 0-1, which is the first year following plan adoption, and subsequent years after plan adoption through the 5-year life of the plan (Year 2, Year 3, Year 4 and Year 5). The Core Team recognized that many mitigation action items have a timeframe that is ongoing due to either funding constraints that delay complete implementation and/or the action item should be implemented each of the five years of the plan, if possible. Therefore, a category of Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate was added.

Even when the political will exists to implement the Action Items, the fact remains that Leyden is a small town that relies heavily on a small number of paid staff, many of whom have multiple responsibilities, and a dedicated group of volunteers who serve on Town boards. However, some Action Items, when implemented by Town staff and volunteers, result in a large benefit to the community for a relatively small cost.

For larger construction projects, the Town has limited funds to hire consultants and engineers to assist them with implementation. For these projects, the Town may seek assistance through the Franklin Regional Council of Governments (FRCOG). However, the availability of FRCOG staff can be constrained by the availability of grant funding.

The Action Plan is split between the two tables: Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan and Table 4-4: 2022 Leyden Emergency Preparedness and Response Action Plan. Table 4-3 details exclusively hazard mitigation action items and Table 4-4 details action items that address emergency preparedness and response, which is beyond the scope of a traditional Hazard Mitigation Plan but are relevant to the Town's Municipal Vulnerability Preparedness planning process.

Potential funding sources for mitigation action items are listed when known. Other potential funding sources are listed in Table 5-1 of this plan. When Town funds are listed as a source to fund hazard mitigation projects or activities, either in part (match) or in full, these funds would be obtained from the Town's "general fund".

This page is blank to accommodate double-sided printing

Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
Critical Facilities & Infrastructure	Use the 2021 Town of Leyden Culvert Assessment and 2018 Leyden High-Risk Stream Crossing Report to prioritize culvert upgrades and/or replacements. Seek funding for construction of properly designed/sized culverts, including "right-sizing" of drainage culverts to accommodate more frequent and intense storms due to climate change.	Flooding	Highway Department, Municipal Assistant	H	MVP Action Grant, DER Culvert Replacement Municipal Assistance Program	Year 1	S, I, E	2022 High	New action item identified during the MVP workshop. Leyden has successfully received funding to complete small bridge upgrades but more work is needed to make the Town's roadways more climate resilient. Culverts and bridges on Brattleboro Road, Keets Brook Road, and Thorne Brook/River Road are high priorities for the Town.
Critical Facilities & Infrastructure	Seek funding for a consultant to prepare designs for a culvert enhancement and wetland restoration project at the site known as "The Bog" on West Leyden Road.	Flooding	Highway Department, Municipal Assistant, Conservation Commission	M	MVP Action Grant, DER Culvert Replacement Municipal Assistance Program, FEMA BRIC	Year 1	S, I, E	2022 High	New action item identified during the MVP workshop. This area frequently overflows during storm events and could have cascading impacts in terms of evacuation and road closures depending on the severity of the event. Remediating this area is a high priority for Town Officials.
Critical Facilities & Infrastructure	Obtain funding for a Rural Roads/Dirt Road assessment to determine low maintenance, low cost climate resilient drainage solutions on the Town's gravel roads. Identify locations where nature-based solutions would be most effective.	Flooding	Highway Department	M	Town[83], MVP Action Grant, FEMA BRIC	Year 1	S, I, E	2022 High	New action item identified during the MVP workshop. The Highway Department is interested in having the assessment done to alleviate the need for costly repairs each year.
Local Plans and Regulations	Secure funding to prepare an update to Leyden's 2010 Open Space & Recreation Plan, which would focus on climate resiliency.	Multiple Hazards	Open Space Committee	L	Town, MVP, FRCOG technical assistance under the DLTA program, Community Compact	Year 2	S, E	2022 High	New action item identified during the MVP workshop. Leyden's OSRP expired in 2017.

[83] Leyden's General Fund (property tax and other revenue) can be used to pay for projects identified in this Plan, but will require a Town Meeting vote to appropriate and spend the money. The volunteer boards have very small budgets for legal notices and stipends for members. Small towns do not have detailed, line item budgets that can be tagged for these projects. If the town plans to fund a large project and money needs to be borrowed/bonded or a grant has been received, a specific line item in the budget would be identified.

Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
Local Plans and Regulations Public Education & Outreach	Assess additional mosquito/pest control options, including placing more pond dunks (larvicide) on public and private properties, determination of future risks due to increase in type and quantity of pests/disease vectors due to climate change, and development of an education and outreach program. Coordinate with the Board of Health to increase educational opportunities/awareness relating to pests and disease control and the Town's participation in the Pioneer Valley Mosquito Control District.	Vector-Borne Diseases	Board of Health, Conservation Comission	L	Town, MVP Action Grant	Years 1-3	S, E	2022 High	New action item identified during the MVP workshop.
Critical Facilities & Infrastructure	Develop and implement a record management plan to digitize and/ or duplicate important records housed in the Town Offices and other town facilities to mitigate the potential loss of information from a hazard event.	Multiple Hazards	Municipal Assistant	M	Town, MVP Action Grant	Year 1	S, I	2016 High / 2022 High	Action item description was carried over from the 2016 plan updated for the 2022 plan. No progress was made since the last Plan due to lack of staff capacity and funding.
Local Plans and Regulations	To improve forest management and mitigate the risk of wildfires in Leyden, work with other Towns in the Mohawk Trail Woodlands Partnership region to implement recommendations from the recently completed Forest Resiliency Plan. Additionally, provide landowners with resources about programs such as the Keystone Foundation, Chapter 61 programs, Women on the Land, etc., to encourage good land stewardship.	Wildfires, Invasive Species	Planning Board, Select Board	M	MVP Action Grant, Forest Stewardship Program	Years 1-2	S, I, E	2016 Low / 2022 High	Action item description was carried over from the 2016 plan updated for the 2022 plan. No progress was made since the last Plan due to lack of staff capacity and funding.
Local Plans and Regulations	Update the Town's Floodplain Bylaw using the 2020 MA Model Floodplain Bylaw to ensure compliance with the NFIP program.	Flooding	Planning Board	L	Town, FRCOG technical assistance under the DLTA program	Year 2	S, E	2022 High	New action item.
Critical Facilities & Infrastructure/Local Plans and Regulations	Examine strategies for improving the Town's existing hazard tree program, such as improving and encouraging coordination between Eversource and the Leyden Tree Warden and increasing funding for the Treen Warden's work. Look for ways to improve the process of identifying tree hazards.	Multiple Hazards	Leyden Tree Warden, Eversource, Finance Committee	L	Town	Year 1	I	2022 Medium	Action item description was carried over from the 2016 plan updated for the 2022 plan. At the MVP Workshop, the Tree Warden expressed additional funding is needed to implement the Town's current maintenance

Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
									plan. The Tree Warden noted Eversource has been a huge help with clearing trees but work is still needed, especially with identifying and clearing diseased trees.
Local Plans & Regulations	Investigate options for limiting the weight of vehicles that pass through Leyden, such as implementing seasonal weight limits for logging trucks traveling on dirt and gravel roads.	Multiple Hazards	Highway Department, Planning Board, Select Board	L	Town, Volunteers	Year 2	S, I	2022 Medium	New action item identified during the MVP workshop. As mud seasons become progressively worse due to climate change, residents have found that logging trucks passing through Town in the spring are damaging local roadways. The Highway Department is interested in looking into how towns in Vermont with similar issues handle this issue.
Local Plans & Regulations	Continue to review and update land use regulations and the development regulatory review process to include climate resiliency provisions such as Best Management Practices for River Corridor areas (FRCOG's River Corridor Toolkit). Measures should address impervious cover, manage stormwater runoff, new development within the 100-year floodplain and River Corridor, and slope and soil stability.	Multiple Hazards	Planning Board	L	Town, FRCOG technical assistance under the DLTA program, MVP Action Grant, EEA Planning Assisatnce Grant	Year 2	I, E	2016 Medium / 2022 Medium	Action item description was carried over from the 2016 plan updated for the 2022 plan. No progress was made since the last Plan due to lack of staff capacity and funding.
Critical Facilities and Infrastructure Local Plans and Regulations	Seek funding and hire a consultant to develop a regional comprehensive invasive species management from inventory stage through management planning and implementation to address existing invasive populations that threaten features such as open space or forests, both of which contribute to resiliency, as well as anticipate new invasives that are likely to move into the area as climates shift. Continue to manage the invasive plants in Town and explore alternative spraying options for Japanese knotweed. Assess biological control options for pests, including gypsy moths, and alternatives to spraying for invasives.	Invasive Species	Highway Department, Conservation Commission	M	Town, MVP Action Grant	Years 3-5	I, E	2022 Medium	New action item identified during the MVP workshop. Leyden would need to coordinate with other Towns, and likely State agencies on this issue, as it extends beyond the borders of Leyden and Leyden does not have the capacity to address the issue on their own. The Leyden Highway Department reported bittersweet growing along Mid County Road and will likely

Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
									impact local infrastructure, as it tends to choke and topple trees.
Public Education and Outreach	To mitigate land erosion on farm fields and improve carbon sequestration, work with CISA/UMass Agricultural Extension to identify cover crops that could be used with changing growing seasons to limit dirt blowing off farm fields in the winter. Additionally, work with the NRCS to identify techniques that could help to minimize the amount of dust/soil blowing off of fields such as inter-seeding between rows after crops are established, flail mowing instead of disking, etc. Techniques will need to be tailored to the farms' needs.	Severe Wind	Agricultural Commission, CISA, NRCS	L-M	NRCS EQUIP Program	Year 2	S, E	2022 Medium	New action item identified during the MVP workshop.
Local Plans and Regulations	When digitized FEMA FIRMs become available, expand and update the Vulnerability Assessment for properties located within the 100-year floodplain, including information on property and crop damages, if available.	Flooding	Planning Board, Board of Assessors	L	Town, Volunteers	Years 4-5	S, I	2016 Low / 2022 Low	Action item description was carried over from the 2016 plan updated for the 2022 plan. This action was not completed since the last Plan because updated maps were not made available.
Local Plans and Regulations	Seek funding to hire a consultant to assess and identify projects that would help to manage erosion in the upper tributaries to the Green River.	Flooding, Erosion	Conservation Commission, Highway Department	M-H	Town, FRCOG, MA DEP 319 Program, MVP Action Grant, 604b	Year 3	E	2022 Low	New action item identified during the MVP workshop.
Critical Facilities & Infrastructure	Re-assess and re-map all water sources for firefighting. These water sources were mapped many years ago, and the Town would like to have updated information about the location of sources, as well as formalized agreements between the Town and private landowners as needed. Seek funding to acquire easements and install pipes to identified water sources.	Wildfires	Fire Department, Public Safety Advisory Committee	L	Town, MVP Action Grant	Year 3	S, I	2022 Low	Action item description was carried over from the 2016 plan updated for the 2022 plan. This study likely will not be accomplished until the Fire Department has been regionalized, as the volunteer department does not have the capacity to complete this project on their own.

Table 4-4: Leyden Preparedness and Response Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
Local Plans and Regulations	Evaluate shared emergency services for the Towns of Leyden and Bernardston.	Multiple Hazards	Select Board	H	Efficiency & Regionalization Grant Program through the MA Community Compact/Division of Local Services	Year 1	S	2022 High	Ongoing. Leyden received an $187,000 Efficiency & Regionalization Grant to study shared police services between Leyden and Bernardston. The UMass Collins Center for Public Management is working on the study.
Local Plans and Regulations	Finalize the updated Emergency Management Plan and distribute the plan to all Town Boards and Committees for review, and then distribute to residents.	Multiple Hazards	Public Safety Advisory Committee	L	Town, Volunteers	Year 1	S, I	2022 High	New action item identified during the MVP workshop. The PSAC is actively working on updating the Emergency Management Plan. The updated plan will include information about: • Local and regional sheltering procedures, including heating and cooling shelters • Information about food and water distribution during an extended event • Reverse 911 protocols
Local Plans and Regulations	In line with the update of the Emergency Management Plan, identify vulnerable populations and foster a communications network in advance of a hazard event to facilitate communication efforts and outreach to those most in need of information and assistance. Focus should be on populations that may be more vulnerable to climate-induced risks, such as extreme temperatures, may lack appropriate shelter during increasingly intense storms, or that may be unprepared if stranded or cut off from supplies due to flooding or storm events. Develop a form to put in the annual town mailing from the Town Clerk that asks residents about what type of assistance they would need during a severe storm event.	Multiple Hazards	Board of Health, Council on Againg, Public Safety Advisory Committee, Town Clerk	L	Town, MVP Action Grant	Year 1 & Updated Annually	S	2022 High	New action item identified during the MVP workshop. The Town's list of vulnerable residents is outdated. Once the list is updated, the Board of Health and Council on Aging should meet to determine how they could best align their programs to meet the needs of vulnerable residents.

Table 4-4: Leyden Preparedness and Response Action Plan									
Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2016 Priority / 2022 Priority	Current Status
Local Plans and Regulations	Develop a communication and evacuation plan for residents living on dead end roads who may become isolated during a severe event. Formalize neighborhood groups using the Village Neighbors Model.	Multiple Hazards	Fire Department, Public Safety Advisory Committee, Board of Health, Council on Againg	L	Town, Volunteers	Year 1	S	2022 High	New action item identified during the MVP workshop.
Critical Facilities & Infrastructure	Continue to pursue Green Communites designation. Once designated, use funds to upgrade municipal buildings to make them more energy efficient.	Multiple Hazards	Municipal Assistant, Planning Board, FRCOG	L	DOER Green Communities Designation Grant Funds & Competitive Grants	Year 2	S, I, E	2022 High	Ongoing. FRCOG is working with the Town on this project, with a projected completion date of May 2023. Buildings that could be used as heating or cooling shelters should be prioritized. Installing Air Source Heat Pumps (ASHPs) in the Town Offices should be a priority.
Public Education and Outreach	Explore options for enhanced and effective emergency communication with residents, such as restarting the EMD column in the Leyden Life Newsletter. Utilize the Town's recently installed broadband internet, and increase transparency and awareness in Town. Pursue higher enrollment in the Reverse 911 Program.	Multiple Hazards	Emergency Management Director	L	Town, Volunteers	Year 1	S	2022 Medium	Action item description was carried over from the 2016 plan updated for the 2022 plan. No progress was made since the last Plan due to lack of staff capacity and funding.
Local Plans & Regulations	Conduct more education and outreach on available weatherization, insulation, energy efficiency, and renewable energy technologies available through Mass Save and other state programs.	Multiple Hazards	Municipal Assistant, Council on Aging, Board of Health	L	Town, Mass Save Community First Partnership	Annual	S, E	2022 Low	New action item. The Town is interested in including more information about these programs in the Leyden Life newsletter.
Local Plans & Regulations	Once the Town has an active Emergency Management Director, join the Franklin County Regional Emergency Planning Committee (REPC) to coordinate evacuation drills. Develop a communication plan for letting residents know of road closures; evacuation routes are likely to change depending on the size and scale of the hazard event.	Multiple Hazards	Emergency Management Director	L	Town	Year 3	S	2022 Low	New action item identified during the MVP workshop.
Local Plans & Regulations	Continue to participate in the Franklin County Regional Emergency Planning Committee (REPC), which is currently working to complete and operationalize the Debris Management Plan. Coordinate with state and	Multiple Hazards	Emergency Management Director	L	Town	Year 3	I	2022 Low	Action item description was carried over from the 2016 plan updated for the 2022 plan. No progress was made since the last Plan due to lack of staff

Table 4-4: Leyden Preparedness and Response Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2016 Priority / 2022 Priority**	**Current Status**
	regional agencies to identify a location(s) in the Town for the temporary storage of contaminated and/or hazardous flood debris.								capacity and funding.

Table 4-5: Completed or Consolidated Leyden 2016 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in Past Plan**	**Current Status**
Critical Facilities & Infrastructure	To reduce the risk to property and infrastructure during high wind events, continue to inspect Town trees annually and conduct pruning or removal of hazardous trees/limbs on a regular basis in conjunction with Eversource to reduce risks/hazards.	Multiple Hazards	Tree Warden, Eversource	L	Town	S, I	High	This action item was consolidated with related action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP.
Critical Facilities & Infrastructure	To reduce risk to infrastructure from high wind events, integrate the use of brush mowing equipment into a regular system of tree maintenance and pruning that complements work the utility company is already doing under their 5-Year Plan.	Multiple Hazards	Tree Warden, Eversource	L	Town	S, I	High	This action item was consolidated with related action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP.
Critical Facilities & Infrastructure	Identify priority areas for tree maintenance near utility lines in town and submit the list to Eversource for inclusion in its five-year action plan, which includes regular tree maintenance to reduce the number of limbs near overhead power lines, to reduce risk to infrastructure from severe winter storms. Meet bi-annually with the utility to ensure priority areas are included in the plan.	Multiple Hazards	Tree Warden, Eversource	L	Town	S, I	High	This action item was consolidated with related action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP.
Local Plans & Regulations	To mitigate impacts of flooding on the built environment, revise the Zoning Bylaw to prohibit any new development within the Special Flood Hazard Areas as shown on the Flood Hazard Boundary Map.	Floods	Planning Board	L	Town	I	Low	This action item was consolidated with related action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP.
Local Plans & Regulations	To minimize flooding impacts in new developments or redevelopment, consider revising the Leyden Zoning Bylaw and Subdivision Regulations to encourage Low Impact Development (LID) stormwater management techniques, which allow for stormwater to infiltrate the ground close to where it falls. LID can be used in addition to, or as an alternative to, traditional “pipe and pond” stormwater systems.	Floods	Planning Board	L	Town	I, E	Medium	This action item was consolidated with related action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP.
Public Education & Outreach	To improve forest management and mitigate the risk of wildfires in Leyden, organize a forum with UMass Extension, local land trusts, and/or DCR staff foresters for Town officials and private landowners to discuss forest management practices.	Wildfires	Conservation Commission, Fire Department, Tree Warden	L	Town	S, E	Low	This action item was updated for the 2022 plan.

This page is blank to accommodate double sided printing

5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Leyden Hazard Mitigation Core Team as they underwent the planning process. Town officials such as the Chair of the Public Safety Advisory Committee and the Municipal Assistant were invaluable resources to the FRCOG and provided background and policy information and municipal documents, which were crucial to facilitating completion of the plan.

When the preliminary draft of the Leyden Hazard Mitigation Plan was completed, copies were disseminated to the Core Team for comment and approval. The Core Team was comprised of representatives of Town boards and departments who bear the responsibility for implementing the action items and recommendations of the completed plan (see the list of Core Team members on the front cover).

Copies of the Final Review Draft of the Hazard Mitigation Plan for the Town of Leyden were distributed to Town boards and officials and to surrounding Towns for review. A copy of the plan was also posted on the Town website for public review. Once reviewed and approved by MEMA, the plan was sent to the Federal Emergency Management Agency (FEMA) for their approval. FEMA approved the plan on October 18, 2022 and on October 11, 2022 the Leyden Board of Selectmen voted to adopt the plan.

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Leyden Hazard Mitigation Plan will begin following its approval by MEMA and FEMA and formal adoption by the Leyden Board of Selectmen. Specific Town departments and boards will be responsible for ensuring the development of policies, bylaw revisions, and programs as described in the Action Plan (Tables 4-3 and 4-4). The Leyden Hazard Mitigation Planning Core Team will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan

The measure of success of the Leyden Hazard Mitigation Plan will be the number of identified mitigation strategies implemented. In order for the Town to become more disaster resilient and better equipped to respond to natural disasters, there must be a coordinated effort between elected officials, appointed bodies, Town employees, regional and state agencies involved in disaster mitigation, and the general public.

Implementation Schedule

<u>Annual Meetings</u>

The Leyden Hazard Mitigation Planning Core Team will meet on an annual basis or as needed (i.e., following a natural or other disaster) to monitor the progress of implementation, evaluate the success or failure of implemented recommendations, and brainstorm for strategies to remove obstacles to implementation. Following these discussions, it is anticipated that the Core Team may decide to reassign the roles and responsibilities for implementing mitigation strategies to different Town departments and/or revise the goals and objectives contained in the plan. At a minimum, the Core Team will review and update the plan every five years. The meetings of the Core Team will be organized and facilitated by the Leyden Municipal Assistant and the Emergency Management Director.

Bi-Annual Progress Report

The Emergency Management Director will prepare and distribute a biannual progress report in years two and four of the plan. Members of the Local Planning Core Team will be polled on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, failure to achieve progress, and any new hazards or problem areas that have been identified. Success or failure to implement recommendations will be evaluated differently depending on the nature of the individual action items being addressed, but will include, at a minimum, an analysis of the following: 1) whether or not the item has been addressed within the specified time frame; 2) whether actions have been taken by the designated responsible parties; 3) what funding sources were utilized; 4) whether or not the desired outcome has been achieved; and 4) identified barriers to implementation. This information will be used to prepare the bi-annual progress report which may be attached as an addendum, as needed, to the local hazard mitigation plan. The progress report will be distributed to all of the local implementation group members and other interested local stakeholders. The Emergency Management Director and the Core Team will have primary responsibility for tracking progress and updating the plan.

Five-Year Update Preparation

During the fourth year after initial plan adoption, the Emergency Management Director will convene the Core Team to begin preparations for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the annual meetings and the biannual progress reports to identify the needs and priorities for the plan update.

Updated Local Hazard Mitigation Plan – Preparation and Adoption

FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the town's approved plan status and its eligibility for FEMA mitigation grants. Because of the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Hazard Mitigation Planning Core Team should begin the process by the end of Year 3. This will help the town avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Core Team may decide to undertake the update themselves, request assistance from the Franklin Regional Council of Governments, or hire another consultant. However the Core Team decides to proceed, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The updated Leyden Hazard Mitigation Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Leyden's government relies on a few public servants filling many roles, upon citizen volunteers and upon limited budgets. As such, implementation of the recommendations of this plan could be a challenge to the Core Team. As the Core Team meets regularly to assess progress, it should strive to identify shortfalls in staffing and funding and other issues which may hinder Plan implementation. The Core Team can seek technical assistance from the Franklin Regional Council of Governments to help alleviate some of the staffing shortfalls. The Core Team can also seek assistance and funding from the sources listed in Table 5-1.

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
National Flood Insurance Program	Pre-disaster insurance	Rolling	DCR	Property Owner, FEMA
Community Assistance Program	State funds to provide assistance to communities in complying with NFIP requirements	Annually	DCR	FEMA/NFIP
Community Rating System (Part of the NFIP)	Flood insurance discounts	Rolling	DCR	Property Owner
Flood Mitigation Assistance (FMA) Program	Cost share grants for pre-disaster planning & projects	Annual	MEMA	75% FEMA/ 25% non-federal
Hazard Mitigation Grant Program (HMGP)	Post-disaster cost-share Grants	Post Disaster	MEMA	75% FEMA/ 25% non-federal
Building Resilient Infrastructure and Communities (BRIC)	National, competitive grant program for projects & planning	Annual	MEMA	75% FEMA/ 25% non-federal
Small Business Administration Disaster Loans	Post- disaster loans to qualified applicants	Ongoing	MEMA	Small Business Administration
Public Assistance Program	Post-disaster aid to state and local governments	Post Disaster	MEMA	FEMA/ plus a non-federal share
Dam & Seawall Repair & Removal Program	Grant and loan funds for design, permitting, and construction of repair or removal of dams	Annual	EEA	Dam and Seawall Repair or Removal Fund
Emergency Management Performance Grant (EMPG)	Funding to assist local emergency management departments in building and maintaining an all-hazards emergency preparedness system, including planning; organizational support; equipment; training; and exercises	When funds are available	MEMA	

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Volunteer Fire Assistance (VFA) Program	Grants and materials to towns with less than 10,000 population for technical, financial and other assistance for forest fire related purposes, including training, Class A foam, personal protective gear, forestry tools, and other fire suppression equipment	Annual	DCR	USDA Forest Service
Federal 604b Water Quality Management Planning Grant	Funding for assessment and planning that identifies water quality problems and provides preliminary designs for Best Management Practices to address the problems	Annual	MA DEP	EPA Clean Water Act
Section 319 Nonpoint Source Competitive Grant Program	Provides grants for wide variety of activities related to non-point source pollution runoff mitigation	Annual	MassDEP	EPA
Economic Development Administration Grants and Investment	Provides grants for community construction projects, which can include mitigation activities	Rolling	FRCOG	U.S. Department of Commerce, EDA
Emergency Watershed Protection	A disaster recovery program made available in emergency situations when neither the state nor the local community is able to repair a damaged watershed	Post-Disaster	NRCS MA	USDA NRCS
Agricultural Management Assistance	Funding for producers to develop or improve sources of irrigation water supply, construct new or reorganize irrigation delivery systems on existing cropland to mitigate the risk of drought	Rolling	NRCS MA	USDA NRCS
Conservation Stewardship Program	Agricultural producers and forest landowners earn payments for actively managing, maintaining, and expanding conservation activities – like cover crops, rotational grazing, ecologically-based pest management, buffer strips, and pollinator and beneficial insect habitat – while maintaining active agricultural production	Rolling	NRCS MA	USDA NRCS

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Environmental Quality Incentives Program (EQIP)	Provides technical and financial assistance to forestry & agricultural producers to plan and install conservation practices that address natural resource concerns including water quality degradation, water conservation, reducing greenhouse gases, improving wildlife habitat, controlling invasive plant species, and on-farm energy conservation and efficiency.	Rolling	NRCS MA	USDA NRCS
Agricultural Lands Conservation Program (ACEP)	Provides financial and technical assistance to help conserve agricultural lands and wetlands.	Rolling	NRCS MA	USDA NRCS
Forest Stewardship Program	Supports private landowners and municipalities to manage woodlands for timber, soil and water quality, wildlife and fish habitat, and recreation	Rolling	DCR / MA Woodlands Institute	USDA Forest Service
Community Forest Stewardship Implementation Grants for Municipalities	Municipalities that manage a town forest or have water supply land currently enrolled in the Forest Stewardship Program apply for 75-25 matching reimbursement grants to implement their forest stewardship plan	Rolling as funding permits	DCR	USDA Forest Service
USDA Community Facilities Direct Loan & Grant	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas	Annual	USDA Rural Development MA	USDA Rural Development
Transportation Improvement Program	Prioritized, multi-year listing of transportation projects in a region that are to receive Federal funding for implementation. Projects are limited to certain roadways and are constrained by available funding for each fiscal year. Any transportation project in Franklin County that is to receive federal funding must be listed on the TIP.	Rolling	Franklin County Transportation Planning Organization / FRCOG	80% Federal / 20% State
Chapter 90 Program	Funds maintaining, repairing, improving and constructing town and county ways and bridges which qualify under the State Aid Highway Guidelines	Annual	Mass DOT	State Transportation Bond

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Culvert Replacement Municipal Assistance Grant	Funds replacement of undersized, perched, and/or degraded culverts located in an area of high ecological value with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria	Annual	MA Division of Ecological Restoration	State Appropriation
MassWorks Infrastructure Program	Funds for public infrastructure such as roadways, streetscapes, water, and sewer	Annual	EOHED	State Appropriation
Municipal Small Bridge Program	5 year program (FY17 – FY21) to assist cities and towns with replacing or preserving bridges with spans between 10' and 20'	Bi-Annual	MassDOT	State Appropriation
Municipal Vulnerability Preparedness (MVP) Planning and Action Grant Programs	Funding to support cities and towns to begin the process of planning for climate change resiliency and implement priority projects; projects proposing nature-based solutions that rely on green infrastructure or conservation and enhancement of natural systems to improve community resilience are given priority for implementation funding through the MVP Action Grant	Annual	EEA	State Appropriation
Land and Water Conservation Fund Grant Program	Funding for municipalities for the acquisition of parkland, development of a new park, renovation of an existing park, development of trails in an existing conservation or recreation area, or the acquisition of conservation land	Annual	EEA	National Park Service
Drinking Water Supply Protection Grant	Provides financial assistance to public water systems and municipal water departments for the purchase of land in existing Department of Environmental Protection (DEP)-approved drinking water supply protection areas, or land in estimated protection areas of identified and planned future water supply wells or intakes	Annual	EEA	EEA
Landscape Partnership Grant	Funding for large-scale (min. 500 acres), joint conservation projects completed in partnership with federal, state, and local governments, and non-profits	Annual	EEA	EEA

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Conservation Partnership Grant	Funds acquisition of conservation or recreation land by non-profit entities	Annual	EEA	EEA
LAND – Local Acquisitions for Natural Diversity	Funding for municipal conservation and agricultural commissions to acquire interests in land that will be used for conservation and passive recreation purposes	Annual	EEA	EEA
PARC - Parkland Acquisitions and Renovations for Communities	Funding for municipalities to acquire parkland, build a new park, or to renovate an existing park	Annual	EEA	EEA
Table Acronym Key: DCR = MA Department of Conservation & Recreation; FEMA = Federal Emergency Management Agency; MEMA = MA Emergency Management Agency; EEA = MA Executive Office of Energy & Environmental Affairs; USDA = U.S. Department of Agriculture; NRCS = Natural Resource Conservation Service; EDA = U.S. Economic Development Administration; EPA = U.S. Environmental Protection Agency; FRCOG = Franklin Regional Council of Governments; MassDOT = MA Department of Transportation; EOHED = MA Executive Office of Housing & Economic Development				

2016 Hazard Mitigation Plan

The Town of Leyden has taken steps to implement findings from the 2016 Hazard Mitigation Plan into the work of the Public Safety Advisory Committee and the 2022 Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Plan. The Core Team incorporated the key vulnerabilities discussed in the 2016 Hazard Mitigation Plan into outreach materials developed as a part of the MVP Plan.

2022 Hazard Mitigation Plan

Upon approval of the Leyden Hazard Mitigation Plan by FEMA, the Core Team will provide all interested parties and implementing departments with a copy of the plan, with emphasis on Table 4-3: 2022 Leyden Hazard Mitigation Prioritized Action Plan and Table 4-4: 2022 Leyden Preparedness and Response Action Plan. The Core Team should also consider initiating a discussion with each department on how the plan can be integrated into that department's ongoing work. At a minimum, the plan should be distributed to and reviewed with the following entities:

- Emergency Management Director
- Public Safety Advisory Committee
- Select Board
- Fire Department
- Police Department
- Highway Department
- Planning Board
- Zoning Board of Appeals
- Conservation Commission
- Franklin County Regional Emergency Planning Committee
- Building Inspector/FCCIP

Some possible planning mechanisms for incorporating the Leyden Hazard Mitigation Plan into existing planning mechanisms to the fullest extent possible could include:

- The Emergency Management Plan and regionalization of services planning underway by the Public Safety Advisory Committee.
- Future Master, Open Space and Recreation, Climate Resiliency planning.
- When the Final Community Resilience Building and Hazard Mitigation Plan for the Town of Leyden is distributed to the Town boards for their review, a letter asking each board to endorse any action item that lists that board as a responsible party would help to encourage completion of action items.
- The Planning Board could include discussions of the Hazard Mitigation Plan Action Items in one meeting annually and assess progress. Current Subdivision Rules and Regulations and Zoning

Bylaws should be reviewed and revised by the EMD, Planning Board, and Select Board based upon the recommendations of this plan. Technical assistance from the FRCOG may be available to assist in the modification of Leyden's current Bylaws.

Continued Public Involvement

The Town of Leyden is dedicated to continued public involvement in the hazard mitigation and climate resilience planning and review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2022 Plan will be maintained and available for review on the Town website through 2027. Individuals will have an opportunity to submit comments for the Plan update at any time. Any public meetings of the Core Team will be publicized. This will provide the public an opportunity to express their concerns, opinions, or ideas about any updates/changes that are proposed to the Plan.

Appendix A – Community Resilience Building Risk Matrices

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Top Priority Hazards: Flooding | Extreme Temperatures | Severe Wind/Thunderstorms | Severe Winter Storms

Features	Location	Ownership	V or S	Top Priority Hazards (Flooding, Extreme Temperatures, Severe Wind/Thunderstorms, Severe Winter Storms)	Priority H - M - L	Time Short Long Ongoing
Infrastructural						
Culverts and bridges	West Leyden Road, Brattleboro Road, Keets Brook Road, River Road/Thorne Brook, Alexander Road	Town & State	S/V	Culverts and bridges throughout town are undersized/under capacity; 19% of Leyden's culverts are in critical condition. The culvert on West Leyden Road is of particular concern, it often overflows during storm events and is known locally as "the bog" due to beavers blocking the culvert. Another area of concern is the wooden bridge over Thorne Brook on River Road. Replacing culverts is becoming even more unfeasible for the Town, as the cost of steel is up 700% this year. The Town received a grant from the DER to replace the culvert on Coates Road. Other culverts that cause frequent flooding issues are marked on the Infrastructure map. **Action: 1) Use the 2021 Town of Leyden Culvert Assessment and 2018 Leyden High-Risk Stream Crossing Report to prioritize culvert upgrades and/or replacements. Seek funding for construction of properly designed/sized culverts, including "right-sizing" of drainage culverts to accommodate more frequent and intense storms due to climate change. 2) Seek funding for a consultant to prepare designs for a culvert enhancement and wetland restoration project at the site known as "The Bog" on West Leyden Road.**	H	O
Power lines	Town-wide/area north of Daniel's Peak	Utility	V	Leyden is at a high elevation - the Town has a lot of peaks and valleys that can contribute to outages. An additional concern is that storm damage can now bring down broadband service. **Action: Examine strategies for improving the Town's existing hazard tree program, such as improving and encouraging coordination between Eversource and the Leyden Tree Warden and increasing funding for the Treen Warden's work. Look for ways to improve the process of identifying tree hazards.**	M	S
Drinking Water	Town-wide	Town/Private	S/V	All residents are on private wells, which are vulnerable to outages during a storm event. The Town has the capacity to distribute drinking water (both the Town Hall and Town Offices will soon have back up generators and could be open after an emergency event). This information needs to be put in the Town's forthcoming Emergency Management Plan so residents know about the program. **Action: Finalize the updated Emergency Management Plan and distribute the plan to all Town Boards and Committees for review, and then distribute to residents. The plan will include information about food and water distribution during an extended event.**	H	S

Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Top Priority Hazards: Flooding | Extreme Temperatures | Severe Wind/Thunderstorms | Severe Winter Storms

Features	Location	Ownership	V or S	Top Priority Hazards	Priority H - M - L	Time Short Long Ongoing
Emergency Communications/Back-up communication infrastructure	Town-wide	Town	S/V	The Town uses a reverse 911 program to get in touch with residents. Broadband installations were completed in early 2021; now most residents are able to use their cell phones during emergencies. In 2021, Franklin County Emergency Services migrated to the new CoMIRS system for dispatching emergency services. Most of Leyden is covered, although gaps in coverage exist in north Leyden along the Green River and along Keets Brook Road. **Action: Explore options for enhanced and effective emergency communication with residents, such as restarting the EMD column in the Leyden Life Newsletter. Utilize the Town's recently installed broadband internet, and increase transparency and awareness in Town. Pursue higher enrollment in the Reverse 911 Program.**	M	O
Dirt/Gravel Roads	Town-wide; see Critical Infrastructure Map	Town	S/V	1. Approximately 70% of the roads in Leyden are unpaved. Gravel roads can exacerbate already present issues with flooding, and become increasingly churned during quick freeze/thaw periods. These conditions add to wear and tear on Town vehicles. Workshop participants noted 2022 had the worst mud season in 8 years. 2. The Town has a STRAP grant to address issues on East Hill Road. 3. The Highway Department has switched to using pea stone on gravel roads instead of sand, which has proven to help with traction. **Action: Obtain funding for a Rural Roads/Dirt Road assessment to determine low maintenance, low cost climate resilient drainage solutions on the Town's gravel roads. Identify locations where nature-based solutions would be most effective.**	H	O
Energy Resiliency/Municipal Buildings	Greenfield Road, West Leyden Road	Town	V	The Town purchased a generator for the Town Offices, which will be installed soon and the Town Hall building now has a new generator. The Town Hall building needs to be insulated. None of the municipal buildings are located within the floodplain. The Town should continue to pursue Green Communities Designation in order to receive grant funds to install energy efficient measures at all municipal buildings. Town buildings should be assessed for solar & battery storage opportunities as well. **Action: Continue to pursue Green Communites designation. Once designated, use funds to upgrade municipal buildings to make them more energy efficient.**	H	O

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Top Priority Hazards

Features	Location	Ownership	V or S	Flooding / Extreme Temperatures / Severe Wind/Thunderstorms / Severe Winter Storms	Priority H - M - L	Time Short Long Ongoing
Water sources for firefighting	Marked on Town Records	Private	S/V	The Town's water sources for firefighting were mapped in a project completed many years ago. The Public Safety Advisory Committee would need to take re-assessing and re-mapping the water sources on as a new project. Committee members noted the water sources have likely not changed since the last study was completed, but the Town would need to work with private landowners and come up with agreements for accessing ponds/dry hydrants located on private property. **Action: Re-assess and re-map all water sources for firefighting. These water sources were mapped many years ago, and the Town would like to have updated information about the location of sources, as well as formalized agreements between the Town and private landowners as needed. Seek funding to acquire easements and install pipes to identified water sources.**	L	L
Town Records	Municipal Buildings	Town	V	The Town started backing up records digitally beginning in 2020; no records prior to 2020 are safely backed up. Files are stored in the basement of the Town Offices (which is not climate controlled) and therefore subject to mold. The Town is working on getting a new software system so that records from different departments will also be backed up in the future. Digitization of older records is needed. **Action: Develop and implement a record management plan to digitize and/ or duplicate important records housed in the Town Offices and other town facilities to mitigate the potential loss of information from a hazard event.**	H	S
Emergency Response	Town-wide	Town	S	The Town has an active Public Safety Advisory Committee, which is currently working on a variety of efforts related to emergency response and emergency preparedness planning. Leyden recently secured an Efficiency and Regionalization Grant, which would look at shared police services for the towns of Leyden and Bernardston. The Collins Center will complete the evaluation. There is an EMD column in the Leyden Life newsletter; this column has been used in the past to get out information about emergency response and preparedness.	N/A	N/A
Evacuation Routes	Greenfield Road, West Leyden Road, Frizzell Hill Road, Brattleboro Road	Town/State	S	There are no primary evacuation routes in Leyden (no major highways run through Town) but a secondary evacuation route is located on Greenfield Road, and a tertiary evacuation route runs along West Leyden Road to Frizzell Hill Road. The Public Safety Advisory Committee or the EMD could work with the REPC to organize drills as needed. A communication plan for letting residents know of road closures should be in place; evacuation routes are likely to change depending on the size and scale of the hazard event. **Action: Once the Town has an active Emergency Management Director, join the Franklin County Regional Emergency Planning Committee (REPC) to coordinate evacuation drills. Develop a communication plan for letting residents know of road closures; evacuation routes are likely to change depending on the size and scale of the hazard event.**	L	O

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Features	Location	Ownership	V or S	Top Priority Hazards: Flooding / Extreme Temperatures / Severe Wind/Thunderstorms / Severe Winter Storms	Priority H - M - L	Time Short Long Ongoing
Zoning Regulations	Town-wide	Town	S	The Town has NRPZ in place, which provides an avenue for land conservation alongside development projects. NRPZ is required for all subdivisions. Stormwater management is addressed in Site Plan Review and Review of Large Developments. The Town is interested in looking to options for adding a bylaw to limit the weight of vehicles that travel through town, as trucks carrying heavy loads damage gravel/dirt roads. **Action: Investigate options for limiting the weight of vehicles that pass through Leyden, such as implementing seasonal weight limits for logging trucks traveling on dirt and gravel roads.**	M	S
Societal						
Availability of health care services	Town-wide	Public/Private	V	With the rise in availability of appointments via telehealth, many seniors have been able to attend health care appointments without traveling. However, depending on road conditions, home health aids can't make it to their patients during prolonged events. The Council on Aging previously had volunteers to drive people to appointments but the service was underutilized because people were hesitant to ask for help.	N/A	N/A
Access to food/water	Town-wide	Public/Private	S/V	Some seniors are signed up for food delivery services, but this doesn't help residents when road conditions are poor. Access to supplies during a prolonged event is a concern. The Town does not have a way to distribute food, but this is an effort that should be detailed in the new emergency management plan. **Action: Finalize the updated Emergency Management Plan and distribute the plan to all Town Boards and Committees for review, and then distribute to residents.**	H	S

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Features	Location	Ownership	V or S	Top Priority Hazards: Flooding / Extreme Temperatures / Severe Wind/Thunderstorms / Severe Winter Storms	Priority H - M - L	Time Short Long Ongoing
Support networks/neighborhood groups	Town-wide	Private	S	The Town has an active Public Safety Advisory Committee, which serves as a support network.	N/A	N/A
Vulnerable populations	Town-wide	Private	V/S	The ability of seniors to age in place in the face of climate change is a concern to Town officials. The cost of services are steadily increasing, and there have been scenarios in which nurses can't reach seniors due to road conditions. Leyden is a designated age-friendly community by AARP, which allows the Town to apply for grants that are available through AARP's network. **Action: In line with the update of the Emergency Management Plan, identify vulnerable populations and foster a communications network in advance of a hazard event to facilitate communication efforts and outreach to those most in need of information and assistance. Focus should be on populations that may be more vulnerable to climate-induced risks, such as extreme temperatures, may lack appropriate shelter during increasingly intense storms, or that may be unprepared if stranded or cut off from supplies due to flooding or storm events. Develop a form to put in the annual town mailing from the Town Clerk that asks residents about what type of assistance they would need during a severe storm event.**	H	O
Shelters	N/A	Town	V	The Town does not have a designated sheltering facility in Town. Both the Town Offices and the Town Hall could serve as a sheltering facility (they have kitchens and are accessible) but the official location will need to be designated in the forthcoming emergency management plan.	N/A	N/A
Cooling Shelter	N/A	Town	V or S	The Town doesn't have a cooling shelter yet but it is a recognized need. See above.	N/A	N/A

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Top Priority Hazards

Features	Location	Ownership	V or S	Flooding / Extreme Temperatures / Severe Wind/Thunderstorms / Severe Winter Storms	Priority H - M - L	Time Short Long Ongoing
Emergency notifications to residents	N/A	Town	S	The Town uses reverse 911 to alert residents of an emergency. A flashing highway/utility sign on Greenfield Road also serves as a notice board. The sign runs on a battery so would still be functional during a short term event. **Action: Explore options for enhanced and effective emergency communication with residents, such as restarting the EMD column in the Leyden Life Newsletter. Utilize the Town's recently installed broadband internet, and increase transparency and awareness in Town. Pursue higher enrollment in the Reverse 911 Program.**	M	S
Isolated residents	Primarily residents who live on a dead end gravel road	Private	V	Alexander Road & Keets Brook Road have been cut off in the past during microbursts. Residents become isolated during severe storm events. Other areas of concern include dead end gravel roads. If the culvert on West Leyden Road (where "The Bog" is located) were to fail, the whole west side of town would be difficult to access. **Action: Develop a communication and evacuation plan for residents living on dead end roads who may become isolated during a severe event. Formalize neighborhood groups using the Village Neighbors Model.**	H	O
Home heating/cooling	Town-wide	Private	V	Residents are now finding it necessary to use air conditioners in the summer months; workshop participants who have lived in Leyden for 45+ years have purchased ACs in the last couple of years to get through heat waves. **Action: Conduct more education and outreach on available weatherization, insulation, energy efficiency, and renewable energy technologies available through Mass Save and other state programs.**	L	O
Vector-borne Diseases	Town-wide	N/A	V/S	Climate change will increase the number of disease carrying vectors (ticks and mosquitoes) and increase demands on the public health system for symptom management and care for infected people. The Town recently joined the PV Mosquito Control District, which provides testing and trapping services. The State accepted the Town's alternative plan for mosquito management after they opted out of the state's aerial spraying programs. **Action: Assess additional mosquito/pest control options, including placing more pond dunks (larvicide) on public and private properties, determination of future risks due to increase in type and quantity of pests/disease vectors due to climate change, and development of an education and outreach program. Coordinate with the Board of Health to increase educational opportunities/awareness relating to pests and disease control and the Town's participation in the Pioneer Valley Mosquito Control District.**	H	S

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

Top Priority Hazards

Features	Location	Ownership	V or S	Flooding	Extreme Temperatures	Severe Wind/Thunderstorms	Severe Winter Storms	Priority H - M - L	Time Short Long Ongoing
Household Disaster Preparedness	Town-wide	Private	S	***The Board of Health sends out information in the Leyden Life newsletter about residential emergency preparedness.***				N/A	N/A
Environmental									
Forests/Forest Health	Town-wide	Public/Private	S/V	Leyden is 83% forested. Considering the last couple of years have been very dry, and wildfire outbreaks in nearby towns during recent droughts, large tracts of unmanaged land are a concern to the Fire Department. Leyden is a part of the Mohawk Trail Woodlands Partnership (MTWP). Through an MVP Action Grant, a Forest Resiliency Plan was put together for the region. **Action: To improve forest management and mitigate the risk of wildfires in Leyden, work with other Towns in the Mohawk Trail Woodlands Partnership region to implement recommendations from the recently completed Forest Resiliency Plan. Additionally, provide landowners with resources about programs such as the Keystone Foundation, Chapter 61 programs, Women on the Land, etc., to encourage good land stewardship.**				H	L
Farmland/prime farmland soils	Town-wide	Public/Private	S	Prime Farmland Soils are located throughout Leyden. The Town's bylaw's state that these soils cannot be removed from Town. Several farms are protected through the APR program, or through a CR.				N/A	N/A
Floodplains	Along the Green River	Private	S	Only 1.5% of Leyden is located within a regulatory floodplain. No critical facilities are located in the floodplain. **Action: Update the Town's Floodplain Bylaw using the 2020 MA Model Floodplain Bylaw to ensure compliance with the NFIP program.**				H	L
Invasive species	Simon Keets Road/Keets Brook Road, Mid County Road	Public/Private	V	Japanese knotweed has been growing along Keets Brook/Shattuck Brook and Couch Brook/Beaver Meadow Brook for the past 5 years and is overtaking the streambanks. Bittersweet is growing along Mid County Road and will likely impact local infrastructure, as it tends to choke and topple trees. **Action: Seek funding and hire a consultant to develop a regional comprehensive invasive species management from inventory stage through management planning and implementation to address existing invasive populations that threaten features such as open space or forests, both of which contribute to resiliency, as well as anticipate new invasives that are likely to move into the area as climates shift. Continue to manage the invasive plants in Town and explore alternative spraying options for Japanese knotweed. Assess biological control options for pests, including gypsy moths, and alternatives to spraying for invasives.**				M	L

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

ALL HAZARDS: severe winter storms, flooding, tornados, dam failure, hurricanes/tropical storms, thunderstorms/microbursts, wildfire, earthquake, landslides, drought, extreme temperatures, invasive species

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

				Top Priority Hazards				Priority	Time
Features	**Location**	**Ownership**	**V or S**	Flooding	Extreme Temperatures	Severe Wind/Thunderstorms	Severe Winter Storms	**H** - **M** - **L**	**S**hort **L**ong **O**ngoing
Erosion	Paige Road/Keets Brook Road	Town	V	Erosion is occurring on Paige Road and Keets Brook Road, and along the banks of the Green River. **Action: Seek funding to hire a consultant to assess and identify projects that would help to manage erosion in the upper tributaries to the Green River.**				L	L

Appendix B – Public Participation

MEETING AGENDA

Leyden Integrated Multi-Hazard Mitigation & MVP Plan

Project Meeting

Tuesday, January 18, 2022 4:00 - 5:30 pm via Zoom

https://bit.ly/LeydenMVP

Project Facilitator: Franklin Regional Council of Governments

1. Introductions
2. Overview of Project and Timeline
3. Discuss Current Concerns about Natural Hazards and Climate Change Stressors, including Leyden's Risk to Each Hazard Based on the Location, Extent, Probability, and Severity of Hazards
4. Review of Draft Critical Facilities & Infrastructure Map and Environmental Resources Map
5. Discuss MVP Workshop Logistics, including stakeholder outreach

Leyden Integrated MVP / Hazard Mitigation Plan

Project Kick-Off Meeting

January 18, 2022

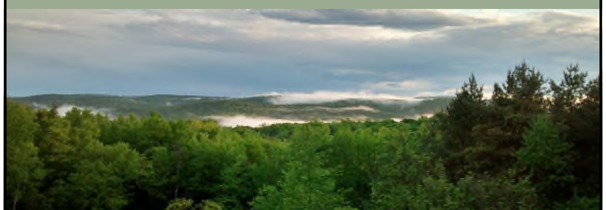
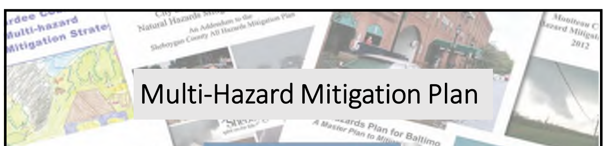


Photo from the Town of Leyden website

Meeting Agenda

- Review Joint MVP/Hazard Mitigation Plan update
- Discuss Current Concerns about Natural Hazards and Climate Change Stressors
- Review critical infrastructure & environmental resource maps
- Discuss MVP Workshop & next steps



Multi-Hazard Mitigation Plan

- The purpose of hazard mitigation is to reduce potential losses from future disasters
- Mitigation plans identify the natural hazards that impact communities, identify actions to reduce losses from those hazards, and establish a coordinated process to implement the plan

---

2014 Leyden Multi-Hazard Mitigation Plan

- Inventoried *historic* hazard events – frequency, magnitude and damages
- Vulnerability assessment for flooding was prepared based on damages from *past* events and location in 100 year floodplain
- Prioritized all hazards and included action items for each hazard

2021 Hazard Risk Assessment

Type of Hazard
Severe Winter Storms
Extreme Temperatures
Invasive Species
Hurricanes / Tropical Storms
Flash Flooding
Severe Thunderstorms / Wind / Microbursts
Earthquakes
Drought
Wildfires
Flooding (100/500 year event)
Tornadoes
Dam Failure
Landslides
Vector-borne Diseases

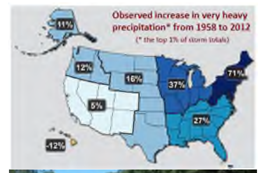
How to evaluate:

- **Location** – What areas and how much of town are affected?
- **Extent / Impact** – How severe are the impacts to property, people, and the environment?
- **Probability of Future Events** – How often does the hazard affect the town now, **and considering climate change, in the future**?

Massachusetts' Changing Climate is Exposing Communities to Greater Risk

Changing weather
- Higher / extreme temperatures
- Changes in precipitation
- More frequent & intense storms

Amplifies existing risks
- Community and regional infrastructure
- Local and regional economies
- Public health
- Natural resources and our environment



Massachusetts Municipal Vulnerability Preparedness (MVP) Program Launched 2017

MVP Program Overview

Build Resilience and Preparedness to more frequent and intense weather events.

Improve pre-event planning, response & recovery, and long-term actions.

A prepared and resilient town will be able to maintain functions, protect its residents and emerge stronger and better prepared for future storm events and a changing climate.

MVP Planning & Designation Process:
- Community Resilience Building Workshop
- Action Plan Matrix and Summary Report
- Listening Session

Once designated, communities can apply for MVP Action Grants to implement high priority actions.

Combined MVP / Hazard Mitigation Process

Hazard Mitigation:
- **Comprehensive inventory of hazards and impacts – must address all hazards in the State HMP**
- **Identifies past, current and future hazards / impacts**
- **Results in actions to address all hazards**

MVP:
- **Focuses on top 4 hazards – defined by the community**
- **Identifies current and future vulnerabilities and strengths**
- **Results in targeted number of high priority actions**

Combined HMP / MVP Plan
- **Consider impacts to:**
  - ✓ **Critical Facilities and Infrastructure**
  - ✓ **Population / Society / Economy**
  - ✓ **Environment**
- **Determine Top Priority Hazards**
- **Identify Actions to Address Impacts and Vulnerabilities**
- **Include Nature Based Solutions**

Consider Impacts To:

Critical Facilities / Infrastructure:
- Roads and bridges
- Power grid
- Drinking Water
- Wastewater Treatment
- Communications
- Housing
- Emergency Shelters / Town Buildings
- Schools
- Access to Hospitals / Medical Facilities

Population / Society:
- Public health
- Access to lifelines (food/water, emergency response personnel, etc.)
- Vulnerable populations
- Public services
- Local / regional economy

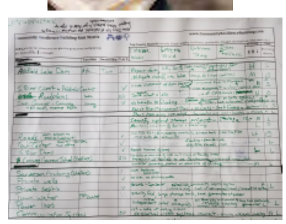
Environment:
- Invasive species
- Wildlife and plant life
- Forests and farms
- Water quality
- Water supply
- Urban forests / street trees

Natural Hazards and Climate Change Stressors

Flooding along the Green River during Tropical Storm Irene.

- What concerns do you have about **climate change and natural hazards** and their impact on Leyden?
- Consider Leyden's
  - ✓ Infrastructure
  - ✓ Society
  - ✓ Environment
- If your concerns are site specific, we'll mark them on the map

MVP Community Resilience Building Workshop



Workshop Process and Outcomes
- Review natural hazard background information to provide context for all participants
- Identify and map vulnerabilities and strengths:
  - Infrastructure
  - Society
  - Natural resources
- Develop and prioritize actions and clearly delineated next steps

MVP Community Resilience Building Workshop

Proposed format:

- ~4 hour meeting to discuss how climate change already is, and will impact Leyden's **infrastructure**, **society**, and **environment**
  - **Should these meetings be virtual or in-person?**
- ~4 hour meeting to draft an action plan based on feedback received during focus groups
  - **Should this meeting be virtual or in-person?**

Community Engagement:

- Are there any community organizations/groups we should try to reach out to?

Next Steps

Community Resilience Building Workshop:

NEED TO SET A DATE!

- Drafting of the integrated Hazard Mitigation and MVP Plan
- Meetings with core team to review drafts
- Public listening session to present findings
- Submission of plan to MEMA and EEA for review by June 30, 2022
- Questions / comments please contact:
  - Michele Giarusso, Municipal Assistant (Selectboard@townofleyden.com)

THANK YOU!

MEETING AGENDA

Leyden Integrated Multi-Hazard Mitigation & MVP Plan

MVP WORKSHOP PART 1

Tuesday, March 22, 2022 2:00 - 6:00 pm

Former Pearl Rhodes Elementary School

7 Brattleboro Road, Leyden MA

Project Facilitator: Franklin Regional Council of Governments

1. Introductions
2. Review Massachusetts' changing climate and how it will impact Leyden's infrastructure, society, and environment
3. Identify strengths and vulnerabilities in each of the three sectors
4. Review of Draft Critical Facilities & Infrastructure Map and Environmental Resources Map
5. Schedule MVP Workshop Part 2 to develop the Action Plan

Town of Leyden

MVP Workshop #1

Tuesday, March 22 2022, 2:00-6:00 pm @ Leyden Town Offices, 7 Brattleboro Road

Name	Affiliation	Contact
Kimberly MacPhee	FRCOG	kmacphee@frcog.org
Michele Giarusso	Leyden	selectboard@townofleyden.com
Bill Brooks	Leyden	highway@townofleyden.com
BILL GLABACH	LEYDEN	SELECTBOARD
LIZ KIDDER	LEYDEN	PublicSafety@townofLeyden.com LizKidder115@gmail.com
DAVID POMERANTZ	LEYDEN	DAVID POMERANTZ@SEACHANGEASSOCIATES.COM
KATHERINE DIMATTEO	LEYDEN	KATHERINE@DIMATTEOCONSULTING.COM
ERICA JENSEN	LEYDEN	EJ3139@GMAIL.COM
Allison Gage	FRCOG	agage@frcog.org

TOWN OF LEYDEN

MUNICIPAL VULNERABILITY PREPAREDNESS PLAN

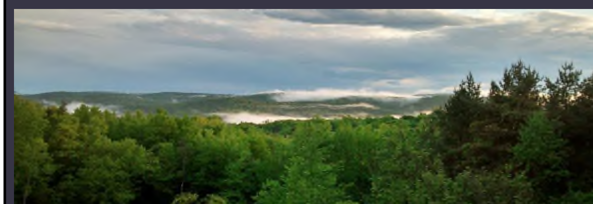


Photo from the Town of Leyden website

3/22/22 MVP Workshop Part 1

Agenda

- Overview of the Integrated Hazard Mitigation & Municipal Vulnerability Preparedness (MVP) Plan
- Review Massachusetts' changing climate & how it will impact Leyden's infrastructure, society, and environment
- Identify Strengths and Vulnerabilities in each of the three sectors
- Review draft Critical Infrastructure and Environmental Resources maps

Combined MVP/Hazard Mitigation Process

Hazard Mitigation:

- Comprehensive inventory of hazards and impacts – must address all hazards in the State HMP
- Identifies past, current and future hazards / impacts
- Results in actions to address all hazards

MVP:

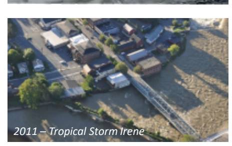
- Focuses on top 4 hazards – defined by the community
- Identifies current and future vulnerabilities and strengths
- Results in targeted number of high priority actions

Combined HMP / MVP Plan

- Consider impacts to:
  - ✓ Critical Facilities and Infrastructure
  - ✓ Population / Society / Economy
  - ✓ Environment
- Determine Top Priority Hazards
- Identify Actions to Address Impacts and Vulnerabilities
- Include Nature Based Solutions

Combined MVP/Hazard Mitigation Process

2008 - Ice Storm



2011 – Tropical Storm Irene

GREENFIELD RECORDER

Downed trees, power outages result from fast-moving storm 10/8/2020

Microburst wreaks havoc in Deerfield, Montague 7/31/2019

Quabbin Reservoir has lost 10 billion gallons of water due to drought 8/31/2016

Wet and wild: Heavy rains cause localized flooding headaches 2/26/2016

Utilities warn that power could be out for days in Northeast 10/30/2017

Heavy weekend rainfall leads to flooding, road closures throughout Franklin County 7/18/2021

MVP Program

Program launched in 2017 and has provided $65 million to communities since then

Visit resilientma.org/mvp/ for a full list of Action Grants!

Examples of local action grants:

- Watershed-Based Assessment and Climate Resiliency Planning Grant
- Flooding Resiliency Projects
- Technical assistance for updating zoning bylaws
- Engineering designs for climate resilient projects
- Culvert enhancements
- Record digitization

Leyden's Changing Climate

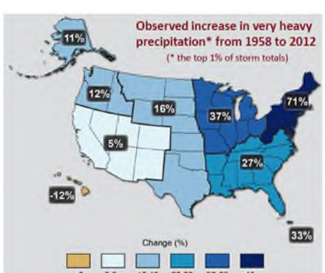
Changing precipitation

Higher temperatures

More frequent & intense storms

Climate change **increases** existing risks Leyden is already facing

Leyden's Changing Climate

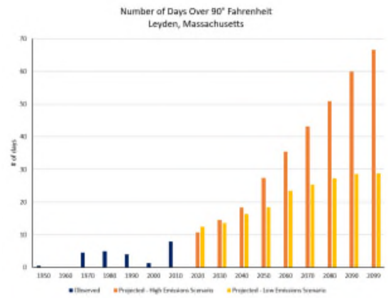


- The Northeast has seen a greater increase in extreme precipitation than any other part of the country, **experiencing a 71% increase in heavy precipitation events between 1958 and 2021.**
- By the end of the century, our area could have **5 additional days of rainstorms that dump over 1 inch of rain.**

Impacts from Changing Precipitation

- Increased total rainfall
  - Impact on the frequency of minor but disruptive flooding events
  - Impact agriculture, forestry, and natural ecosystems
- More intense downpours
  - Increased risk of flooding
  - Increased damage to property and critical infrastructure
  - Impacts to water quality
- Changes to rainfall and snowfall patterns
  - Impacts to certain habitats and species with specific physiological requirements
  - Reduced snow cover for recreation and tourism
  - Potential increase in frequency of episodic droughts

Leyden's Changing Climate



- Since the beginning of the century, temperatures in MA have increased almost 3 degrees Fahrenheit
- The number of days per year with maximum temperatures over 90°F is projected to **increase by 18 days by the 2050s, and by 32 days by the end of the end of the century.**

Impacts from Increasing Temperatures

- Public health
  - Increase in heat-related illnesses and mortality
  - Urban residents face greater risks
- Health of plants, animals, and ecosystems
  - Increased pests
  - Changes to growing seasons
- Economic sectors
  - More sick days due to heat-related illnesses
  - Reduced crop production and impacts to livestock and fisheries
- Infrastructure
  - Larger demands on energy systems
  - Stress on train tracks, roads and bridges, and other critical infrastructure

Leyden's Changing Climate

Extreme weather events are anticipated to increase due to climate change. Scientists predict the following factors will all **increase** over time:

Frequency

Intensity

Duration

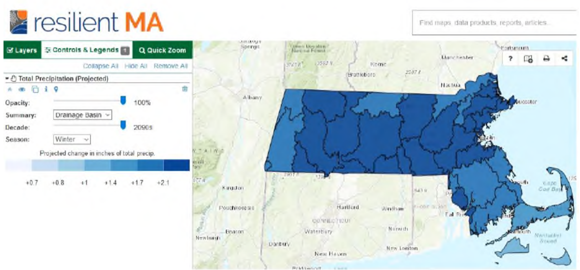
Geographic extent

- Tropical Storm Irene dumped 10" – 14" of rain
- "Snow-tober" in October 2011, in which 24 inches of snow fell in an early storm and caused $3 billion in damages across the Northeast

ResilientMA Climate Change Clearinghouse

www.resilientma.org

ResilientMA Climate Change Clearinghouse



Outcomes

1. Understand strengths and vulnerabilities in three sectors

Infrastructure | Society | Environment

2. Brainstorm actions to build on strengths and address vulnerabilities

Strength & Vulnerability Assessment

Examples

	Strength	Vulnerability
Infrastructure	• Up to date culvert assessment & repair prioritization plan	• Erosion on gravel roads
Environment	• Large parcels of conserved land	• Eroded riverbanks
Society	• Active reverse 911 program	• Challenges associated with aging in place amplified due to climate change

Top Hazards

- Extreme Temperatures
- Drought
- Severe Wind/Thunderstorms
- Severe winter storms – snow & ice
- Flooding
- Invasive Species
- Hurricanes/Tropical Storms
- Landslides/erosion

Next Steps

- Second half of CRB Workshop: Developing a Prioritized Action Plan
  - Meeting date TBD, March 2022
- Public Listening Session – Spring 2022

MEETING AGENDA

Leyden Integrated Multi-Hazard Mitigation & MVP Plan

MVP Workshop #2

Tuesday, April 19th 2:00 – 6:00pm

Leyden Town Offices

7 Brattleboro Road, Leyden MA

Project Facilitator: Franklin Regional Council of Governments

MVP Workshop Part 2 – Developing Leyden's Action Plan

- Welcome & Introductions
- Review findings from Leyden's Strength and Vulnerability Assessment
- Review MVP Action Grant Criteria
- Brainstorm Resiliency Actions & Discuss Updates to the 2016 Hazard Mitigation Action Plan
- Prioritize Resiliency Actions

Town of Leyden
MVP Workshop #2
Tuesday April 19, 2022, 2p.m.-- 6p.m.

Location
7 Brattleboro Road, Leyden MA

Name	Affiliation	Email
Allison Gage	FRCOG	agage@frcog.org
Tamsin Flanders	FRCOG	~~[illegible]~~ tflanders@frcog.org
William Brooks	Leyden Hwy	highway@townofleyden.com org
Liz Kidder	LEYDEN	Lizkidder115@gmail.com
KATHERINE DIMATTEO	LEYDEN	KATHERINE@DIMATTEOCONSULTING.COM
Glenn Caffery	Leyden	glenncaffery@gmail.com
B. Wallace	Leyden	bwallace@gmail.com
Michele Giarusso	Leyden	
WILLIAM GLABACH	Leyden SELECTBOARD	
Marcia Miller	Leyden BOH	marcia.miller65@gmail.com
ERICA JENSEN	LEYDEN SELECT BOARD	EJ3179@GMAIL.COM

TOWN OF LEYDEN

MUNICIPAL VULNERABILITY PREPAREDNESS PLAN

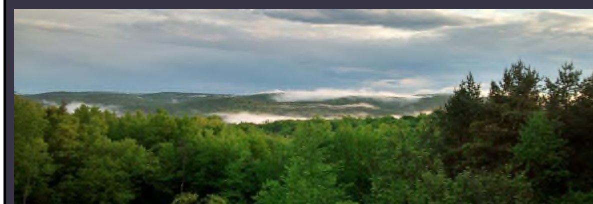


Photo from the Town of Leyden website

4/19/22

MVP Workshop Part 2

Agenda

- Project overview and summary of CRB Workshop #1
- Review MVP Action Grants
- Brainstorm Resiliency Actions & Update Actions from Leyden's last Hazard Mitigation Plan
- Discuss Plan Wrap Up & Next Steps

Combined MVP/Hazard Mitigation Process

Hazard Mitigation:

- **Comprehensive inventory of hazards and impacts – must address all hazards in the State HMP**
- **Identifies past, current and future hazards / impacts**
- **Results in actions to address all hazards**

MVP:

- **Focuses on top 4 hazards – defined by the community**
- **Identifies current and future vulnerabilities and strengths**
- **Results in targeted number of high priority actions**

Combined HMP / MVP Plan

- **Consider impacts to:**
  - ✓ **Critical Facilities and Infrastructure**
  - ✓ **Population / Society / Economy**
  - ✓ **Environment**
- **Determine Top Priority Hazards**
- **Identify Actions to Address Impacts and Vulnerabilities**
- **Include Nature Based Solutions**

Hazard Identification

- Extreme Temperatures
- Drought
- Severe Wind/Thunderstorms
- Severe winter storms – snow & ice
- Flooding
- Invasive Species
- Hurricanes/Tropical Storms
- Landslides/erosion

What concerns do you have about climate change and natural hazards and their impact on Leyden's environmental resources?

- ✓ **Pose the greatest threat to Leyden's environment currently**
- ✓ **Pose the greatest threat to the town's environmental resources over the next decade or longer**
- ✓ **What Leyden should do to improve their resiliency**

Leyden's Changing Climate

- Changing precipitation
- Higher temperatures
- More frequent & intense storms

Climate change **increases** existing risks Leyden is already facing

Planning Process Overview

1. Engage Community → 2. Identify impacts & hazards → 3. Assess vulnerabilities & strengths → 4. Develop & prioritize actions → 5. Take action

Types of Action Grants

- Planning, Assessments, and Regulatory Updates
- Nature-based Solutions for Ecological and Public Health
- Resilient Redesigns and Retrofits for Critical Facilities and Infrastructure

MVP Program

Program launched in 2017 and has provided $65 million to communities since then

Visit resilientma.org/mvp/ for a full list of Action Grants!

Examples of local action grants:

- Watershed-Based Assessment and Climate Resiliency Planning Grant
- Flooding Resiliency Projects
- Technical assistance for updating zoning bylaws
- Engineering designs for climate resilient projects
- Culvert enhancements
- Record digitization

Nature Based Solutions

MVP Municipal Vulnerability Preparedness

The State defines Nature-Based Solutions as "projects that restore, protect, and/or manage natural systems and/or mimic natural processes to address hazards like flooding, erosion, drought, and heat islands in ways that are cost-effective, low maintenance, and multibeneficial for public health, safety, and well-being.

A GeoCell retaining wall on the South River in Conway before and after TS Irene – example of a "band-aid" failing

NBS project was designed to prevent further erosion and sedimentation on the North River in Colrain after severe damage from TS Irene

Nature Based Solutions

MVP Municipal Vulnerability Preparedness

Aerial view of "The Bog" on West Leyden Road, a site that is frequently flooded due to an undersized culvert

Right Sizing Culverts to accommodate larger flows

- Projects can reduce flood risks downstream and reduce erosion hazards at crossings and allow for fish passage
- Many culverts in Franklin County are undersized and need to be replaced
- Can tie into other projects, such as wetland restoration

Example of a culvert replacement to meet MA Stream Crossing Standards

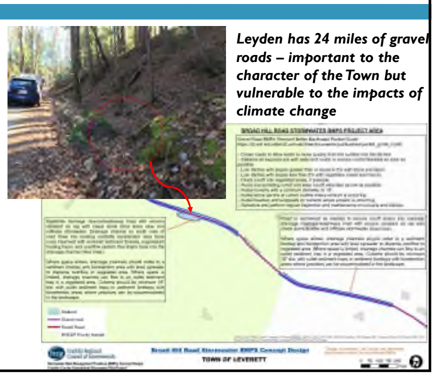
Nature Based Solutions

MVP Municipal Vulnerability Preparedness

Building Resilient Rural Roads

- Managing stormwater runoff is increasingly difficult with climate change and the more frequent and intense storms Leyden is experiencing
- Implementing stormwater BMPs can help reduce damage to critical roadways

Leyden has 24 miles of gravel roads – important to the character of the Town but vulnerable to the impacts of climate change



Nature Based Solutions

MVP Municipal Vulnerability Preparedness

South River Meadow Restoration Project

In this example, a reconnected floodplain absorbs higher flows during a storm affecting the South River in Conway.

Ultimately the project resulted in:

- Reduced flooding and erosion on the Town's property as well as the adjacent property
- Reduced downstream sediment loading
- Improved habitat
- Improved recreation resources

Nature Based Solutions

Why focus on NBS projects?

- **Enhanced public safety** by reducing risks from flooding, erosion, drought, and heat risks to vulnerable populations and community assets.
- **Avoided infrastructure costs** of short- and long-term maintenance, unplanned repairs and safety improvements due to flooding and failure from intense rain events.
- **Promotes biodiversity**, important for environmental health and safeguarding natural resources like water, food, and shelter.

And other **ecosystem services**, such as improving air and water quality, flood protection, groundwater recharge, carbon sequestration, human health and well-being

Projects ineligible for MVP Funding

- Diesel generators
- Tree removal
- Emergency preparedness projects that don't incorporate climate projections/planning
- Projects that repair to previous conditions without consideration of climate projections

Funding for MVP Projects

- Towns can apply for MVP Action Grants once designated
- ***UPDATE: Leyden qualifies for a 10% match (instead of 25%) because of its status as an economically disadvantaged rural community***
- Eligible match sources include Town Volunteer time, any volunteer project partners, any federal grant programs

Plan for Today

Identified strengths or vulnerabilities based on first 2 community meetings

- *Italicized Resiliency actions are actions that need to be updated from your last Hazard Mitigation Plan*
- Regular text are actions we had previously discussed – do they make sense?
- Add & update resiliency actions

Next Steps

- Send draft of Integrated Leyden Hazard Mitigation Plan and Municipal Vulnerability Preparedness plan out for review
- Host a Public Listening Session on May 2nd during SB Meeting & 2 week public comment period
- Submit plan to MA EEA & MEMA for MVP Designation and obtain approval for the updated Hazard Mitigation Plan

Leyden Hazard Mitigation and Municipal Vulnerability Preparedness Plan

PUBLIC MEETING

The Town of Leyden and the Franklin Regional Council of Governments invite residents to hear about and comment on the integrated Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan:

- ✓ **Attend the public meeting: May 18th @ 5:00pm**
- ✓ **Provide public comment between May 18 – June 1:**
  - **Integrated HMP/MVP Plan will be posted on the Town website**
  - **Submit a comment via email to Allison Gage at the Franklin Regional Council of Governments, agage@frcog.org**

WE WANT YOUR FEEDBACK!

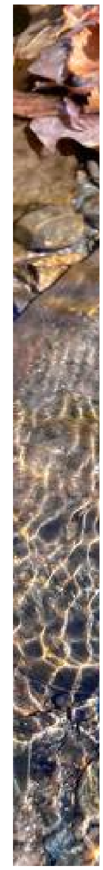
Wednesday, May 18, 2022 5:00 p.m.
Register in advance: https://bit.ly/leydenmvp

GREENFIELD RECORDER

(https://www.recorder.com)

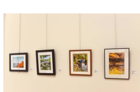
North County Notebook: May 17, 2022

This photo, titled "Bound" and taken by Carol Dunn of Hanover, Connecticut, earned best in show at the Fiddleheads Gallery's second annual photography exhibit in Northfield. Contributed Photo/Carol Dunn



This phot
Gallery's






(/byline?byline=)
Published: 5/16/2022 3:49:12 PM
Modified: 5/16/2022 3:47:24 PM

Hazard mitigation discussion planned for Wednesday

LEYDEN — The town, with the Franklin Regional Council of Governments (FRCOG), will hold a virtual public listening session on Wednesday, May 18, at 5 p.m. to review findings and priority actions that have come out of more than a year of discussions on community resilience building and hazard mitigation.

According to a press release from Allison Gage, FRCOG's senior land use and natural resources planner, Leyden is seeking to become designated as a Municipal Vulnerability Preparedness (MVP) community through the Massachusetts Executive Office of Energy and Environmental Affairs' MVP Program. Two workshops were held in the spring to discuss the impacts of climate change, identify the town's top hazards of concern, review strengths and vulnerabilities, and brainstorm actions to increase resiliency in three categories: infrastructure, society and environment. By becoming an MVP community, Leyden will be eligible to apply for MVP Action Grants to pursue identified action items.

The process will also result in an updated Hazard Mitigation Plan for the town, the release states. Once the plan is approved by the Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA), the town will also be able to apply for hazard mitigation funding from those agencies.

Interested residents can register to participate in Wednesday's meeting at bit.ly/leydenmvp (https://us02web.zoom.us/meeting/register/tZAlcOCrrDIuGt1c8od5pEaqLPPdBGCMq-9q).

CPR certification class planned for May 19

NORTHFIELD — Northfield EMS will offer a CPR certification class at the Senior Center on Thursday, May 19, from 10 a.m. to 2 p.m.

Only nine slots are available, so participants must register by calling 413-498-2901, ext. 114. The cost is $15.

Photo exhibit on display through June 12

NORTHFIELD — The Deerfield Valley Art Association's Fiddleheads Gallery at 105 Main St. is hosting its second annual photography exhibit through June 12.

The entries were judged by Greenfield Recorder photographer Paul Franz. The awards are as follows:

■Best in show — "Bound" by Carol Dunn.

■First place — "Untitled No. 2" by Edmund Burke.

■Second place — "Waiting for the Tourists" by Carol Dunn and "Dry Your Eye" by Matt Guertin.

■Third place — "Sunset Farm" by Anne Colturi, "Heartbreak" by Christine Daugherty and "Modern Dancer" by Vimala Steadman.

■Honorable mentions — "Magical Peony" by Anne Colturi, "Fungi at the Quabbin" by Anne Colturi, "Caged Daisies" by Christine Daugherty, "Spiral Ripple" by Melanie Phillips, "Hibernian Hall" by Nina Rossi and "Cuban Girl" by Vimala Steadman.

The gallery is open on Fridays and Saturdays from noon to 5 p.m., and Sundays from noon to 4 p.m. COVID-19 vaccinations are required to enter and masks are recommended.

For more information, visit deerfieldvalleyart.org (https://www.deerfieldvalleyart.org/).

Attorney to speak on long-term care planning

BERNARDSTON — Kate Downes, a local real estate planning and elder affairs attorney, will present a free workshop on Monday, May 23, at 4 p.m. at the Bernardston Senior Center.

Downes will discuss strategies for paying for in-home, assisted-living and skilled-nursing care, including qualifying for various MassHealth programs, according to a Senior Center newsletter. There will be time for questions following the presentation.

To-go meals available May 27

NORTHFIELD — To-go meals of spaghetti bolognese, mixed green salad, a roll and lemon poke cake will be available for pick-up at the Northfield Senior Center's kitchen door on Friday, May 27, at 11:30 a.m.

There is a suggested donation of $5 per meal. Reservations must be made by calling the Senior Center at 413-498-2901, ext. 114 or emailing seniorcenter@northfieldma.gov by Monday, May 23.

Zumba offered weekly

BERNARDSTON — The Bernardston Senior Center is now offering weekly Zumba cardio workouts on Mondays from 10 to 10:30 a.m.

For details, call the Senior Center at 413-648-5413.

Town of Leyden HMP/MVP Public Listening Session Summary

A public listening session and public comment period were held to provide Leyden residents and Town Officials an opportunity to review and comment on the draft Leyden Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan.

The public listening session was held as a standalone meeting on May 18, 2022. FRCOG staff presented the MVP program as well as findings from the workshops, provided opportunities for feedback on the Town's top resiliency actions, and answered questions from attendees.

After the presentation, attendees asked questions about or discussed the following topics:

- Droughts and how they impact farmers and their water supply
- How the town should collect information on vulnerable residents. Participants noted that they understand it can be a sensitive issue to ask for medical/personal information but they want to have good records in the event of an emergency. FRCOG staff connected participants with the Heath BOH, as they are getting underway with a similar initiative.
- Nature-based solutions
- MVP Action Grant funding

Attendance

- Michele Giarusso, Municipal Assistant
- Jerry McCarthy, Resident
- Katherine DIMatiero, Town Moderator
- Beth Kuztido, Board of Health Chair
- Barbara Wallace, Public Safety Advisory Committee
- Elizabeth Kidder, Public Safety Advisory Committee
- Emily Boss, Franklin Land Trust

The entry below was published in the Leyden Life Newsletter, which is widely read by residents.

Leyden Begins Work on Municipal Vulnerability Preparedness Plan

Leyden has received a grant from the State to develop a Municipal Vulnerability Preparedness Plan and to update our current Hazard Mitigation Plan, which will result in the town being designated as an “MVP Community.” This MVP status will allow Leyden to apply for implementation grants to build projects and advance work that helps the Town be more resilient and prepared for the lasting effects of climate change. Additionally, having an up to date Hazard Mitigation Plan will ensure that we are still eligible for pre- and post-disaster funding from FEMA. The Plan will examine both the strengths and vulnerabilities in town, particularly looking from the three perspectives of infrastructure, people, and natural resources. The Town will be working with the Franklin Regional Council of Governments (FRCOG) to complete this project.

Why should we be concerned about climate change in Leyden?

According to down-scaled climate data from resilientMA.org, the following are the main changes we are expected to see:

- An increase in average temperature, as well as more extreme heat and extreme temperature fluctuations;
- An increase in annual precipitation and an increase in very heavy precipitation events, where more rain, snow or ice falls in a short period of time, interspersed at times with very dry periods
- Stronger storms with higher winds, due to an overall warmer climate with more moisture in the atmosphere.

Damage to roads, bridges, culverts, buildings, and natural habitats are a few impacts that have already been experienced in the region from increased extreme weather. Additionally, ecosystems that are expected to be particularly vulnerable to climate change include coldwater streams and fisheries, hemlock forests, northern hardwood forests, vernal pools, which are plentiful in Leyden. Warming temperatures and changes in precipitation will push plant and animal species northward or to higher elevations. Higher temperatures, along with changes in stream flow, will degrade water quality. Coldwater species will decline, while an increase in stronger storms leads to more flooding and erosion. A shift to winter rains instead of snow will potentially lead to more runoff, flooding, and greater storm damage along with less spring groundwater recharge.

While climate change will continue to be a major challenge globally, local efforts and decisions have real and lasting impacts on mitigating and adapting to future climate change.

Next Steps

The Town will be hosting a series of public meetings over the coming year to collect information from municipal officials and residents to develop our MVP plan. The first series of meetings will focus on identifying which features of Leyden’s infrastructure, society, and environment are most vulnerable to the impacts of climate change, followed by a meeting to develop an action plan to address identified vulnerabilities. **We are holding a kickoff meeting on Tuesday, November 16, 2021 at 2:00pm at the Town Office building (7 Brattleboro Road). Please join us to learn more about the project!**

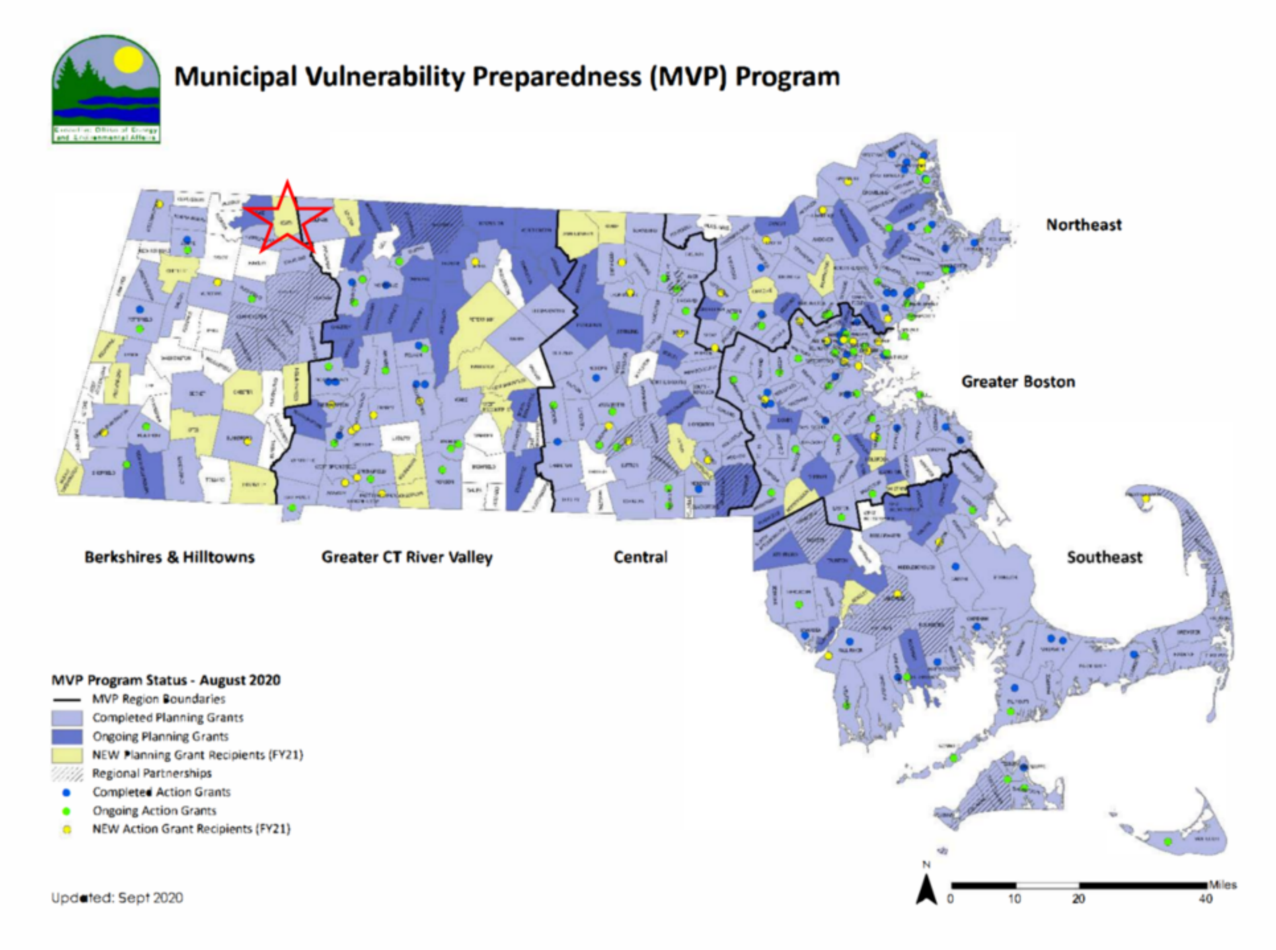
In the meantime, a page will be maintained on the Town website to keep everyone up to date on meetings and the planning process. Please check the website soon. For more information on this project, please contact Michele Giarusso, Municipal Assistant (selectboard@townofleyden.com) or Allison Gage, Land Use & Natural Resources Planner at the FRCOG (agage@frcog.org).

Building a Resilient Leyden

Take a tour to learn more about Leyden's Municipal Vulnerability Preparedness planning efforts, and find out how you can provide input.

FRCOG & The Town of Leyden
February 24, 2021

Overview of the Municipal Vulnerability Preparedness Planning Grant



The Town of Leyden was awarded a **Municipal Vulnerability Preparedness (MVP) planning grant** in 2020 by the MA Executive Office of Energy and Environmental Affairs. Leyden joins many other towns in Franklin County and the Commonwealth working towards their MVP Designation.

Since 2017, the MVP program has awarded cities and towns with over **$44 million to improve resilience to climate change.**

While developing an MVP Plan, the Town will also be working to update their Hazard Mitigation Plan, which will ensure the Town remains eligible for pre-and post-disaster funding through FEMA.

The MVP program allows Leyden to assess strengths and vulnerabilities of the Town's **infrastructure, society, and natural resources**. A better understanding of how to address Leyden's vulnerabilities and build on its strengths will help build a community that is resilient to the impacts of climate change. The plan will also help the Town to:

- Understand connections between natural hazards and local and regional planning/mitigation efforts;
- Develop and prioritize resilient actions for the town, residents and our local organizations and businesses; and
- Identify actions that can reduce the impact of hazards and increase resilience, and later qualify us for funding to implement these important actions.

> *A climate resilient community will be able to maintain functions, protect its residents, and emerge stronger and better prepared for future storm events and a changing climate.*

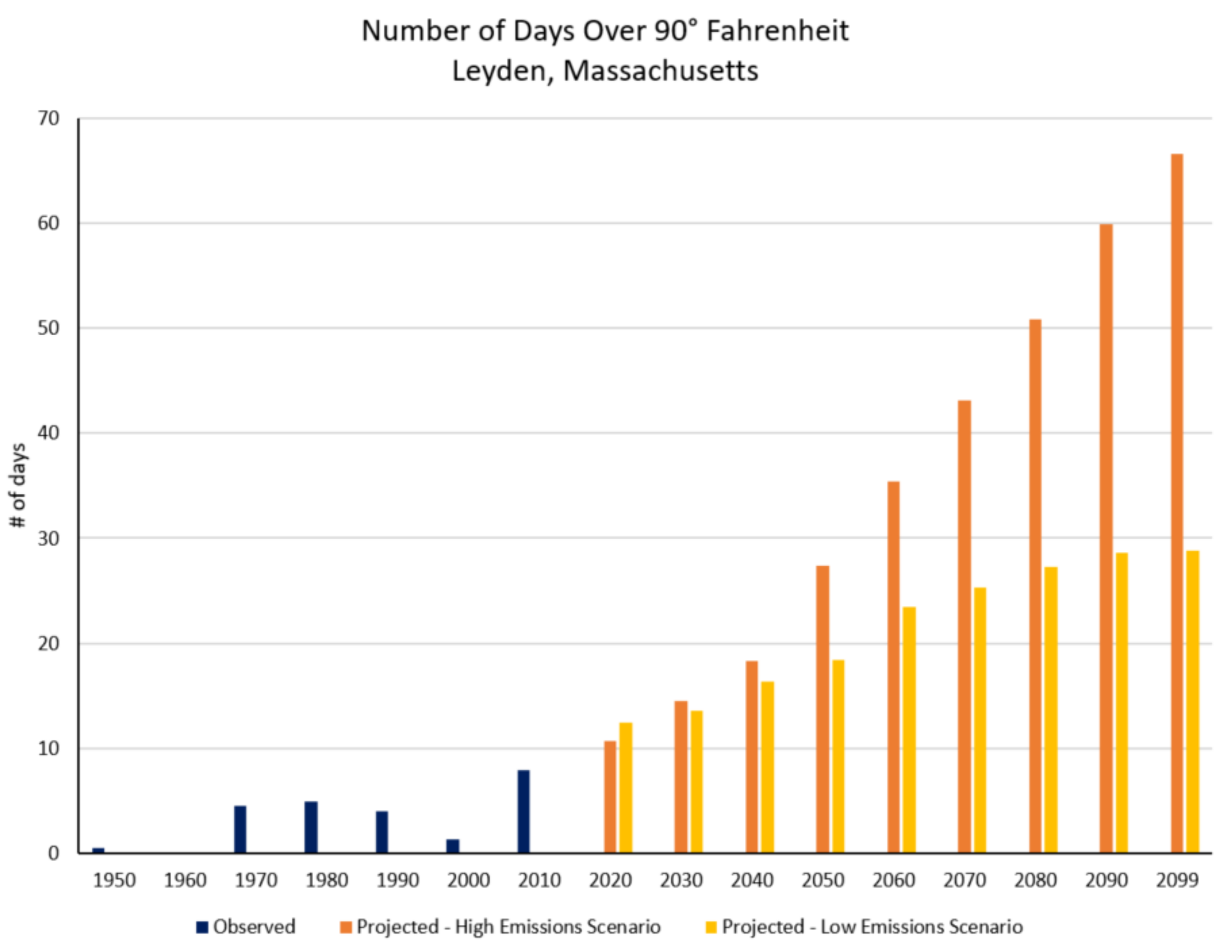
Building resilience to more frequent and intense weather events is important for the Town of Leyden.

According to down-scaled climate data from resilientMA.org, the following are the main changes we are expected to see:

- An increase in average temperature, as well as more extreme heat and extreme temperature fluctuations;
- An increase in annual precipitation and an increase in very heavy precipitation events, where more rain, snow or ice

falls in a short period of time, interspersed at times with very dry periods;
- Stronger storms with higher winds, due to an overall warmer climate with more moisture in the atmosphere.

Keep scrolling to learn more about these climate change impacts.



Rising Temperatures

Since the beginning of the century, temperatures in Massachusetts have increased almost 3 degrees Fahrenheit. Perhaps the most noticeable difference most of us have already recognized is that **winter temperatures have risen approximately 4 degrees Fahrenheit.**

The number of days per year with daily maximum temperatures over 90°F is projected to **increase by 18 days by the 2050s, and by 32 days by the end of the end of the**

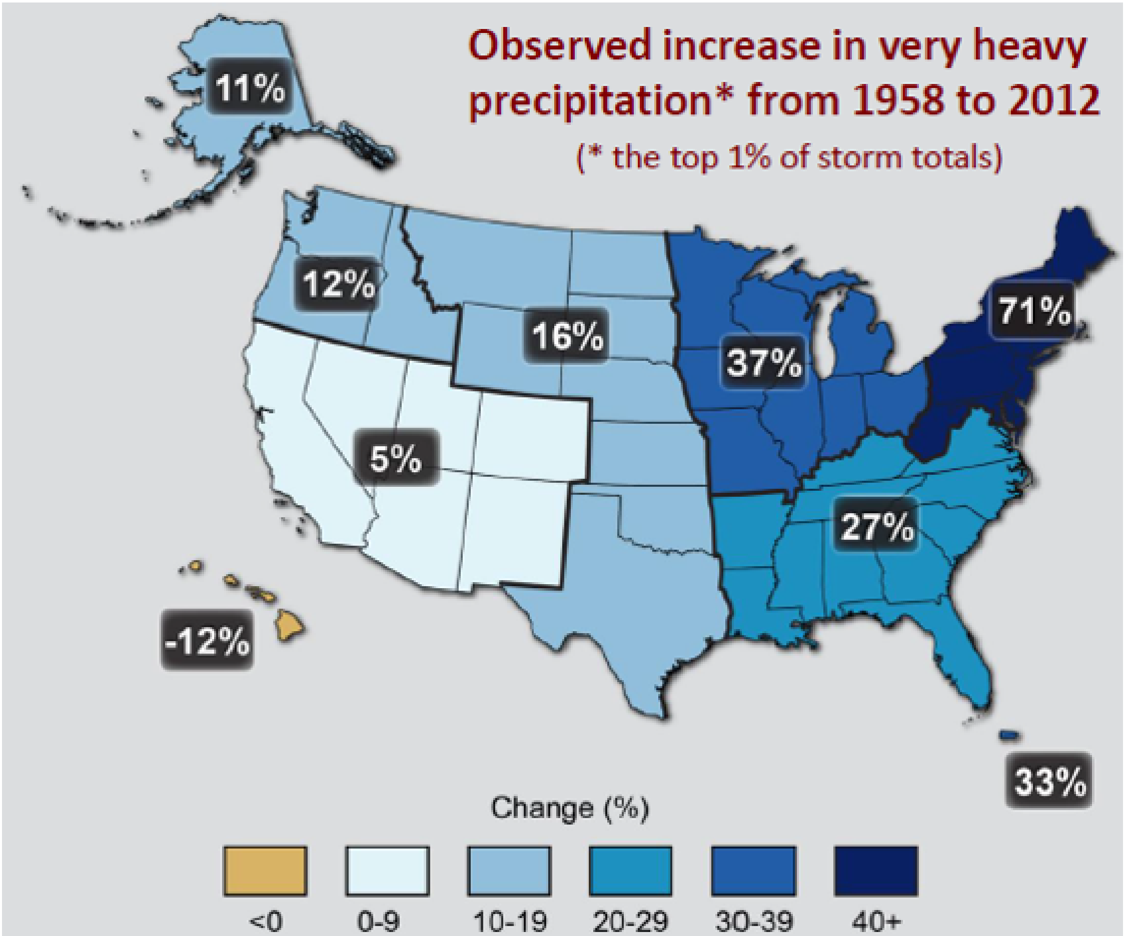
century. However, projections show **there could be as many as 67 days** with a maximum temperature above 90°F by the end of the century.

Explore more climate data

How could rising temperatures impact Leyden?

- Vulnerable populations may not have access to heating or cooling equipment
- There is an increased risk of Lyme disease due to milder winters; tick populations may be prevalent earlier in the spring and later in the fall
- Higher heat, increased humidity and longer and more frequent heat waves can lead to dehydration and heat stroke - this is especially a concern for farm workers
- Residents can be exposed to increased air pollution

- Unseasonably warm weather may disrupt freeze/thaw cycles and impact maple syrup production



Changes in Precipitation

The Northeast has seen a greater increase in extreme precipitation than any other part of the country, experiencing a **71% increase** in heavy precipitation events between 1958 and 2012.

By the end of the century, our area could have **5 additional days** of rainstorms that dump over 1 inch of rain.

Explore more climate data

Maxar | Esri, HERE, Garmin, GeoTechnologies, Inc.   Powered by Esri

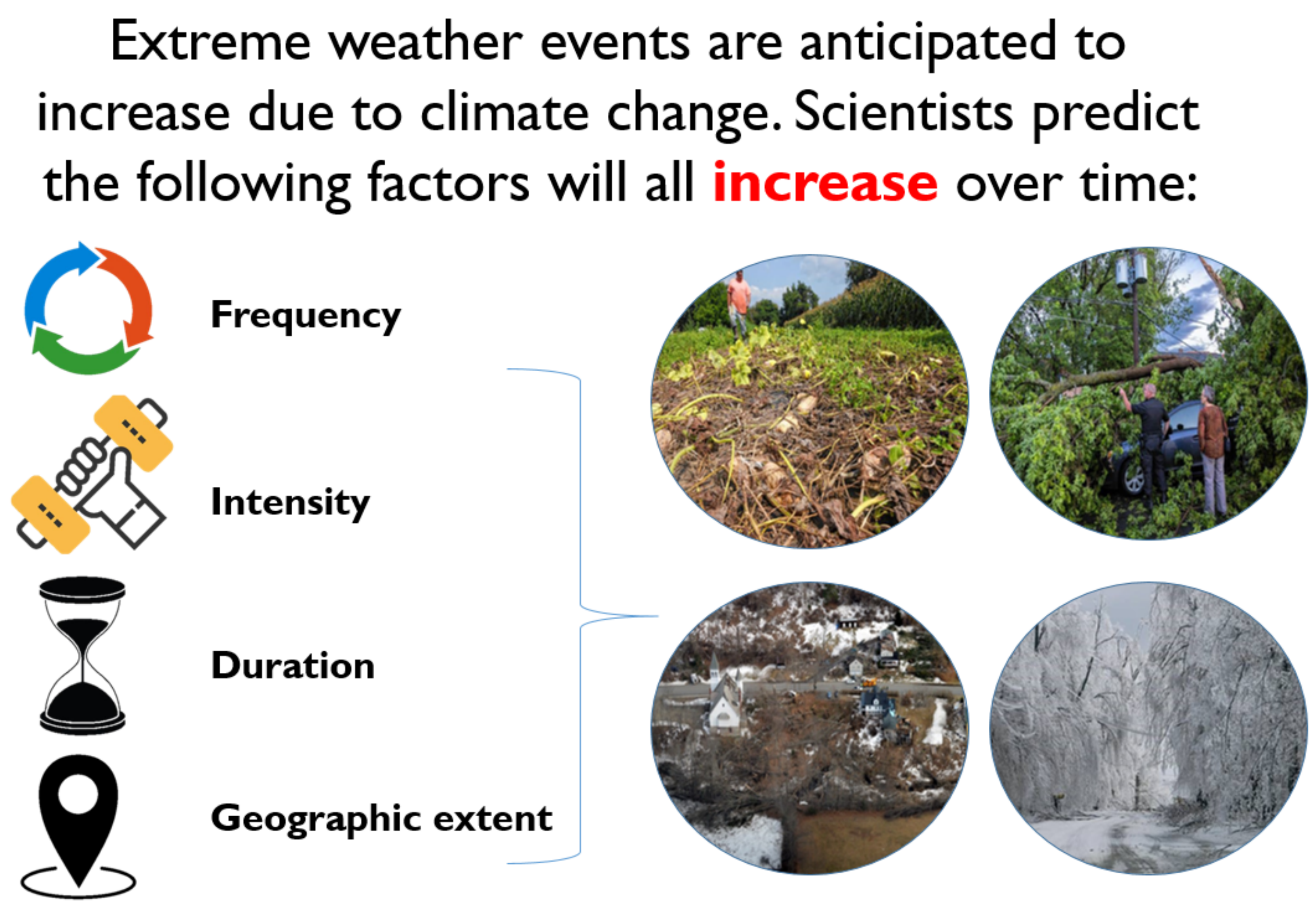
How could changes in precipitation impact Leyden?

One way to think about impacts of more frequent and intense precipitation events is to consider what features are located within the 100-year floodplain, as shown in blue on the map. Are there important facilities within the floodplain? What areas of the Town are most vulnerable to flooding? Areas that frequently experience localized flooding are highlighted in orange.

Additional impacts to consider include:

- Although Massachusetts will see an increase in precipitation, it will likely come in the form of winter rain. Winter rains may lead to more seasonal runoff and greater storm damage.
- There will likely be an increase in the number of dry days in the summer and fall, which can stress local crops and natural ecosystems.
- Heavy rains and storms may compromise native trees and vegetation, which makes forests, fields and wetlands more

vulnerable to invasive plant and pest species.



Extreme Weather

Extreme weather events have impacted the region over the past decade. Some examples include:

- Tropical Storm Irene in August 2011 dumped 10"-14" of rain and caused extensive flood damage
- "Snow-tober" in October 2011, in which 24 inches of snow fell in an early storm and caused $3 billion in damages across the Northeast

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have **higher wind speeds.** This is because a warmer atmosphere will hold more water, and **hurricanes are efficient at wringing water out of the atmosphere and dumping it on land.**

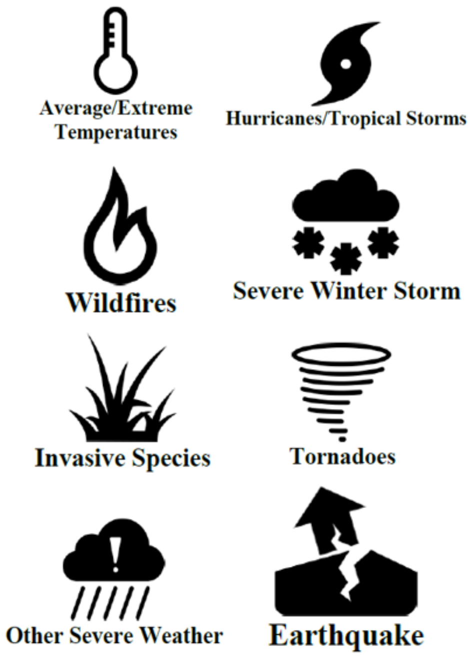
How could extreme weather impact Leyden?

- Local businesses may face interruptions/economic disruption
- Increased risk of property damage, for both business owners and home owners, and costly repairs for damaged municipal infrastructure
- The town's natural resources such as forests and rivers could be damaged

Overview of the Planning Process

The MVP Planning Committee is looking forward to hosting a series of public meetings and workshops to gather information for this plan.

Our goal for these meetings is to identify how Leyden has been impacted by a changing climate, the Town's strengths and vulnerabilities, and and potential community actions. The next series will provide an overview on the information we are hoping to gather.



1 - Characterize Leyden's Top Hazards

The purpose of this task is to identify which hazards have impacted Leyden in the past, which are currently affecting the Town, and determine which will post the greatest risk in the future.

	Strength	Vulnerability
Infrastructure	• Trees near powerlines are routinely cut	• Undersized culverts or bridges
Environment	• Large parcels of conserved land	• Culverts are blocked by beaver dams
Society	• Residential emergency preparedness	• Sheltering facility lacks backup power

2 - Identify Strengths and Vulnerabilities

The next step is to focus on determining Leyden's strengths and vulnerabilities in the three MVP program sectors: Infrastructure, Environment, and Society. Examples of strengths and vulnerabilities are shown in the table to the right.

The purpose of this task is to identify which aspects of the community are impacted by natural hazards as well as the features that help to make the community stronger and more resilient to these hazards.

Examples:

Upgrade culverts, flood-proof drinking water supplies

Evacuation drills and extreme weather communications protocols to protect vulnerable populations

Protect wetlands and floodplains to improve flood resiliency

Photo credit: Mass DER

3 - Identify and Prioritize Community Actions

The last step is to identify resiliency actions for each of the three sectors; actions can either build upon one of the town's strengths or address a vulnerability.

Projects that restore, protect, and/or manage natural systems and/or mimic natural processes to address hazards like flooding, erosion, drought, and heat islands in ways that are cost-effective, low maintenance, and multibeneficial for public health, safety, and well-being.

Riverbank restoration on the North River, Colrain MA

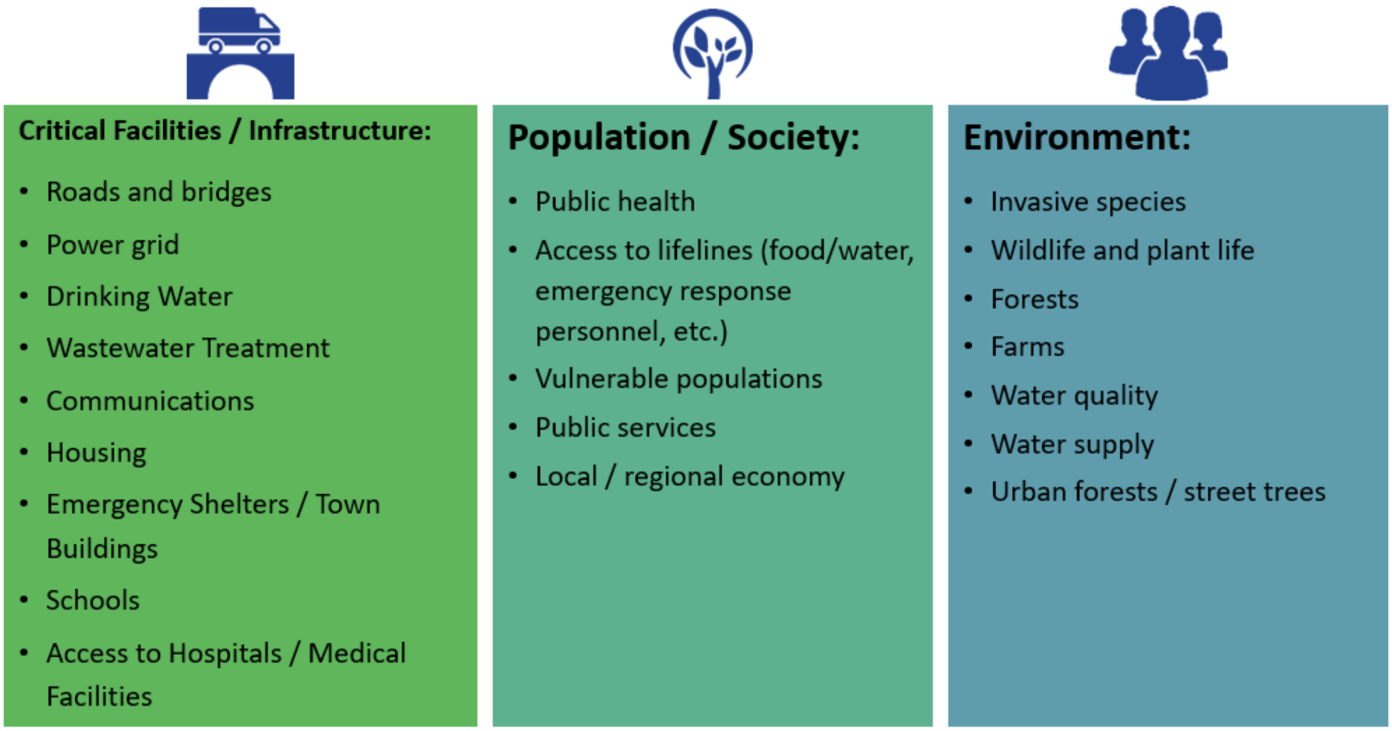
Low impact development project, Greenfield MA

The MVP program emphasizes **nature based solutions.** These actions work with nature to help us adapt to environmental challenges, and can either use natural systems, mimic natural processes or work in tandem with engineering to address natural hazards.

During the planning process and public meetings, we'll discuss how these projects could be beneficial to the Town and where they could be sited.

If you're interested in learning more about nature based solutions, the MVP program has an excellent digital tookit - click on the box below to go to the website.

NBS Toolkit



Before the meetings, consider which aspects of Leyden's **infrastructure**, **society**, or **environment** are particularly vulnerable or already resilient to the effects of climate change, considering the information presented in the previous section of the StoryMap. To the right are some examples in each category.

We want to hear from you!

If you are interested in providing your own feedback for the plan, please respond to the survey below, or consider attending an upcoming session. We will post details about future meetings on the main webpage. Also, keep an eye out in the Leyden Life newsletter for entries about the project - we will be posting a new survey with each newsletter. Thank you in advance for your input!

Leyden MVP Survey #1

Additional Resources

Click on the links below to learn more about the MVP program, MVP Action grants, and projects that have been awarded funding through the program.

Resilient MA

MVP Program Information

MVP Action Grants

Examples of Completed Projects

Community Resilience Building

Cover Photo The Greenfield Recorder

Appendix C – FEMA Final Plan Review Tool

LOCAL MITIGATION PLAN REVIEW TOOL - Final

Town of Leyden, MA

The *Local Mitigation Plan Review Tool* demonstrates how the Local Mitigation Plan meets the regulation in 44 CFR §201.6 and offers States and FEMA Mitigation Planners an opportunity to provide feedback to the community.

- The Regulation Checklist provides a summary of FEMA's evaluation of whether the Plan has addressed all requirements.
- The Plan Assessment identifies the plan's strengths as well as documents areas for future improvement.
- The Multi-jurisdiction Summary Sheet is an optional worksheet that can be used to document how each jurisdiction met the requirements of each Element of the Plan (Planning Process; Hazard Identification and Risk Assessment; Mitigation Strategy; Plan Review, Evaluation, and Implementation; and Plan Adoption).

The FEMA Mitigation Planner must reference this *Local Mitigation Plan Review Guide* when completing the *Local Mitigation Plan Review Tool*.

Jurisdiction: Town of Leyden, MA	**Title of Plan:** Leyden Community Resilience Building and Hazard Mitigation Plan	**Date of Plan:** 06/16/2022 **Resubmit:** 9/12/2022
Single or Multi-jurisdiction plan? Single	**New Plan or Plan Update?** Update	
Local Point of Contact & Title: Michele Giarusso, Municipal Assistant **Address:** Town of Leyden 7 Brattleboro Road Leyden, MA 01301 Phone: 413-774-4111, x1 Fax: 413-772-0146 Email: selectboard@townofleyden.com	**Regional Point of Contact:** Kimberly Noake MacPhee, P.G., CFM., Land Use & Natural Resources Planning Program Manager; Franklin Regional Council of Governments **Address:** 12 Olive Street, Suite 2 Greenfield, MA 01301 Phone: 413-774-3167 x130 Fax: 413-774-3169 Email: KMacPhee@frcog.org	

State Reviewer:	**Title:**	**Date:**
Jeffrey Zukowski	Hazard Mitigation Planner	6/27/2022; 9/12/2022 & 10/13/2022

FEMA Reviewer:	**Title:**	**Date:**
Claire Fetters Brigitte Ndikum-Nyada	CERC Planner Community Planner	07/11/2022 8/1/2022 to 8/3/2022; 9/21-9/22; 10/14/22-10/19/22
Date Received in FEMA Region I	6/27/2022; 9/12/2022; 10/13/2022	
Plan Not Approved	8/3/2022	
Plan Approvable Pending Adoption	9/22/2022	
Plan Adopted	10/11/2022	
Plan Approved	**10/14/2022**	
Plan will expire	10/13/2027	

SECTION 1:
REGULATION CHECKLIST

INSTRUCTIONS: The Regulation Checklist must be completed by FEMA. The purpose of the Checklist is to identify the location of relevant or applicable content in the Plan by Element/sub-element and to determine if each requirement has been 'Met' or 'Not Met.' The 'Required Revisions' summary at the bottom of each Element must be completed by FEMA to provide a clear explanation of the revisions that are required for plan approval. Required revisions must be explained for each plan sub-element that is 'Not Met.' Sub-elements should be referenced in each summary by using the appropriate numbers (A1, B3, etc.), where applicable. Requirements for each Element and sub-element are described in detail in this *Plan Review Guide* in Section 4, Regulation Checklist.

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
ELEMENT A. PLANNING PROCESS			
A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))	Ack., p. i; Sec. 1, pp. 5-9; App. A; App. B	X	
A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))	Ack., p. I; Sec. 1, pp. 5-9; App. A; App. B	X	
A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))	Sec. 1, p. 9; App. A	X	
A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))	Sec. 1, p. 9; References included throughout the plan	X	
A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))	Sec. 5, p. 244	X	
A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))	Sec. 5, pp. 235-242	X	
ELEMENT A: REQUIRED REVISIONS			
ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT			
B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))	Sec. 3, pp. 42-199	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))	Sec. 3, pp. 42-199	X	
B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))	Sec. 2, pp. 26-32; Sec. 3, pp. 42-199	X	
B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))	Sec. 3, p. 67	X	
ELEMENT B: REQUIRED REVISIONS			
ELEMENT C. MITIGATION STRATEGY			
C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))	Sec. 2, pp. 32-34; Sec. 4, pp. 200-220; Sec. 5, pp. 237-242	X	
C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))	Sec. 2, p. 14; Sec. 3, p. 67; Sec. 4, pp. 210-211	X	
C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))	Sec. 4, pp. 221-222	X	
C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))	Sec. 2, pp. 34-41; Sec. 4, pp. 226-232	X	
C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))	Sec. 4, pp. 221-232	x	
C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))	Sec. 5, pp. 243-244	X	
ELEMENT C: REQUIRED REVISIONS			
ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION (applicable to plan updates only)			
D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))	Sec. 2, pp. 10-25	X	
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))	Sec. 4, pp. 226-233; Sec. 5, p. 243	x	
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))	Sec. 3, p. 185; Sec. 4, pp. 226-233	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
ELEMENT D: REQUIRED REVISIONS			
ELEMENT E. PLAN ADOPTION			
E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))	The adoption certificate is on file. Approval **10/14/2022** and expires 10/13/2027	X	
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))	Not applicable.		
ELEMENT E: REQUIRED REVISIONS **See recommended correction below**			
ELEMENT F. ADDITIONAL STATE REQUIREMENTS (OPTIONAL FOR STATE REVIEWERS ONLY; NOT TO BE COMPLETED BY FEMA)			
F1.			
F2.			
ELEMENT F: REQUIRED REVISIONS			

SECTION 2:
PLAN ASSESSMENT

A. Plan Strengths and Opportunities for Improvement

This section provides a discussion of the strengths of the plan document and identifies areas where these could be improved beyond minimum requirements.

Recommended Corrections:

- Prior to plan adoption, ensure the HMP title on the plan's cover (i.e., "Leyden Community Resilience Building and Hazard Mitigation Plan," is reconciled with the current title on the adoption resolution document on page 248 (i.e., "*The Town of Leyden Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan.")*
- Update all references to the Pre-Disaster Mitigation (PDM) Program. The Building Resilient Infrastructures and Communities (BRIC) Program has replaced PDM. For more information about BRIC, please visit https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities.
- The Hurricanes/Tropical Storm hazard profile includes a brief sentence to add stories and information from the Core Team about how hurricanes have affected the town in recent years. Add that information to provide a local snapshot of events.
- Correct the date of the previous hazard mitigation plan on page 221 of the plan. The reference states that the previous plan was from **2014**, but other references state that it was from 2016.

Element A: Planning Process

Strengths:

- The planning process is well detailed. Adding the meeting materials will help guide future updates.
- A range of existing studies, reports, and plans were reviewed and incorporated. The result is a plan that is comprehensive and current.
- The plan documents the timeline and schedule for how the plan will be maintained. It includes specific tasks to be accomplished.
- The following required revision was met with the resubmitted revised HMP: **A3-a.:** The language on page 9 was edited to clarify that no comments were received during the public comment period.

Opportunities for Improvement:

- Consider diversifying stakeholder representation. Include people from the business community, non-profits, state entities, academia, planning boards, conservation commissions, or other interested parties. Doing so will expand the types of concerns to address and the networks to engage. It will also strengthen the plan and its implementation.
- Consider adding specific mitigation measure evaluation criteria to the plan monitoring procedures. This will allow progress to be better quantified.

Element B: Hazard Identification and Risk Assessment

Strengths:

- The plan does an excellent job of showing how the probability or severity of future hazard events may change due to changes in climate, population, or land use.
- Hazard profiles are well-defined. There is detailed information about the context of the hazard and the risk it presents to the community.
- The plan has a thorough hazard identification and risk assessment. When quantitative data was not available at the local level, the plan used data from the county or state and provided a qualitative discussion.

Opportunities for Improvement:

- Provide the date of the repetitive loss data. Continue to monitor the planning area for areas that are vulnerable to repetitive loss. Update the plan if the number of repetitive loss properties changes.

Element C: Mitigation Strategy

Strengths:

- The plan gives a comprehensive, detailed description of the community's existing programs, plans, and policies that relate to mitigation. It looks at how they could be expanded and further reduce risk.
- Mitigation actions directly address the vulnerabilities identified in the risk assessment.
- Mitigation actions are analyzed; costs and benefits are assessed.
- The following required revision was met with the resubmitted revised HMP: **C5-c.:** Tables 4-3 and 4-4 to clarify the available funding sources. A footnote was added to explain how Town funding could be used.

Opportunities for Improvement:

- Be sure to use specific language when describing how the plan update will be integrated into other planning mechanisms during its five-year lifespan. Using actionable language ensures elements from the hazard mitigation plan will be integrated into the town’s other planning work.
- The plan included local plans and regulations, structure and infrastructure projects, and education and awareness programs as mitigation actions. Think about natural system protections for the next plan update.

Element D: Plan Update, Evaluation, and Implementation (*Plan Updates Only*)

Strengths:

- The plan connects changes in development directly to changes in risk.
- The development section of the plan explains the zoning and permitting process (and any recent changes to it) in the town.
- The following required revision was met with the resubmitted revised HMP: **D2.a.:** In Table 4-5, “obsolete” was meant to indicate “no longer relevant.” There is a narrative for each of the action items in Table 4-5 that says “This action item was consolidated with related

action items, updated during the MVP Planning process and included in the Leyden MVP Plan and added to Table 4-3 or 4-4 of the HMP." I changed the title of Table 4-5 to read "Completed or Consolidated Leyden 2016 Hazard Mitigation Actions."

Opportunities for Improvement:

- This update HMP addressed element D2.a., in ways that could be improved to enhance the plan and improve the implementation of these actions. Tables 4-3 and 4-5 include the status of previous actions. Are these a comprehensive list of the previous plan's actions? For each action that was in the previous plan's mitigation strategy, update its status. Explain why the action was carried over to the new plan. Is the action ongoing, or was it completed during the previous plan's lifespan? If actions are completed and no longer relevant, they could be converted to programs or capabilities.
- Clearly state how priorities changed since the previous plan. To aid in the discussion, compare the previous plan's goals to the plan update's goals.
- Describe development trends using the best available and most current data. Include information from other community plans and the US Census.

B. Resources for Implementing Your Approved Plan

Refer to the Massachusetts Integrated State Hazard Mitigation and Climate Action Plan, Resilient MA Climate Clearinghouse, and State's Climate Action Page to learn about hazards relevant to Massachusetts and the State's efforts and action plan.

Technical Assistance:

FEMA

- Climate Resilience in Action | FEMA.gov: This page showcases efforts happening across the country, every day, to strengthen our communities. Together, we can build a climate resilient nation.
- FEMA Climate Change: Provides resources that address climate change.
- FEMA Hazard Mitigation Planning Online Webliography: This compilation of government and private online sites is a useful source of information for developing and implementing hazard mitigation programs and plans in New England.
- FEMA Library: FEMA publications can be downloaded from the library website. These resources may be especially useful in public information and outreach programs. Topics include building and construction techniques, NFIP policies, and integrating historic preservation and cultural resource protection with mitigation.
- FEMA Risk MAP: Technical assistance is available through Risk MAP to assist communities in identifying, selecting, and implementing activities to support mitigation planning and risk reduction. Attend Risk MAP discovery meetings that may be scheduled in the state, especially any in neighboring communities with shared watersheds boundaries.

Other Federal

- EPA Resilience and Adaptation in New England (RAINE): A collection of vulnerability, resilience and adaptation reports, plans, and webpages at the state, regional, and community levels. Communities can use the RAINE database to learn from nearby communities about building resiliency and adapting to climate change.
- EPA Soak Up the Rain: Soak Up the Rain is a public outreach campaign focused on stormwater quality and flooding. The website contains helpful resources for public outreach and easy implementation projects for individuals and communities.
- NOAA C-CAP Land Cover Atlas: This interactive mapping tool allows communities to see their land uses, how they have changed over time, and what impact those changes may be having on resilience.
- NOAA Sea Grant: Sea Grant's mission is to provide integrated research, communication, education, extension and legal programs to coastal communities that lead to the responsible use of the nation's ocean, coastal and Great Lakes resources through informed personal, policy and management decisions. Examples of the resources available help communities plan, adapt, and recovery are the Community Resilience Map of Projects and the National Sea Grant Resilience Toolkit
- NOAA Sea Level Rise Viewer and Union for Concerned Scientists Inundation Mapper: These interactive mapping tools help coastal communities understand how their hazard risks may be changing. The "Preparing for Impacts" section of the inundation mapper addresses policy responses to protect communities.
- NOAA U.S. Climate Resilience Toolkit: This resource provides scientific tools, information, and expertise to help manage climate-related risks and improve resilience to extreme events. The "Steps to Resilience" tool may be especially helpful in mitigation planning and implementation.

State

- Massachusetts Emergency Management Agency: The Massachusetts State Hazard Mitigation Officer (SHMO) and State Mitigation Planner(s) can provide guidance regarding grants, technical assistance, available publications, and training opportunities.
- Massachusetts Departments of Conservation and Recreation and Environmental Protection can provide technical assistance and resources to communities seeking to implement their hazard mitigation plans.
- MA Mapping Portal: Interactive mapping tool with downloadable data

Not for Profit

- Kresge Foundation Online Library: Reports and documents on increasing urban resilience, among other topics.
- Naturally Resilient Communities: A collaboration of organizations put together this guide to nature-based solutions and case studies so that communities can learn which nature-based solutions can work for them.
- Rockefeller Foundation Resilient Cities: Helping cities, organizations, and communities better prepare for, respond to, and transform from disruption.

Funding Sources:

- Massachusetts Coastal Resilience Grant Program: Funding for coastal communities to address coastal flooding, erosion, and sea level rise.
- Massachusetts Municipal Vulnerability Preparedness program: Provides support for communities to plan for climate change and resilience and implement priority projects.
- Massachusetts Water Quality Grants: Clean water grants that can be used for river restoration or other kinds of hazard mitigation implementation projects.
- Federal Grants Resource Center and Grants.gov: Lists of grant opportunities from federal agencies (HUD, DOT/FHWA, EPA, etc.) to support rural development, sustainable communities and smart growth, climate change and adaptation, historic preservation, risk analyses, wildfire mitigation, conservation, Federal Highways pilot projects, etc.
- FEMA Hazard Mitigation Assistance (HMA): FEMA's Hazard Mitigation Assistance provides funding for projects under the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), and Flood Mitigation Assistance (FMA). States, federally recognized tribes, local governments, and some not for profit organizations are eligible applicants.
- GrantWatch: The website posts current foundation, local, state, and federal grants on one website, making it easy to consider a variety of sources for grants, guidance, and partnerships. Grants listed include The Partnership for Resilient Communities, the Institute for Sustainable Communities, the Rockefeller Foundation Resilience, The Nature Conservancy, The Kresge Climate-Resilient Initiative, the Threshold Foundation's Thriving Resilient Communities funding, the RAND Corporation, and ICLEI Local Governments for Sustainability.
- USDA Natural Resource Conservation Service (NRCS) and Rural Development Grants: NRCS provides conservation technical assistance, financial assistance, and conservation innovation grants. USDA Rural Development operates over fifty financial assistance programs for a variety of rural applications.